CLIMATE CHANGE
09/2013

Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2013

National Inventory Report for the German Greenhouse Gas Inventory 1990 - 2011

Umwelt Bundesamt

| CLIMATE CHANGE | 09/2013

Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2013

National Inventory Report for the German Greenhouse Gas Inventory 1990 - 2011

Federal Environment Agency, Germany

UMWELTBUNDESAMT

This publication is only available online. It can be downloaded from http://www.uba.de/uba-info-medien-e/4504.html along with a German version and a summary.

ISSN 1862-4359

Publisher: Federal Environment Agency (Umweltbundesamt)
Wörlitzer Platz 1
06844 Dessau-Roßlau
Germany
Phone: +49-340-2103-0
Fax: +49-340-2103 2285
Email: info@umweltbundesamt.de
Internet: http://www.umweltbundesamt.de
http://fuer-mensch-und-umwelt.de/

Edited by: Section I 2.6 Emissions Situation
Michael Strogies, Patrick Gniffke

Dessau-Roßlau, May 2013

Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2013

National Inventory Report

for the German Greenhouse Gas Inventory

1990 - 2011

Federal Environment Agency, Germany

Resubmission

(changes only related to SEF reporting)

Dessau, 15.05.2013

Contact

This report was produced in the framework of work of the National Co-ordination Agency (Single Entity) for the *National System of Emissions Inventories* (Nationales System Emissionsinventare; NaSE), sited within the Federal Environment Agency (UBA). Contributions for the chapters on agriculture, and on land use, land-use changes and forestry, were prepared by the Johann Heinrich von Thünen Institute (TI).

The electronic version of this report, along with the pertinent emissions data in the Common Reporting Format (CRF) (Version 1.1.0, based on the CSE database, and with trend tables last revised as of 26 November 2012, is available on the Web site of the Federal Environment Agency:
http://www.umweltbundesamt.de/emissionen/publikationen.htm

Translation: **Eric Allen**

Authors

Management of the report as a whole: Michael Strogies, Patrick Gniffke (UBA I 2.6)

For the individual chapters:

Part I: Annual deliveries for the inventories [ip = in part]:

Chapters 1.1.1 & 1.1.2	Rosemarie Benndorf (UBA I 2.1)
Chapters 1.1.3, 1.2.1ip, 1.2.3, 1.3ip, 1.6ip	Dirk Günther (UBA I 2.6)
Chapters 1.2.1.6, 1.2.2 , 1.3.2, 1.3.3, 1.6ip	Stephan Schiller (UBA I 2.6)
Chapters 1.3.3.1.7, 1.6.2ip	Robert Kludt (UBA I 2.6)
Chapters 1.3.2.4, 1.5, 2, 3.2.1, 3.2.3-5, 3.2.13	Michael Strogies (UBA I 2.6)
Chapters 1.7., 1.8	Detlef Rimkus (UBA I 2.6)
Chapter 3.2	Petra Icha. Jens Langenfeld (UBA I 2.5), Marion Dreher (UBA I 2.5), Kristina Juhrich (UBA I 2.6)
Chapter 3.2.2.2	Sabine Gores (Öko-Institut Berlin), Michael Kotzulla (UBA I 2.6), Frank Wetzel (UBA I 3.2)
Chapter 3.2.2.3	Katharina Koppe (UBA I 3.2), Michael Kotzulla (UBA I 2.6)
Chapters 3.2.6 – 3.2.8, 3.2.9.6	Petra Icha, Jens Langenfeld (UBA I 2.5), Rolf Beckers (UBA III 2.1), Kristina Juhrich (UBA I 2.6)
Chapter 3.2.9.1	Petra Icha (UBA I 2.5), Sebastian Plickert (UBA III 2.2)
Chapters 3.2.9.2 - 3.2.9.3, 3.2.9.5, 3.2.9.7 - 3.2.9.11	Petra Icha (UBA I 2.5)
Chapter 3.2.9.4	Petra Icha (UBA I 2.5), Almut Reichart (UBA III 2.1)
Chapter 3.2.10.1	Sabine Gores (Öko-Institut Berlin), Michael Kotzulla (UBA I 2.6), Frank Wetzel (UBA I 3.2)
Chapters 3.2.10.2 - 3.2.10.5	Gunnar Gohlisch, Nadja Richter (UBA I 3.1)
Chapters 3.2.11 + 3.2.12	Anja Behnke (UBA III 2.1), Reinhard Böhnke (UBA I 2.5)
Chapter 3.3.1	Jürgen Ilse (Gesamtverband Steinkohle), Christian Böttcher (UBA I.2.6); Sebastian Plickert (UBA III 2.2)
Chapter 3.3.2	Edda Hoffmann (UBA III 2.1), Karen Pannier (UBA III 2.1); Christiane Lohse (UBA I 2.3), Andreas Bertram (UBA I 2.3) Christian Böttcher (UBA I.2.6)
Chapter 4.2.1 - 4.2.2	Maja Bernicke (UBA III 2.2)
Chapter 4.2.3	Robert Kludt (UBA I 2.6)
Chapter 4.2.4	Jens Reichel (UBA III 2.1)
Chapter 4.2.5	Robert Kludt (UBA I 2.6)
Chapter 4.2.6	Martina Held (UBA III 2.2), Robert Kludt (UBA I 2.6)
Chapter 4.2.7	Sandra Leuthold (UBA III 2.2)
Chapter 4.2.8	Maja Bernicke (UBA III 2.2)
Chapters 4.3.1 & 4.3.2	Jens Reichel (UBA III 2.1)

Chapter 4.3.3	Johannes Drotleff (UBA III 2.1)
Chapter 4.3.4	Jens Reichel (UBA III 2.1)
Chapter 4.3.5	Jens Reichel (UBA III 2.1), Johannes Drotleff (UBA III 2.1), Edda Hoffmann (UBA III 2.1)
Chapter 4.4.1	Sebastian Plickert (UBA III 2.2)
Chapters 4.4.2 & 4.4.3	Christian Lehmann (UBA III 2.2)
Chapter 4.4.4	Cornelia Elsner (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 4.4.5	Cornelia Elsner (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 4.5	Almut Reichart (UBA III 2.1)
Chapter 4.5.2	Ulrich Gromke (UBA III 2.1)
Chapters 4.6 - 4.7	Kerstin Martens (UBA III 1.4), Cornelia Elsner (UBA III 1.4) David Kuntze (UBA I 2.6)
Chapter 5.2	Folke Dettling (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 5.3	Folke Dettling (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 6	Johann Heinrich von Thünen-Institut (TI AK): Hans-Dieter Haenel, Claus Rösemann
Chapter 7.1	Johann Heinrich von Thünen-Institut (TI): Annette Freibauer, Karsten Dunger, Andreas Gensior, Thomas Riedel, Andreas Laggner, Birgit Laggner, Wolfgang Stümer
Chapter 7.2	Johann Heinrich von Thünen-Institut (TI WO): Karsten Dunger, Wolfgang Stümer, Katja Oehmichen, Thomas Riedel, Daniel Ziche, Erik Grüneberg, Nicole Wellbrock
Chapters 7.3 -7.8	Johann Heinrich von Thünen-Institut (TI AK): Annette Freibauer, Andreas Gensior, Andreas Laggner
Chapter 8.2	Wolfgang Butz (UBA III 2.4)
Chapter 8.3	Dietmar Wunderlich, Christine Galander (UBA III 2.5)
Chapter 8.5	Tim Hermann, Wolfgang Butz (UBA III 2.4)
Chapter 10	Michael Kotzulla (UBA I 2.6)

<u>Part II: Supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol</u>

Chapter 11	Johann Heinrich von Thünen-Institut (TI WO): Wolfgang Stümer, Katja Oehmichen, Karsten Dunger, Johanna Steuk
Chapter 11.7, 12, 14	Deutsche Emissionshandelsstelle (DEHSt):
Chapter 13	Dirk Günther (UBA I 2.6)
Chapter 15	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), Referat KI 1.1

<u>Annexes:</u>

Annexes 1, 4	Michael Strogies (UBA I 2.6)
Annex 2	Marion Dreher (UBA I 2.6),
Annex 2, Chapter 18.7	Kristina Juhrich (UBA I 2.6)
Annex 2, 18.8	David Kuntze (UBA I 2.6)
Annex 3	Authors in keeping with specialised responsibility in Chapters 3-15
Annex 3, Chapter 19.1.1	Marcus Machat (UBA E 1.1), Frank Zander (Institut für Energetik und Umwelt: IE gGmbH), Dr. Dieter Merten (IE gGmbH)
Annex 3, Chapter 19.5	Johann Heinrich von Thünen-Institut (TI): Annette Freibauer, Karsten Dunger, Andreas Gensior, Thomas Riedel, Andreas Laggner, Wolfgang Stümer
Annex 5	Detlef Rimkus (UBA I 2.6)

Annex 6	Dirk Günther (UBA I 2.6), Authors in keeping with specialised responsibility
Annex 6, Chapter 22.1.2	Stephan Schiller (UBA I 2.6)
Annex 6, Chapter 22.1.3	Kevin Hausmann (UBA I 2.6)
Annex 7	Detlef Rimkus (UBA I 2.6)

Imprint

Published by: Umweltbundesamt (Federal Environmental Agency), Wörlitzer Platz 1, 06844 Dessau, Deutschland

Kapitel 3.2.2.2	Sabine Gores (Öko-Institut Berlin), Michael Kotzulla (UBA I 2.6), Frank Wetzel (UBA I 3.2)

Inhaltsverzeichnis

List of figures

List of tables

List of Abbreviations

AbfAblV	Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (Abfallablagerungsverordnung)
ABL	Old German Länder
AGEB	Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)
AK	Working group (Arbeitskreis)
ALH	All other deciduous/broadleaf trees with high life expectancies (BWI tree-species group)
ALN	All other deciduous/broadleaf trees with low life expectancies (BWI tree-species group)
ANCAT	Abatement of Nuisances from Civil Air Transport
AR	Activity data (=AD)
ARD	Afforestation, reforestation, deforestation
ATKIS	Official topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem)
AWMS	Animal Waste Management System
BAFA	Federal Office of Economics and Export Control
BAT	Best Available Technique
BDZ	Federal Association of the German Cement Industry (Bundesverband der Deutschen Zementindustrie)
BEF	Biomass-expansion factor
BEU	Balance of emissions sources for stationary and mobile combustion processes (Bilanz der Emissionsursachen für stationäre und mobile Verbrennungsprozesse)
BGR	Federal Institute for Geosciences and Raw Materials (Bundesanstalt für Geowissenschaften und Rohstoffe)
BGS	Fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) publicly connected to such operations
BGW	Federal Association of the German Gas and Water Industry (Bundesverband der deutschen Gas- und Wasserwirtschaft)
BHD	Diameter at breast height (= DBH; tree-trunk diameter at a height of 1.30 m above the ground)
BHKW	Combined heat and power (CHP) unit (Blockheizkraftwerk)
BKG	Federal Agency for Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie)
BImSchV	Statutory Ordinance under the Federal Immission Control Act
BML	cf. BMELV
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMELV	Federal Ministry of Food, Agriculture and Consumer Protection
BMVEL	cf. BMELV
BMVG	Federal Ministry of Defence

BMWA	cf. BMWi
BMWi	Federal Ministry of Economics and Technology
BoHE	Main survey on soil use (Bodennutzungshaupterhebung)
BREF	BAT (Best Available Technique) Reference Documents
BSB	Biological oxygen demand (= BOD; Biologischer Sauerstoffbedarf)
BSB_5	Biological oxygen demand within 5 days (BOD_5)
BV Kalk	German Lime Association (Bundesverband der Deutschen Kalkindustrie)
BÜK	Soil-overview map (Bodenübersichtskarte)
BWI	National Forest Inventory (Bundeswaldinventur)
BZE	Forest Soil Inventory (Bodenzustandserhebung im Wald)
C_2F_6	Hexafluorethane
CAPIEL	Coordinating Committee for the Associations of Manufacturers of Industrial Electrical Switchgear and Controlgear in the European Union
CFC	Chlorofluorocarbons (= Fluorchlorkohlenwasserstoffe (FCKW))
CFI	Continuous Forest Inventory
CH_4	Methane
C_{org}	Organic carbon stored in the soil
CO	Carbon monoxide
CO_2	Carbon dioxide
CORINAIR	Coordination of Information on the Environment, sub-project: Air
CORINE	Coordinated Information on the Environment
CRF	Common Reporting Format
CSB	Chemical oxygen demand (COD)
D	Germany (Deutschland)
D7	Tree-trunk diameter at a height of 7 m above the ground
DEHSt	German Emissions Trading Authority (Deutsche Emissionshandelsstelle)
DESTATIS	Federal Statistical Office (Statistisches Bundesamt Deutschland)
DFIU	Franco-German Institute for Environmental Research, at the University of Karlsruhe (Deutsch-Französisches Institut für Umweltforschung an der Universität Karlsruhe)
DG	Landfill gas (Deponiegas)
DGMK	German Association of Oil, Natural Gas and Coal Science (Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle eV.)
DIN	DIN standard (Deutsche Industrienorm)
DIW	German Institute for Economic Research (Deutsches Institut für Wirtschaftsforschung)
DLR	German Aerospace Center (Deutsches Zentrum für Luft- and Raumfahrt)
DMKW	Diesel-engine power stations (Dieselmotorkraftwerke)
D_N	Nitrogen in wastewater
DOC	Degradable organic carbon Degradable organic carbon)
DOC_F	Fraction of DOC dissimilated (converted into landfill gas) Fraction of DOC dissimilated)
DSWF	"Forest Fund Database" for the former GDR (Datenspeicher Waldfonds)
DTKW	Steam-turbine power stations (Dampfturbinenkraftwerke)
DVGW	German Association of the Gas and Water Industry (Deutsche Vereinigung des Gas- und Wasserfachs eV.)
EBZ	Energy Balance line in the BEU (Energiebilanzzeile)

EEA	European Environment Agency
EECA	European Electronic Component Manufacturers Association
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz); promulgated in Federal Law Gazette Part I No. 40 of 31 July 2004, p. 1918 ff.)
EF	Emission factor
EI	Emission index = emission factor
E_{KA}	Inhabitant connected to wastewater-treatment system (Einwohner mit Kläranlagenanschluss)
EL	Fuel oil EL (EL = easily liquid)
EM	Emission
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
EMEV	Emissions-relevant energy consumption (Emissionsrelevanter Energieverbrauch)
ERT	Expert Review Team
ESIA	European Semiconductor Industry Association
ETS	EU Emissions Trading Scheme
EU	European Union
EU-EH	ETS (Europäischer Emissionshandel)
EUROCONTROL	European Organisation for the Safety of Air Navigation
EUROSTAT	Statistical Office of the European Communities
EW	Population (Einwohnerzahl)
FA	Combustion systems (Feuerungsanlagen)
FAP	Specialised contact person in the NaSe (Fachlicher Ansprechpartner)
FAL	Federal Agricultural Research Centre
FAO	United Nations Food and Agriculture Organisation of the United Nations
FCKW	CFC (Fluorchlorkohlenwasserstoffe)
F gases	Hydrofluorocarbons
FHW	District heating stations (Fernheizwerke)
FKW	Perfluorocarbons (PFC) PFC
FKZ	Research project number (Forschungskennzahl)
FV	Responsible expert (Fachverantwortlicher) in the NaSE
FWL	Thermal output from combustion (Feuerungswärmeleistung)
GAS-EM	GASeous EMissions (a calculation programme for emissions in the agriculture sector)
GEREF	GERman Emission Factor Database
GFA	Large combustion systems (Großfeuerungsanlagen)
GG	Total weight (Gesamtgewicht)
GIS	Gas-insulated switching systems
GMBL	Joint Ministerial Gazette (Gemeinsames Ministerialblatt)
GMES	Global Monitoring for Environment and Security
GMKW	Gas-engine power stations (Gasmotorkraftwerke)
GPG	Good Practice Guidance
GSE FM-INT	GMES Services Elements Forest Monitoring: Inputs for national greenhouse-gas reporting
GT	Gas turbines

GTKW	Gas-turbine power stations (Gasturbinenkraftwerke)
GuD	Gas and steam turbine power stations (Gas- und Dampfturbinenkraftwerke)
GWP	Global Warming Potential
HFC	Hydrofluorocarbons (= HFKW)
HFCKW	Hydrochlorofluorocarbons (HCFCs; Wasserstoffhaltige Fluorchlorkohlenwasserstoffe)
HFKW	Hydrofluorocarbons (HFC)
HK	Key category (Hauptkategorie); is applied to both emissions sources and sinks
HS-GIS	High-voltage gas-insulated switching systems
IAI	International Aluminium Institute
IE	Included elsewhere
IEA	International Energy Agency
IEF	Implied emission factor
IfE	Institute for Energy and Environment (Institut für Energetik und Umwelt)
IFEU	Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung)
IKW	Industrial power stations (Industriekraftwerke)
IMA	Interministerial Working Group (Interministerielle Arbeitsgruppe)
IPCC	Intergovernmental Panel On Climate Change
IS08	Inventory Study 2008 (Inventurstudie 2008)
K	Fuel input for power generation (direct drive)
k.A.	No entry (keine Angabe)
KP	Kyoto Protocol
KS	Sewage sludge (Klärschlamm)
l	Level (= Level assessment pursuant to IPCC Good Practice Guidance)
LF	Agriculturally used land (landwirtschaftlich genutzte Flächen)
LKW	Truck (Lastkraftwagen)
LTO	Landing/take-off cycle
LUCF	Land Use Change and Forestry
LULUCF	Land Use, Land Use Change and Forestry
MBA	Mechanical-biological waste treatment (MBT; Mechanisch-Biologische Abfallbehandlung)
MCF	Methane Conversion Factor
MS	Medium voltage (Mittelspannung)
MSW	Municipal solid waste
MVA	Waste incineration plant (Müllverbrennungsanlage)
MW	Megawatt
N	Nitrogen
N_2O	Nitrous oxide (laughing gas)
NA	Not applicable
NASA	National Aeronautics and Space Administration
NaSE	German National System of Emissions Inventories (Nationales System Emissionsinventare)
NBL	New German Länder (neue Bundesländer)
NE	Not estimated
NEAT	Non-energy Emission Accounting Tables

NEC	Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain air pollutants National Emission Ceilings).
NEV	Non-energy-related consumption (nichtenergetischer Verbrauch)
NFR	New Format on Reporting, Nomenclature for Reporting to the UN ECE
NFZ	Utility vehicles (Nutzfahrzeuge)
NH_3	Ammonia
NIR	National Inventory Report
NMVOC	Non-Methane Volatile Organic Compounds
NO	Not occurring
NO	Nitrogen monoxide
NSCR	Non-selective catalytic reduction
OCF	One-component foam (installation foam)
OX	Oxidation factor
PAH	Polycyclic aromatic hydrocarbons (= PAK)
PAK	Polycyclic aromatic hydrocarbons (Polycyclische aromatische Kohlenwasserstoffe; = PAH)
PARTEMIS	Measurement and prediction of emissions of aerosols and gaseous precursors from gas turbine engines
PCDD/F	Polychlorinated dibenzo-dioxins/- furans
PF	Process combustion (Prozessfeuerungen)
PFC	Perfluorocarbons
PKW	Automobile (Personenkraftwagen)
PU	Polyurethane
QK	Quality control (QC; Qualitätskontrolle)
QS	Quality assurance (QA; Qualitätssicherung)
QSE	Quality System for Emissions Inventories
REA	Flue-gas desulphurising plant (Rauchgasentschwefelungsanlage)
ROE	Oil equivalent (OE; Rohöleinheit)
RSt	Raw steel
RWI	Rheinisch-Westfälisches Institut für Wirtschaftsforschung
S	Fuel input for power generation
S	Heating oil, heavy (high viscosity; "Heizöl S")
S&A Report	Synthesis and Assessment Report
SA	Heating oil, heavy (high viscosity; low sulphur content; "Heizöl SA")
SE	Sampling error
SF_6	Sulphur hexafluoride
SKE	Hard-coal units (Steinkohleneinheiten)
SNAP	Selected Nomenclature for Air Pollution
SO_2	Sulphur dioxide
STEAG	STEAG Aktiengesellschaft (a large power producer in Germany)
T	Trend (= trend assessment pursuant to IPCC Good Practice Guidance, in the source-category overview tables)
TA Luft	Technical directive on air quality control; First General Administrative Provision on the Federal Immission Control Act (Clean Air Directive; Technische Anleitung zur Reinhaltung der Luft)
TAN	Total Ammoniacal Nitrogen

THG	Greenhouse gases (GHG; Treibhausgase)
TI	Johann Heinrich von Thünen Institute
TI-AK	Johann Heinrich von Thünen Institute, Institute of Climate-Smart Agriculture (Institut für Agrarklimaschutz)
TI-WO	Johann Heinrich von Thünen Institute, Institute for Forest Ecosystems (Institute für Waldökosysteme)
TM	Dry matter (Trockenmasse)
TOC	Total Organic Carbon
TREMOD	Traffic Emission Estimation Model
TS	Siccative (Trockenstoff)
TÜV	Technischer Überwachungsverein (Certifying body for technical and product safety)
TVF	Tonne of utilisable production (Tonne verwertbare Förderung)
UBA	Federal Environment Agency (Umweltbundesamt)
UN ECE	United Nations Economic Commission for Europe
UN FCCC	United Nations Framework Convention on Climate Change
UN	United Nations
UStatG	Environmental Statistics Act (Umweltstatistikgesetz)
VDEh	German Iron and Steel Institute (Verein Deutscher Eisenhüttenleute; in 2003, renamed "Stahlinstitut VDEh")
VDEW	Electricity Industry Association (Verband der Elektrizitätswirtschaft)
VDI	Association of German Engineers (Verein Deutscher Ingenieure e.V.)
VDN	Association of German network operators (Verband der Netzbetreiber e.V.)
VDZ	German Cement Works Association (Verein Deutscher Zementwerke e.V.)
VGB	Technical association of operators of large power stations (Technische Vereinigung der Großkraftwerksbetreiber e.V.)
VIK	Association of the Energy and Power Industry (Verband der Industriellen Energie- and Kraftwirtschaft e.V.)
VOC	Volatile Organic Compounds
VS	Volatile Solids
W	Fuel input for heat generation
WS	Portion of a specific wastewater treatment system (e.g. aerobic, anaerobic)
WZ	Economic activity listed in the National Classification of Economic Activities (NACE; Wirtschaftszweig)
XPS	Extruded polystyrene
ZSE	Central System of Emissions (CSE)

Units and sizes

Multiplication factors, abbreviations, prefixes and symbols

		Prefix/symbol	
Multiplication factor	Abbreviation	Name	Symbol
1,000,000,000,000,000	10^{15}	peta	P
1,000,000,000,000	10^{12}	tera	T
1,000,000,000	10^{9}	giga	G
1,000,000	10^{6}	mega	M
1,000	10^{3}	kilo	k
100	10^{2}	hecto	h
0.1	10^{-1}	deci	d
0.01	10^{-2}	centi	c
0.001	10^{-3}	milli	m
0.000001	10^{-6}	micro	µ

Units and abbreviations

Abbreviation	Units
°C	degrees Celsius
a	year
cal	calorie
g	gram
h	hour
ha	hectare
J	joule
m^3	cubic metre
ppm	parts per million
t	tonne
W	watt

Standard conversions

Units	is equivalent to
1 tonne (t)	1 megagram (Mg)
1 kilotonne / thousand tonnes (kt)	1 gigagram (Gg)
1 megatonne / million tonnes (Mt)	1 teragram (Tg)

Reading the introductory information tables

The introductory information tables appear at the beginning of each source category chapter. Each such table provides an overview of the relevant source category's importance and of the methods used in connection with it.

CRF 1.x.x.x (example)	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**339,017.9**	**(27.76 %)**	**305,235.0**	**(32.56 %)**	**-10.0 %**
All fuels	**N_2O**	**L**	**T**	**3,610.0**	**(0.30 %)**	**3,371.1**	**(0.36 %)**	**-6.6 %**
All fuels	**CH_4**	**-**	**T**	**185.8**	**(0.02 %)**	**1,567.8**	**(0.17 %)**	**744.0 %**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2			CS

Key category

The upper section of the table shows the key-category-analysis lines that are relevant for the source category in question; the emissions, as an absolute figure (Gg CO_2 equivalent) and as a percentage of total emissions in 1990 and in the last reported year; and the pertinent emissions trend between the base year and the last reported year. In the NIR, the term "key category" is used synonymously with the term "key source".

L = Key category in terms of emissions level
T = Key category in terms of emissions trend
T2 = Key category pursuant to Tier-2 analysis

Gas

The lower section of the table provides information about the methods used, the source for the activity data and the emission factors (EF) used.

Method used

D = IPCC default
RA = Reference Approach
T1 = IPCC tier 1
T1a/ T1b/ T1c = IPCC tier 1a/ 1b/ 1c
T2 = IPCC tier 2
T3 = IPCC tier 3
C = CORINAIR
CS = Country-specific
M = Model

Source for the activity data

M = Model
Q = Questionnaires, surveys
PS = Plant-specific data
AS = Associations, business organizations
RS = Regional statistics
NS = National statistics
IS = International statistics

Emission factor (EF)

D = IPCC default
C = CORINAIR
CS = Country-specific
PS = Plant-specific
M = Model

0 SUMMARY (ES)

As a Party to the United Nations Framework on Climate Change (UNFCCC), since 1994 Germany has been obliged to prepare, publish and regularly update national emission inventories of greenhouse gases. In February 2005, the Kyoto Protocol entered into force. As a result, for the first time ever the international community of nations is required to implement binding action objectives and instruments for global climate protection. This leads to extensive obligations vis-à-vis the preparation, reporting and review of emissions inventories. As a result of Europe's own implementation of the Kyoto Protocol, via the adoption of EU Decision 280/2004[1], these requirements became legally binding for Germany in spring 2004.

Pursuant to Decision 3/CP.5, all Parties listed in ANNEX I of the UNFCCC are required to prepare and submit annual National Inventory Reports (NIRs) containing detailed and complete information on the entire process of preparation of such greenhouse-gas inventories. The purpose of such reports is to ensure the transparency, consistency and comparability of inventories and support the independent review process. The Secretariat of the Framework Convention on Climate Change has made submission of the inventory report a prerequisite for performance of the agreed inventory reviews.

Pursuant to to decision 15/CMP.1, as of 2010 all of the countries listed in ANNEX I of the UN Framework Convention on Climate Change that are also parties to the Kyoto Protocol must submit annual inventories in order to be able to make use of flexible mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol.

Together with the inventory tables, Germany submits a National Inventory Report (NIR), which refers to the period covered by the inventory tables and describes the methods and data sources on which the pertinent calculations are based. The report and the report tables in the Common Reporting Format (CRF) have been prepared in accordance with the UNFCCC guideline on annual inventories (FCCC/SBSTA/2006/9) and in accordance with the *IPCC Good Practice Guidance* (IPCC-GPG, 2000) and the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC-GPG LULUCF, 2003). The NIR contains a Part II, along with additional sub-chapters, that fulfill the expanded requirements under the Kyoto Protocol and the relevant obligations at the European level.

<u>Part I of the NIR</u>, comprising Chapters 1 to 10, contains all the information relevant to the annual greenhouse-gas inventory.

Chapter 1 provides background information about climate change and about greenhouse-gas inventories, as well as further information relative to the Kyoto Protocol. This section describes the National System pursuant to Article 5.1 of the Kyoto Protocol, which system is designed to aid and assure compliance with all reporting obligations with respect to atmospheric emissions and removals in sinks. In addition, this chapter describes the basic principles and methods with which the emissions and sinks of the IPCC categories are calculated, presents a short summary of key-category assessment and describes the Quality System for Emissions Inventories (QSE). The chapter concludes with sections on uncertainties analysis and completeness analysis.

[1] Decision No. 280/2004/EC of the European Parliament and the Council of 11 February 2004 on a system for monitoring greenhouse-gas emissions in the Community and for implementing the Kyoto Protocol (OJ EU L 49 p. 1).

Chapter 2 provides a general overview of development of emissions of direct and indirect greenhouse gases and of removals of carbon dioxide in sinks.

Chapters 3 through 9 present information about the individual source and sink groups. Along with general descriptions and information relative to the methods used, sub-chapters in this section also include information about pertinent uncertainties, quality assurance and quality control, recalculations carried out and planned improvements for relevant source and sink categories.

The inventories, the National System and the Quality System for Emissions Inventories have all been further improved in keeping with the results of the reviews that have taken place in recent years. More-detailed information about recalculations, and information relative to the improvements and changes made with regard to the last greenhouse-gas inventory, is presented in **Chapter 10** .

Part II of the NIR, comprising **Chapters 11 to 16**, presents the so-called "Kyoto-NIR", in fulfillment of the expanded requirements for Kyoto reporting, and in keeping with the required organisation (annotated NIR).

Chapter 11 contains all information relative to Kyoto reporting in the areas of land use, land-use changes and forestry (LULUCF), especially the definition of "forest" chosen, details on the land-classification technique used and all information relative to selected activities pursuant to Arts. 3.3 and 3.4 of the Kyoto Protocol.

Chapter 12 is devoted completely to accounting for Kyoto units, a process for which, in Germany, the German Emissions Trading Authority (DEHSt) is responsible.

Chapters 13 and 14 provide an overview of changes made in the National System, and at the German Emissions Trading Authority, with the aim of ruling out the possibility of any undue influences on Kyoto reporting.

Chapter 15 lists all the measures that Germany is taking to minimise negative impacts pursuant to Article 3 (14).

Chapter 16 presents any required further information relative to Kyoto reporting.

Annexes 1 through 7, comprising **Chapters 17-23**, contain more-detailed descriptions of key categories, of individual source categories, of the CO_2-reference procedure, of completeness issues, of the National System and the Quality System, of the CSE emissions database and of uncertainties.

More-detailed information about specific relevant issues is presented in the literature listed in **Chapter 24**.

The Federal Environment Agency makes all calculations for the greenhouse-gas inventory and carries out all relevant compilation. Data on emissions and sinks in the land use, land-use changes and forestry sector have been provided by the Johann Heinrich von Thünen Institute (TI).

0.1 Background information on greenhouse-gas inventories and climate change (ES.1)

0.1.1 Background information about climate change (ES1.1)

Ever since the start of industrialisation, significant trans-regional and global changes in the substance balance of the atmosphere have been observed as a consequence of human activities. Worldwide, concentrations of carbon dioxide (CO_2) have risen by approximately 35 % compared to their levels in pre-industrial times, whilst those of methane (CH_4) have increased by 145 % and those of nitrous oxide (N_2O) have risen by 18 %. Furthermore, a number of brand-new substances such as chlorofluorocarbons (CFCs), halons, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6) have entered the atmosphere which almost never occur in nature and are generated almost exclusively by humans. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[2] shows that human impacts on climate are scientific fact.

0.1.2 Background information about greenhouse-gas inventories (ES1.2)

In February 2005, the Kyoto Protocol entered into force. As a result, the international community of nations is required to implement binding action objectives and instruments for global climate protection. In the framework of the Kyoto Protocol, the European Union has committed to reducing its greenhouse-gas emissions by 8% by the 2008–2012 period, in comparison to their base-year levels (1990 and 1995[3]) (the EU comprised 15 Member States at the time it made this commitment). This commitment has been divided within the EU in the framework of a burden-sharing agreement between the participating Member States[4]. Under this agreement, Germany has agreed to reduce its emissions by 21 % in comparison to the base year and thus has agreed to make a substantial contribution to fulfillment of the EU's commitment. Consequently, Germany's relevant measures, and its calculations relative to emissions reductions, are being followed with considerable interest.

0.1.3 Background information relative to supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol (ES.1.3)

The present report, in keeping with decision 15/CMP.1, presents, for the first time, supplementary information pursuant to Article 7 (1) of the Kyoto Protocol, for support of the review process under the Kyoto Protocol. This information includes:

- General information on inventory preparation in connection with reporting pursuant to Article 3 (3) Kyoto Protocol and for the selected additional activities pursuant to Article 3 (4) Kyoto Protocol; (cf. Chapter 11)
- Information regarding the certificates under the Kyoto Protocol in connection with decisions 13/CMP.1 and 5/CMP.1; (cf. Chapter 12)

[2] IPCC Fourth Assessment Report: Climate Change 2007, available in the Internet at: http://www.ipcc.ch/ipccreports/assessments-reports.htm

[3] For HFC, PFC and SF_6

[4] Burden-sharing agreement, adopted with Council Decision 2002/358/EC of 25 April 2002 concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder [OJ L 130 of 15 May 2002]

- Information regarding changes in the National System of emissions reporting pursuant to Article 5 (1) of the Kyoto Protocol; (cf. Chapter 13)
- Information regarding changes in the National Registry; (cf. Chapter 14)
- Information regarding minimisation of negative impacts pursuant to Article 3 (14) of the Kyoto Protocol; (cf. Chapter 15)

0.2 Combined greenhouse-gas emissions, their removals in sinks, and emissions and removals from KP-LULUCF activities (ES.2)

0.2.1 Greenhouse-gas inventory (ES.2.1)

By 2011, Germany had fulfilled its obligations within the framework of the aforementioned European burden-sharing, by achieving a reduction of 25.6 % with regard to the base-year emissions determined in 2007[5], 1,232,429.543 Gg (CO_2 equivalent). Overall, emissions in 2011 were 2.9 % below their level in the previous year, which was relatively emissions-intensive. In fact, emissions in 2011 were only slightly higher than the level seen in 2009, which was strongly affected by the global economic crisis (cf. Chapter 2.1).

Development of greenhouse gases in Germany since 1990, by greenhouse gases (without CO_2 from LULUCF)

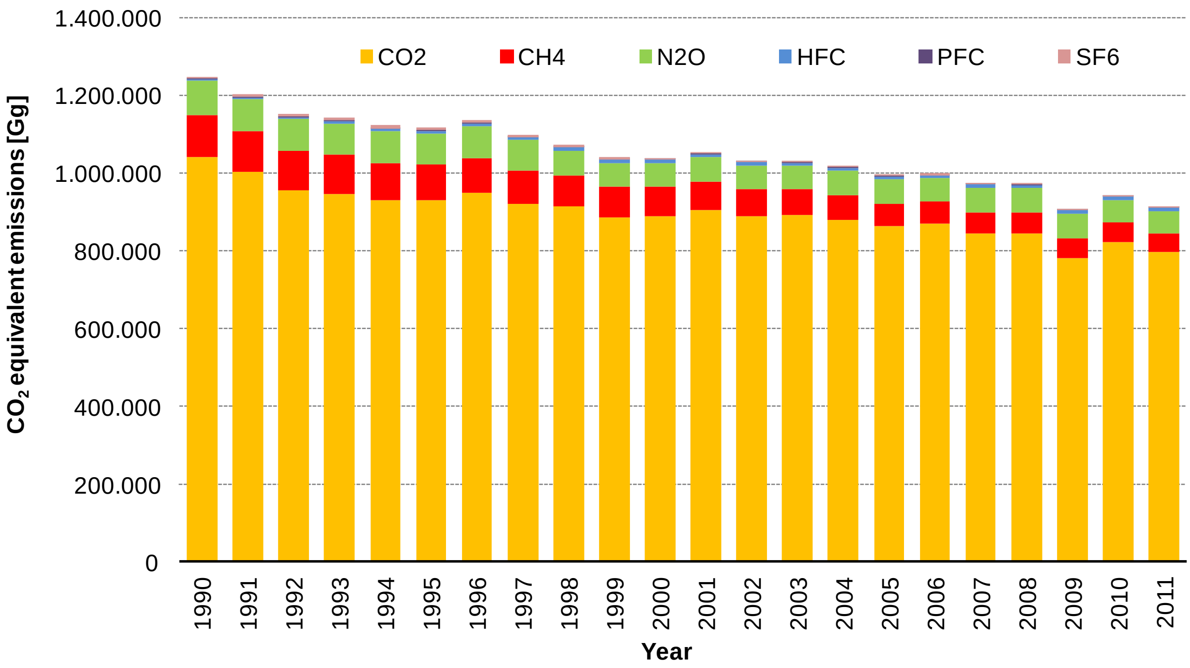


Figure 1: Development of greenhouse gases in Germany since 1990, by greenhouse gases [6,]

The individual greenhouse gases contributed to this development to varying degrees (cf. Table 1). This is hardly surprising given that, in any given year the various greenhouse gases

[5] The reference figures for determining achievement of reduction obligations under the Kyoto Protocol have been defined in keeping with results of the review, carried out in 2007, of the initial report and of reporting for 2006 pursuant to Article 8 of the Kyoto Protocol. Pursuant to its obligations under the Kyoto Protocol and EU burden sharing (Council Decision 2002/358/EC), Germany's reduction obligations amount to 21 %.

[6] CO_2 emissions from, and removals in, soils are reported under land-use changes and forestry.

account for varying proportions of total emissions (cf. Table 2). Detailed tables are provided in Annex Chapter 22.3.

In 2011, carbon-dioxide releases were once again the most significant greenhouse-gas emissions, accounting for 87.1 % of all such emissions. Most of the carbon dioxide is released via stationary and mobile combustion of fossil fuels. As a result of a disproportionately large reduction of other greenhouse-gas emissions, CO_2 emissions' share of total emissions has increased by over 4 percentage points since the base year. Methane (CH_4) emissions, caused predominantly by animal husbandry, fuel distribution and landfills, accounted for a 5.3 % share in 2010. Emissions of nitrous oxide (N_2O), caused primarily by agriculture, industrial processes and burning of fossil fuels, contributed 6.2 % of greenhouse-gas releases. Fluorocarbons (so-called "F gases") accounted for about 1.4 % of total emissions. The distribution of greenhouse-gas emissions in Germany is typical for a highly developed and industrialised country.

Table 1: Emissions trends in Germany, by greenhouse gas and source category

GG emissions / removals, in CO_2 equivalents (Gg)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Net CO_2 emissions / removals	1,005,890	895,151	856,337	871,823	877,524	854,680	853,256	791,974	834,511	807,118
CO_2 emissions (not including LULUCF)	1,041,914	930,781	891,400	864,716	870,739	847,397	845,761	783,734	826,063	798,058
CH_4	109,950	92,635	75,104	59,484	56,896	54,226	53,609	51,510	50,388	48,845
N_2O	86,804	79,600	61,669	61,179	60,362	62,026	63,457	63,489	54,897	57,144
HFC	4,592	7,012	7,623	8,640	8,708	8,742	8,843	9,443	8,963	9,177
PFC	2,627	1,780	792	695	550	484	472	338	285	230
SF_6	4,642	6,779	4,269	3,480	3,398	3,334	3,115	3,065	3,194	3,316
Total emissions / removals, including LULUCF	1,214,506	1,082,957	1,005,794	1,005,301	1,007,438	983,492	982,752	919,818	952,239	925,830
Total emissions, not including CO_2 from LULUCF	1,250,529	1,118,588	1,040,857	998,194	1,000,653	976,209	975,257	911,578	943,791	916,769

GG emissions/sinks, by source and sink categories, in CO_2 equivalents (Gg)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
1. Energy	1,020,323	902,094	856,189	824,214	828,818	804,887	805,221	751,531	789,179	760,572
2. Industrial processes	94,271	96,884	77,514	78,841	79,616	81,737	78,920	72,175	68,738	69,388
3. Solvent and other product use	4,477	3,553	2,909	2,052	2,074	1,949	1,812	1,626	1,882	1,794
4. Agriculture	87,963	75,866	76,021	71,423	69,896	68,752	71,624	69,618	68,365	70,360
5. Land use, land-use changes & forestry	-35,758	-35,370	-34,802	7,372	7,051	7,546	7,759	8,510	8,721	9,335
CO_2	*-36,024*	*-35,630*	*-35,063*	*7,107*	*6,785*	*7,283*	*7,495*	*8,240*	*8,448*	*9,060*
N_2O & CH_4	*266*	*260*	*261*	*264*	*266*	*263*	*264*	*270*	*272*	*274*
6. Waste	43,230	39,931	27,963	21,399	19,983	18,621	17,416	16,359	15,354	14,381

Table 2: Contributions to emissions trends in Germany, by greenhouse gas and source category

GG emissions / sinks; shares for various GG, not including CO_2 from LULUCF (%)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
CO_2 emissions (not including LULUCF)	83.3	83.2	85.6	86.6	87.0	86.8	86.7	86.0	87.5	87.1
CH_4	8.8	8.3	7.2	6.0	5.7	5.6	5.5	5.7	5.3	5.3
N_2O	6.9	7.1	5.9	6.1	6.0	6.4	6.5	7.0	5.8	6.2
HFC	0.4	0.6	0.7	0.9	0.9	0.9	0.9	1.0	0.9	1.0
PFC	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
SF_6	0.4	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

GG emissions / sinks; shares for emission & sink categories, not including CO_2 from LULUCF (%)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
1. Energy	81.6	80.6	82.3	82.6	82.8	82.5	82.6	82.4	83.6	83.0
2. Industrial processes	7.5	8.7	7.4	7.9	8.0	8.4	8.1	7.9	7.3	7.6
3. Solvent and other product use	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4. Agriculture	7.0	6.8	7.3	7.2	7.0	7.0	7.3	7.6	7.2	7.7
5. Land use, land-use changes & forestry (N_2O)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6. Waste	3.5	3.6	2.7	2.1	2.0	1.9	1.8	1.8	1.6	1.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Information about the relevant trends is provided in Chapter 2, while all detailed tables relative to discussion of trends are provided in Annex Chapter 22.3.

0.2.2 KP-LULUCF activities (ES.2.2)

Removals of CO_2 pursuant to Article 3.3 increased by 0.8 % with respect to 2010. N_2O emissions increased by 1.3 %.

CO_2 removals pursuant to Article 3.4, via Forest Management activities, have remained nearly constant throughout the report period. Emissions of CH_4 (forest fires) decreased by 58.8 % with respect to the previous year, while emissions of N_2O remained constant.

0.3 Combined emissions estimates, and trends for source and sink groups, including KP-LULUCF activities (ES.3)

0.3.1 Greenhouse-gas inventory (ES.3.1)

Figure 2 shows the contributions of individual source and sink categories to total greenhouse-gas emissions. It highlights the relative constancy of the relative shares of the various source and sink categories and the absolute predominance of energy-related emissions. On the other hand, absolute energy-related emissions have continuously decreased over time. The fluctuations that are superimposed over this trend are largely temperature-related. Because winter temperatures affect heating patterns, they also affect energy consumption for heating, and thus they have major impacts on annual trends in energy-related CO_2 emissions.

All in all, emissions of greenhouse gases have decreased considerably with respect to the base year for the 2006 report[7], whose emissions were determined to be 1,232,429,543 Gg CO_2 equivalent (25.6 % decrease of CO_2-equivalent emissions). Considerations of the various components involved confirm this trend, to varying degrees. With respect to the base-year emissions, the relevant emissions changes for the most important greenhouse gases in terms of quantity were as follows: - 23.4 % for carbon dioxide (CO_2), - 55.6 % for methane (CH_4) and - 34.2 % for nitrous oxide (N_2O). The corresponding trends for the so-called "F" gases, which contribute about 1.4 % of greenhouse-gas emissions overall, have not been as clearly similar to each other, however. In keeping with the introduction of new technologies, and with use of these substances as substitutes, since base year 1995 SF_6 emissions decreased by 51.1 % and PFC emissions dropped by 87.1 %, while HFC emissions increased by 30.9 %.

With respect to the previous year, 2010, which was relatively emissions-intensive, total emissions decreased by 2.9 %, primarily as a result of weather-related decreases in CO_2 emissions from the residential (-22.4%) and commercial and institutional (-10.7%) sectors. When the past three years are considered as a whole, it is clear that the impacts of the global economic crisis have outweighed all other factors affecting emissions, however.

[7] The reference figures for determining achievement of reduction obligations under the Kyoto Protocol have been defined in keeping with results of review of the initial report and of reporting for 2006 pursuant to Article 8 of the Kyoto Protocol. Such definition does not take account of any further possible improvements in the basic data. Pursuant to its obligations under the Kyoto Protocol and EU burden sharing (Council Decision 2002/358/EC), Germany's reduction obligations amount to 21 %.

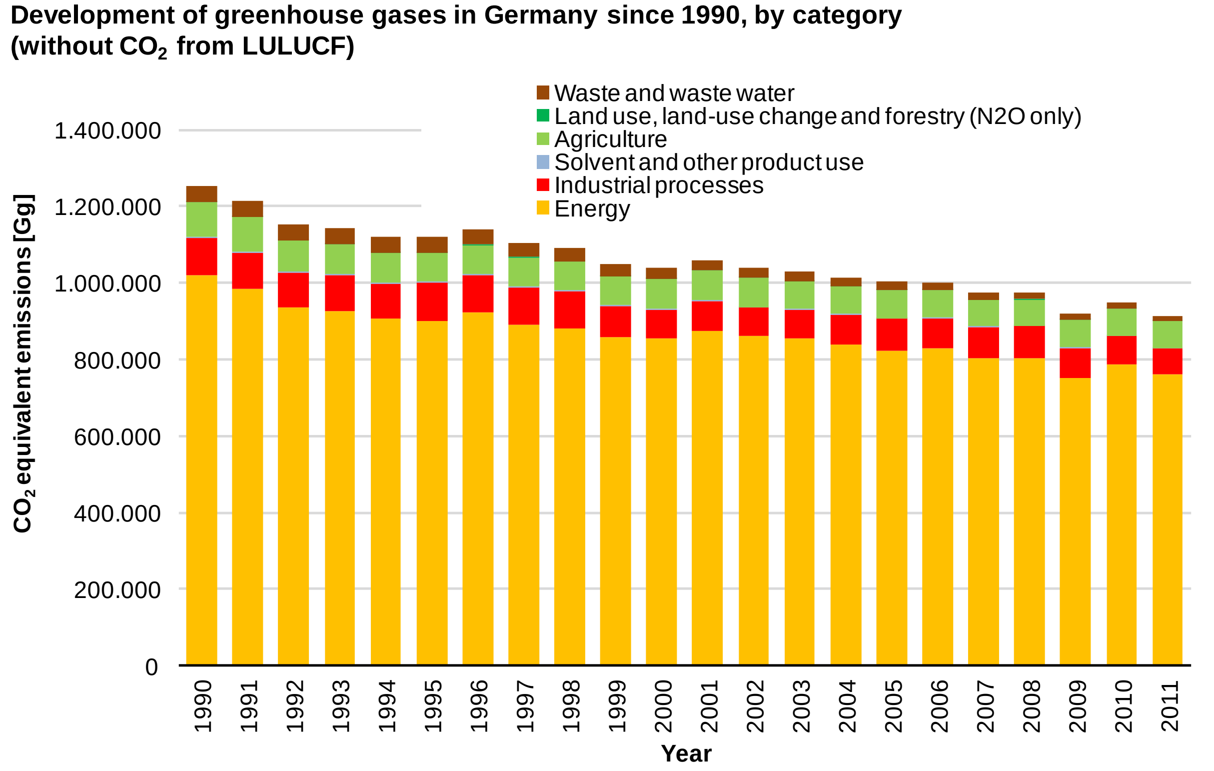


Figure 2: Emissions trends in Germany since 1990, by source categories[8,]

Figure 3 shows the relative developments of emissions from polluter categories since 1990. The most significant reduction occurred in the area of waste emissions. Increased recycling of recyclable materials (Packaging Ordinance), and reuse of materials as compost (Biowaste Ordinance), have led to a reduction in the quantity of waste that is landfilled and hence to a reduction in landfill emissions. Emissions-reducing measures carried out in 1997 and 2009 in the sector of adipic-acid production had major impacts on emissions from industrial processes. Emissions from solvent and other product use decreased markedly, as a result of decreased narcotic use of N_2O. The development of emissions from agriculture essentially follows the development of livestock data. A detailed discussion of emissions trends is presented in Chapter 2, Trends in Greenhouse Gas Emissions.

[8] CO_2 emissions from, and removals in, soils are reported under land-use changes and forestry.

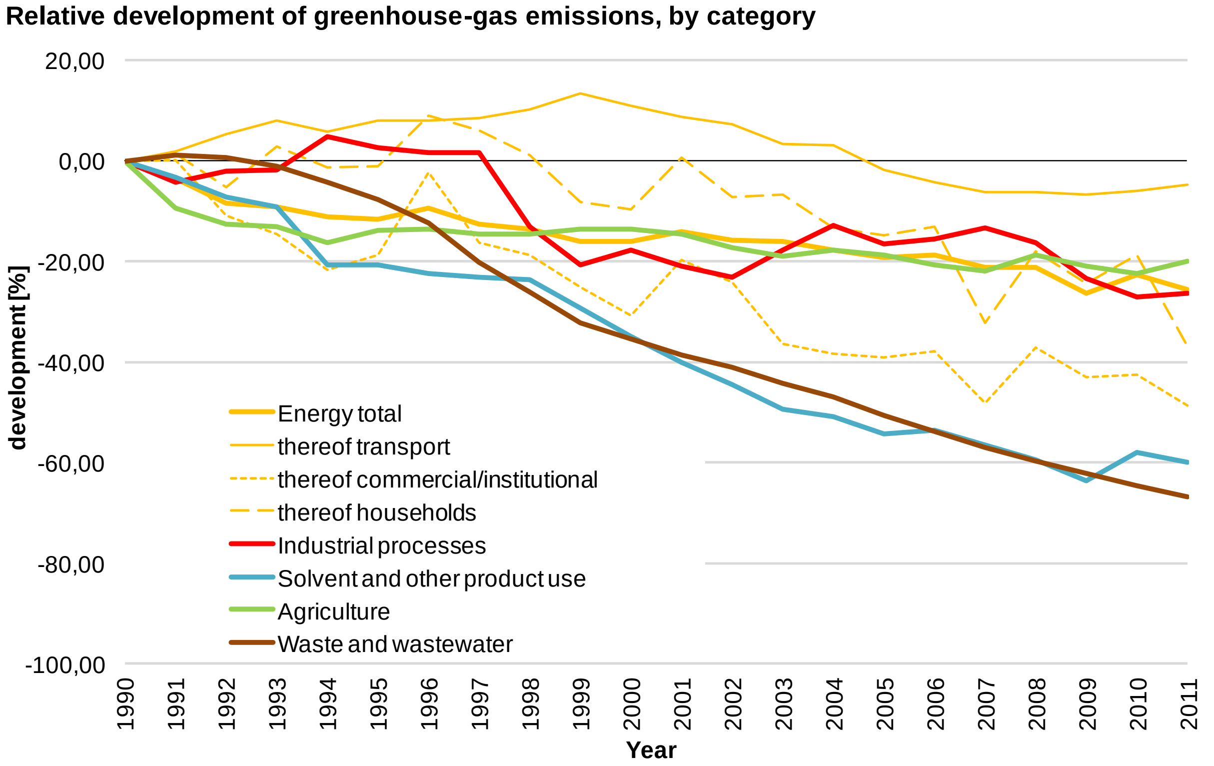


Figure 3: Relative development of greenhouse-gas emissions since 1990, by source categories[9,10]

0.3.2 KP-LULUCF activities (ES.3.2)

Germany reports under KP-LULUCF Article 3 (3), and it reports in the area of forest management with regard to the selected additional activities pursuant to Article 3 (4) Kyoto Protocol. It reports emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide.

Under Article 3.3, it is reporting removals of -5,633.58 Gg CO_2 equivalent. The emissions are composed of CO_2 removals via afforestation and reforestation, amounting to -5,772.26 Gg CO_2 equivalent, and emissions from deforestation, amounting to 138.68 Gg CO_2 equivalent. In the deforestation category, emissions of 138.64 Gg CO_2, and of 0.04 Gg CO_2 equivalent of N_2O, are reported.

Under Article 3.4, it reports removals of -27,681.89 Gg CO_2 equivalent. The removals are composed of CO_2 removals via afforestation and reforestation, amounting to -30,301.83 Gg CO_2 equivalent, and emissions of 2,629.94 Gg CO_2 equivalent. Under Article 3.4, it reports CO_2 removals of -27,748.47 Gg CO_2, N_2O emissions of 65.27 Gg CO_2 equivalent and CH_4 emissions of 1.33 Gg CO_2 equivalent.

On afforestation areas, a removals increase of -72.45 Gg CO_2 equivalent was determined for the period from 2010 to 2011. In the deforestation category, a slight emissions increase of 27.07 Gg CO_2 equivalent was seen. On the other hand, removals in connection with forest management decreased slightly from 2010 to 2011. The decrease amounted to 15.32 Gg CO_2 equivalent (cf. also Table 15 in Chapter 2.5).

[9] CO_2 emissions from, and removals in, soils are reported under land-use changes and forestry.
[10] The reference value consists of the emissions in 1990 (=100%), and not of base-year emissions.

1 INTRODUCTION

1.1 Background information regarding greenhouse-gas inventories and climate change, and supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

1.1.1 Background information about climate change

Climate change consists of changes in average weather conditions, and in extreme events, over an extended period of time; it can occur in a particular area or be global.

Climate change may be attributable to the following causes:

- Changes in so-called "geo-astrophysical parameters" such as the solar constant, elements of the earth's orbit, etc.
- Changes in the earth's surface
- Changes in the energy balance in the "earth's surface and atmosphere" system
- Changes in the substance balance in the atmosphere (such as changes in the concentration of greenhouse gases).

Greenhouse gases, among which are carbon dioxide, nitrous oxide (laughing gas), methane, ozone and other gases (especially water vapour, the most important natural greenhouse gas), have a particular property. They allow the energy-rich radiation falling onto the earth from the sun (primarily in the visible, short-wave range) to pass almost unhindered, yet partially absorb the long-wave radiation emitted by the heated earth. This places them in an energetically excited state for a brief time, after which they return to their original basic state whilst emitting infrared radiation. Heat radiation occurs equally in all spatial directions – in other words, a substantial portion of this is returned to the earth's surface ("*thermal back radiation*"). So that this additional quantity of energy may nevertheless be irradiated (this must occur due to the dynamic, energetic equilibrium, at whose centre are the earth and the atmosphere), the earth must have a correspondingly higher temperature. This is a simplified description of the greenhouse effect.

Without the greenhouse gases occurring naturally, life on our planet would not be possible. Instead of having an average global temperature of approximately 15°C, the earth would have an average temperature of approximately –18°C. In other words, the natural greenhouse effect protects our life on earth.

Since the beginning of the industrial era, mankind has brought about marked changes in the atmosphere's substance cycles. These changes have been caused by humans' energy-intensive lifestyles and related emissions of greenhouse gases. Since 1750, the worldwide concentration of carbon dioxide (CO_2) has increased by about 39 % (as of 2011, Global Carbon Project, 2012), while that of methane (CH_4) has more than doubled and that of nitrous oxide (N_2O) has increased by about 19 % (BLASING, T.J., 2012). Furthermore, a number of brand-new substances such as chlorofluorocarbons (CFCs), halons, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6) have entered the atmosphere which almost never occur in nature and are generated almost exclusively by humans. In spite of being "trace gases", greenhouse gases have considerable impacts. Their increasing concentrations have led to the anthropogenic (human-caused) greenhouse effect, which supplements the natural greenhouse effect.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (2007) is very clear on the following point: Observations and measurements unambiguously indicate that the climate system is warming, with respect to its pre-industrial state, and that humans are primarily responsible for this trend. The global warming is clearly apparent in the increase of the average global near-ground air temperature, amounting to 0.76°C in the period 2001 to 2005 with respect to to pre-industrial levels (1859 to 1899); in the increase of the average temperature of the world's oceans (for layer 0 to 700 m, by 0.10°C for the period 1961 to 2003); in extensive melting of ice and snow; and in the increase of average global sea level. Pursuant to the IPCC (2007), these trends have intensified, and the rate of warming seen over the past 50 years (1996 to 2005) is twice as high as that of the past 100 years (IPCC 2007: S. 237, WG I). The climate change will have extensive impacts on ecological and societal systems, with potentially serious consequences.

If dangerous impacts of climate change are to be prevented, global warming must be constrained to no more than 2 °C in comparison to pre-industrial levels. Of that increase, 0.7°C have already taken place. To that end, so the IPCC (2007), greenhouse-gas emissions have to peak, and a trend reversal has to take place, by 2020 at the latest. Furthermore, so the IPCC (2007), by 2050 global emissions have to be reduced by at least 50 %, with respect to 2000, if the temperature increase is to be limited to 2 to 2.4 °C.

1.1.2 Background information about greenhouse-gas inventories

The world's nations were quick to recognize that the expected temperature changes would pose threats to ecosystems and to human civilisation, because the changes would take place relatively quickly, and existing systems would not be able to adapt to the new climate conditions without suffering damage.

The Framework Convention on Climate Change was adopted in 1992, in Rio de Janeiro, by nearly all nations of the world. Since 1994, the countries listed in Annex I of the Framework Convention on Climate are required to submit annual inventories of greenhouse gases, as of 15 April of each year, to the Secretariat of the Framework Convention. Such inventories must include data on emissions and sinks for the base year (1990 for CO_2, N_2O, CH_4; 1995 for HFCs, PFCs, SF_6) and for all years until two years prior to the year of the relevant report.

At the third Conference of the Parties, held in Kyoto, legally binding obligations on emissions limitations and reductions were defined, for the first time, for industrialised countries. Pursuant to the Kyoto Protocol, industrialised nations must reduce their emissions of the six greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) by an average of 5.2 percent by 2012. In the framework of the Kyoto Protocol, the European Union (then with 15 Member States) has committed to reducing its greenhouse-gas emissions by 8% by the 2008–2012 period, in comparison to their base-year levels. This commitment has been divided up between the participating Member States via a burden-sharing arrangement[11] whereby Germany is called on to make a substantial contribution of a 21 % emissions reduction in comparison to the base year.

The effectiveness and success of the Kyoto Protocol vis-à-vis reduction of global greenhouse gas emissions depends on two key factors: Whether its Parties abide by the rules of the

11 Burden-sharing agreement; adopted via Council decision 2002/358/EC

Protocol and meet their obligations, and whether the emissions data used for controlling compliance are reliable. As such, national reporting and the subsequent international review of emissions inventories play a key role.

1.1.3 Background information relative to supplementary information, as required pursuant to Article 7 (1) of the Kyoto Protocol (KP NIR 1.1.3.)

Pursuant to decision 15/CMP.1 of the 1st COP of the Kyoto Protocol, as of 2010 all of the countries listed in ANNEX I of the UN Framework Convention on Climate Change that are also parties to the Kyoto Protocol must submit annual inventories in order to be able to make use of flexible mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol.

In 2008 (with the NIR 2008), Germany began early, on a voluntary basis, to fulfill these reporting obligations. In the process, over the past two years it has begun preparing intensively for the binding reporting required pursuant to Art. 7 of the Kyoto Protocol.

The first binding report, that for 2010 (NIR 2010), was reviewed in detail in September 2010 in the framework of an In-Country Review. That review led to recalculations for some source categories of the 2010 report, as well as to a resubmission of the data in November 2010. Additional changes called for by the 2010 In-Country Review were implemented in the 2011 and 2012 reports or are being implemented in the present 2013 report.

In submitting its eleventh National Inventory Report (NIR 2013), Germany also submits its sixth inventory report, pursuant to the Kyoto Protocol, that includes all of the information called for in Art. 7.

Information relative to Arts. 3.3 and 3.4 of the Kyoto Protocol (KP-LULUCF) is provided in Chapter 11. Information on bookkeeeping relative to Kyoto units is presented in Chapter 12. The relevant changes in the National System are described in Chapter 13, and the changes in the National Registers are described in Chapter 14. Information on minimisation of negative influences pursuant to Art. 3 (14) of the Kyoto Protocol is presented in Chapter 15.

1.2 Description of institutionalisation of inventory preparation, including the legal and procedural definitions relative to the planning, preparation and management of the inventory

Article 5.1 of the *Kyoto Protocol* mandates the establishment of National Systems for preparation of greenhouse-gas emissions inventories. The National System for Germany fulfils the requirements of the *Guidelines for National Systems* (UNFCCC Decision 19/CMP.1), requirements which are binding under the *Kyoto Protocol* and *Decision 280/2004/EC*.

The National System provides for the preparation of inventories conforming to the principles of transparency, consistency, comparability, completeness and accuracy. Such conformance is achieved through use of the methodological regulations from the Revised 1996 *IPCC Guidelines* and the *IPCC Good Practice Guidance*, through ongoing quality management and through continuous inventory improvement.

In recent years, decisive progress has been made in institutionalising the National System. On the basis of an agreement between state secretaries of the involved ministries, such progress began via the establishment of the national co-ordinating committee (Single

National Entity), issuance of an in-house directive for the Federal Environment Agency and development of a procedure for using monitoring data from European emissions trading. Further institutionalisation is now taking place primarily via signing of relevant agreements with other federal institutions, with industrial associations and with individual business enterprises.

1.2.1 Overview of the institutional, legal and procedural definitions relative to preparation of greenhouse-gas inventories and of supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

In Germany, the National System has been institutionalised, in the main, at three levels: at the ministerial level, at the level of the Federal Environment Agency (UBA), and at a level outside of the federal administrative sector.

At the ministerial level, the National System has been established under the leadership of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), via an agreement 5 June 2007 signed by state secretaries of the participating ministries that serves as a pertinent policy paper and is entitled "National Emissions Reporting System" ("Nationales System zur Emissionsberichterstattung"). The System now incorporates other German ministries, including the Federal Ministry of the Interior (BMI), the Federal Ministry of Defence (BMVg); the Federal Ministry of Finance (BMF), the Federal Ministry of Economics and Technology (BMWi), the Federal Ministry of Transport, Building and Urban Development (BMVBS) and the Federal Ministry for Food, Agriculture and Consumer Protection (BMELV). As a result, the process of emissions-inventory preparation now includes all of the key institutions that are in a position to make high-quality specialised contributions to it. The policy paper on emissions reporting defines the relevant responsibilities of the various participating federal ministries, and it mandates that the National System is to be built on the basis of existing data streams. Where the data streams are incomplete, the pertinent gaps are to be closed by the responsible ministries, via suitable activities. In support of the reporting process, the participating ministries established a co-ordinating committee (cf. Chapter 1.2.1.1).

The "National Emissions Reporting System" policy paper also assigns the Federal Environment Agency the task of serving as the Single National Entity for Germany (cf. Chapter 1.2.1.2). The Single National Entity integrates other specialised units within the National System, at the level of the Federal Environment Agency. For co-ordination of pertinent work within the Federal Environment Agency, a working group on emissions inventories was established (cf. Chapter 1.2.1.3). For implementation of the IPCC Good Practice Guidance within the Federal Environment Agency, with regard to quality control and assurance, a Quality System of Emissions was established in 2005, via an in-house directive (cf. Chapter 1.3.3.1.1).

In addition, numerous external institutions and organisations outside of the federal administrative sector are integrated within the National System (cf. Chapter 1.2.1.4).

The following Figure 4 provides an overview of the structure of the National System in Germany.

The "National Emissions Reporting System" policy paper of 5 June 2007 is presented in Annex Chapter 22.1.1.

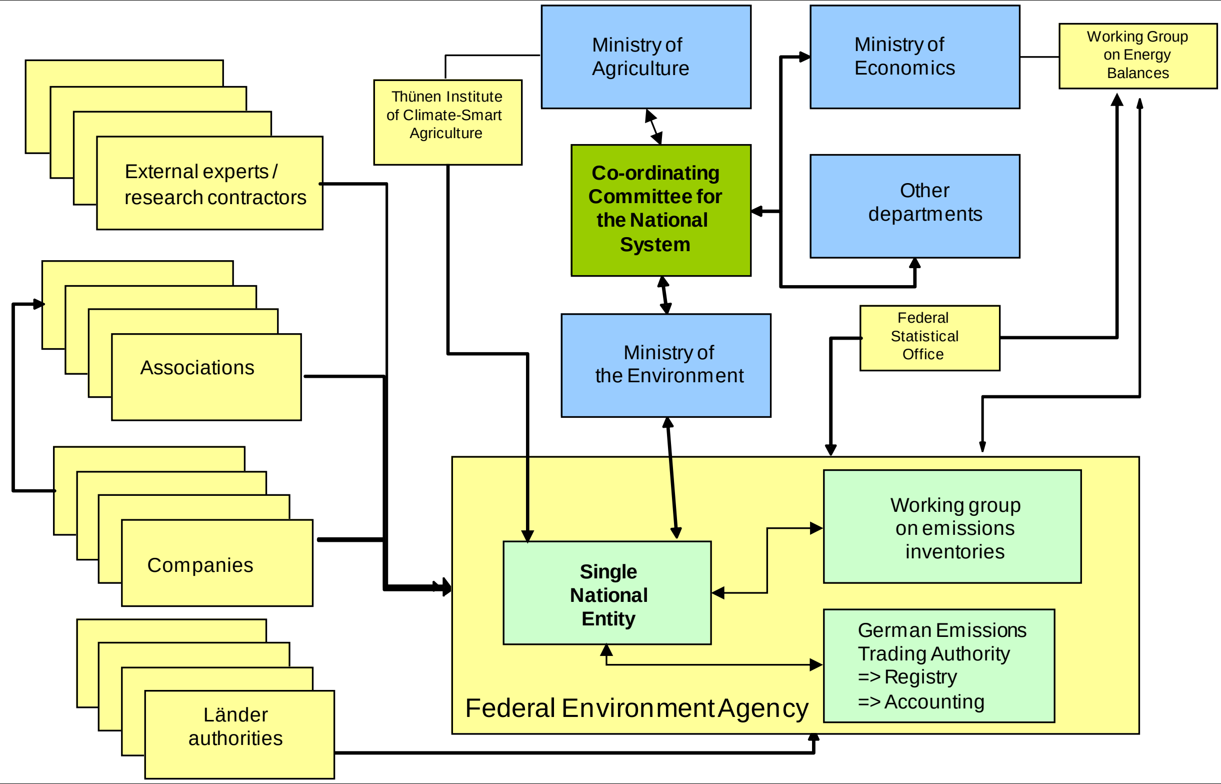


Figure 4: Structure of the National System of Emissions (NaSE)

1.2.1.1 The National Co-ordinating Committee

In its Sec. 2, the state secretaries' resolution of 5 June 2007 provides for the establishment of a National Co-ordinating Committee that is to be headed by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and to include representatives of all federal ministries that participate in emissions reporting.

The National Co-ordinating Committee has the tasks of supporting the emissions-reporting process and clarifying open issues pertaining to the National System. In particular, the Committee carries out consultations with regard to gaps in data streams and settles issues pertaining to assigned responsibilities.

In addition, the National Co-ordinating Committee is responsible for approving inventories and the reports required pursuant to Arts. 5, 7 and 8 of the Kyoto Protocol.

The National Co-ordinating Committee met for the first time on 21 December 2007. It meets at least once per year, at the invitation of the BMU. Between meetings, the participating federal ministries carry out co-ordination via electronic communication.

The National Co-ordinating Committee has become a basic component of the National System. The body's establishment has implemented the recommendation expressed in the Initial Review 2007, Paragraph 11, and it has contributed to the institutionalisation of the National System of Emissions Reporting.

1.2.1.2 Single National Entity (co-ordination agency) for the National System

The state secretaries' policy paper appointed the Federal Environment Agency to carry out tasks of the **Single National Entity** for emissions reporting (**national co-ordination**

agency). The Federal Environment Agency's in-house directive (Hausanordnung) 11/2005 gave section "Emissions Situation" (FG I 2.6) responsibility for carrying out that function.

The Single National Entity's tasks include planning, preparing and archiving of inventories, describing inventories in the inventory reports and carrying out quality control and assurance for all important process steps. The *Single National Entity* serves as a central point of contact, and it co-ordinates and informs all participants in the *National System*. During the period 2003 to 2007, the Single National Entity has given priority to developing new data sources. Since 2008, its focus has been especially on improving existing data sources, and safeguarding their availability for the long term, by improving the **institutionalisation of the National System**. Furthermore, institutions that need to be integrated within the *National System* have been identified and are now being successively integrated (cf. Chapter 1.2.1.4). Other important work has had to do with implementing the Quality System for Emissions Inventories (cf. Chapter 1.2.2).

The Single National Entity has developed two key **instruments** for carrying out those tasks:

The Federal Environment Agency's *Central System on Emissions* (CSE) database is the national, central database for emissions calculation and reporting. It is used for central storage of all information required for emissions calculation (methods, activity data, emission factors). The CSE is the main instrument for documentation and quality assurance at the data level.

Both within and outside of the Federal Environment Agency, the Quality System for Emissions Inventories (QSE) provides the necessary framework for good inventory practice and for routine quality assurance. Established within the Federal Environment Agency in 2005 via in-house directive 11/2005, it comprises the processes necessary for continually improving the quality of greenhouse-gas-emissions inventories. The framework it provides includes defined responsibilities and quality objectives relative to methods selection, data collection, calculation of emissions and relevant uncertainties and recording of completed quality checks and their results (confirmation that objectives were reached, or, where objectives were not reached, listing of the measures planned for future improvement). Ongoing quality improvement in the framework of the QSE is supported by a database that serves as the repository for all tabular documents emerging from the national QC/QA process (QC/QA plan, checklists, lists of responsibilities, etc.).

The quality control procedures have been developed with the help of external experts, taking special account of the Federal Environment Agency's work structures, general guidelines for quality assurance and the *IPCC Good Practice Guidance*.

Since 2008, the QSE has been expanded to cover the entire National System. This has occurred via integration of additional authorities, institutions and inventory experts in the quality-management process – via specification of minimum requirements for data documentation, QC/QA and archiving. In addition, the procedure is designed to enable other organisations to build their own internal quality assurance systems on the basis of their existing structures. It thus addresses the comments provided in Paragraph 18 of the 2007 Initial Review. The QSE is described in detail in Chapter 1.2.2.

The manner in which these instruments interact in the framework of inventory preparation is shown in Figure 5.

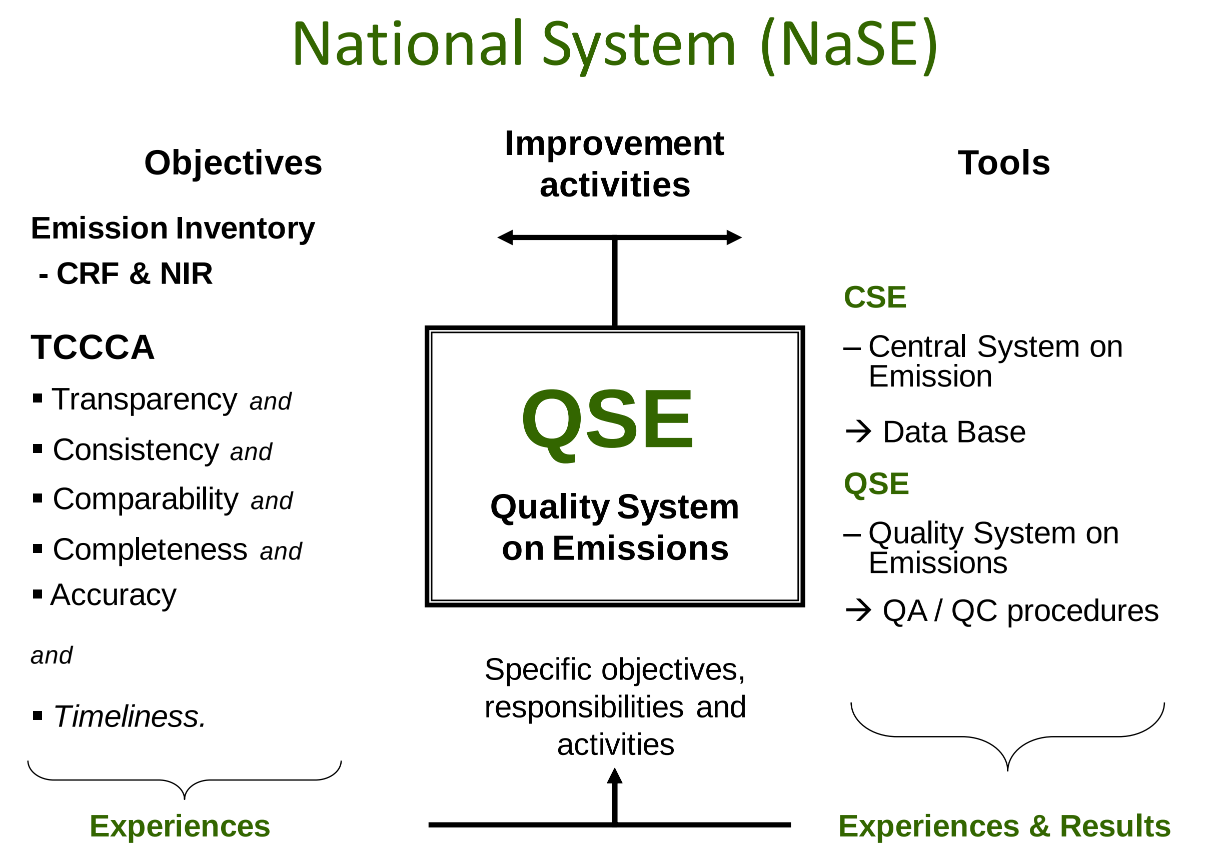


Figure 5: NaSE – Objectives and instruments

1.2.1.3 Working Group on Emissions Inventories, in the Federal Environment Agency

In its inventory work, and especially in work relative to emission factors, the Single National Entity receives significant support from other working units of the Federal Environment Agency. In addition, associations, companies and other independent organisations are integrated within the National System, for purposes of data provision, primarily via the Federal Environment Agency's specialised units that are responsible for the specific issues involved in each case.

In 2003, a *Working Group on Emissions Inventories* was set up to co-ordinate relevant work within the Federal Environment Agency; it liaises with all of the agency's employees who are involved in inventory preparation.

The Single National Entity convenes meetings of the working group twice a year. In addition, relevant members of the working group are expected to meet as necessary to discuss specific issues and to make the necessary in-house arrangements.

Necessary information is provided via the working group's events and through an intranet site, of the Single National Entity, devoted to emissions reporting.

To inform all of the Federal Environment Agency staff who participate in inventory preparation about any relevant changes, the Single National Entity also issues a monthly e-mail newsletter regarding the CSE database and a quarterly e-mail newsletter on the National System.

1.2.1.4 Co-operation by the Single National Entity with other federal institutions and with non-governmental organisations, in the framework of the National System

In the "National Emissions Reporting System" policy paper, the involved ministries have defined their responsibilities relative to the various relevant source and sink categories.

Furthermore, the relevant resolution sets forth that involved federal ministries are to undertake suitable activities to close data gaps that fall within their areas of responsibility. As necessary, data gaps are to be closed via provision of pertinent data, or via relevant calculations. In some cases, required data may be provided by reliable third parties.

For some of the data streams moving to the Single National Entity from other federal institutions, special agreements have to be concluded between a) the relevant institution in the case in question and b) the Single National Entity.

With regard to **data provision by the *Federal Statistical Office***, relative to emissions reporting, a legal arrangement was made in 2009, in the framework of the 3rd SME Relief Act (Mittelstandsentlastungsgesetz 3; MEG 3), that enables provision of data, from confidential energy, environmental and production statistics, for purposes of emissions reporting. On that basis, on 13 January 2010 an administrative agreement between the Federal Environment Agency and the *Federal Statistical Office* came into force that specifies data deliveries for emissions-reporting purposes. The agreement provides for annual reviews of the Federal Environment Agency's data requirements. The list of provided data was revised for the first time in June 2010. No changes in data requirements emerged in 2011 and 2012.

Furthermore, the "National Emissions Reporting System" policy paper assigns responsibility for the areas of agriculture and LULUCF to the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV). The BMELV has commissioned its subordinate departments to carry out the tasks necessary for emissions reporting. That commissioning took place via a directive of 29 July 2007 to the (then) Federal Agricultural Research Centre (FAL). As a result of a restructuring of the FAL as of 1 July 2008, the tasks are now carried out by the **Johann Heinrich von Thünen Institute (TI)**. The relevant work includes all tasks in the agriculture and forestry sectors that are necessary for the preparation of the annual emissions inventories, including the writing of the relevant reports. The TI sends the pertinent data and report to the Single National Entity.

On 13 February 2008, the TI concluded an agreement with the Federal Statistical Office on provision of emissions data on the basis of agricultural statistics. In addition, a research and development agreement between the TI and the *Association for Technology and Structures in Agriculture* (KTBL) has been in place since 7 July 2009. That agreement specifies the necessary supporting work for emissions reporting.

In keeping with an ERT requirement that emerged in the 2010 In-Country Review, the BMELV and the TI extensively revised the concept for preparation of emissions and carbon inventories in source and sink groups 4 and 5 (agriculture and forestry), including the quality-assurance concept for KP-LULUCF (Arts. 3.3. and 3.4 KP).

Furthermore, a working group on emissions reporting has been established within the TI, to serve as liaison to the Single National Entity within the Federal Environment Agency. That working group also has responsibility for planning and QC/QA for source categories CRF 4 and CRF 5. The establishment of the new body addresses the reference provided in

Paragraph 16 of the 2007 Initial Review. In addition, an action plan has been carried out that addressed the reporting problems identified by the ERT in the 2010 Review.

Responsibility for co-ordination of the Working Group on Emissions Reporting lies with the TI's Institute of Agricultural Climate Research (AK). Responsibility for reporting on agriculture and LULUC lies with the same institute, while responsibility for reporting on forests pursuant to the Convention and Kyoto Protocol Arts. 3.3 and 3.4 lies with the TI's Institute for Forest Ecosystems.

The working group on emissions reporting at the TI is integrated within the National System via direct (inter-departmental) participation within the Single National Entity's communications structures. The working group at the TI is also part of the working group on emissions inventories (Arbeitskreis Emissionsinventare – AKEI) within the Federal Environment Agency.

At least twice per year, additional co-ordinating meetings take place between the working group at the TI and the Single National Entity, for purposes of co-ordination and information provision – for example, with regard to inventory improvements and research projects.

Involvement of economic associations, companies and other independent organisations is achieved primarily via those departments of Federal Environment Agency divisions I and III that are responsible for pertinent concrete issues. The *Single National Entity* supports the departments in discussion of reporting requirements and in determination of requirements for data-sharing by associations. The data flows are continually reviewed by the Single National Entity and, where necessary, are safeguarded by suitable agreements between the Single National Entity and associations / business enterprises.

The Working Group on Energy Balances (AGEB) is contractually obligated, via the Federal Ministry of Economics and Technology (BMWi), to provide Energy Balances. Use of a co-ordinated schedule ensures that a provisional Energy Balance for the last reported year is prepared on time, and is transmitted to the Federal Environment Agency, by 31 July of each year, for purposes of inventory preparation.

In 2008, a sample agreement was prepared for inclusion of non-governmental agencies within the National System. That agreement is used to involve stakeholders, under binding terms, within preparation of inventories. The sample agreement is adapted to the various data suppliers' own requirements and needs as is necessary. In July 2009, the Federal Ministry of Economics and Technology (BMWi), and the Federal Environment Agency, concluded an agreement with the German Chemical Industry Association (VCI) and German producers regarding data provision in the source categories Ammonia (2.B.1) and Nitric acid (2.B.2). In addition, agreements on data provision were reached with producers of adipic acid (2.B.3) located in Germany. Furthermore, an association agreement was concluded with the VDD industry association for bitumen paper and bitumen roof sheeting relative to the source category Bitumen for roof sheeting (2.A.5). Since 2009, data for the aforementioned source categories for emissions reporting have been provided on the basis of these agreements. In addition to ensuring long-term data availability, the agreements with the VCI and the VDD associations have led to considerable improvements of data quality in the relevant source categories. With these efforts, the Single National Entity is addressing the reference provided in Paragraph 18 of the 2007 Initial Review.

In June 2011, the Single National Entity, acting with the support of the responsible ministry, the Federal Ministry of Economics and Technology (BMWi), entered into a cooperation agreement with the Wirtschaftsvereinigung Stahl German steel industry association. That agreement had become necessary because the Federal Statistical Office had discontinued its data collection and publication activities for Fachserie 4 Reihe 8.1 (iron and steel statistics) as of 31 December 2009, due to the expiration of the pertinent legal basis (Raw materials act; Rohstoffstatistikgesetz). That move had considerably reduced the availability of the bases for calculations in that area, and it created a significant gap in the pertinent data streams. The new cooperation agreement closed that gap. The agreement assures data provision by both member companies of the assocation and by non-member companies.

A relevant voluntary commitment of semiconductor manufacturers with production sites in Germany, a commitment that served as the basis for data provision for source category 2.F.6, expired on 31 December 2010. In August 2012, the Single National Entity acted to close the resulting potential data gap by entering into a cooperation agreement with the Electronic Components and Systems (ECS) division of the German Electrical and Electronic Manufacturers' Association (ZVEI). This move will assure long-term provision of data to the Federal Environment Agency for source category 2.F.6.

1.2.1.5 Binding schedule in the framework of the National System

The binding schedule for preparation of emissions inventories and of the NIR is announced to all relevant internal and external stakeholders via the Federal Environment Agency's intranet site and via publication within the NIR itself:

11 May	The Federal Environment Agency's national co-ordinating agency (Single National Entity) requests responsible experts to submit data and report texts
31 July	Delivery of energy data of the Working Group on Energy Balances (AGEB), of statistical data of the Federal Statistical Office and of data provided under agreements with associations and companies, where such data serve as the basis for further calculations
by 1 September	Deliveries of ready-to-use inventory data from the Federal Environment Agency and from external institutions of the NaSE
as of 2 September	Validation / discussion of deliveries by responsible experts and quality managers, taking account of review results
by 1 October	Preparation of CRF time series and of national trend tables; final editing by the Single National Entity within the Federal Environment Agency
8 November	In-house consultations at the Federal Environment Agency
as of 15 November	Final quality assurance by the QSE/CSE/NIR co-ordinator
25 November	Report of the Single National Entity to the BMU, for commencement of inter-ministerial co-ordination relative to the CRF data and the National Inventory Report
20 December	Approval via departmental co-ordination (initiated by the BMU)
2 January	Final editing by the Federal Environment Agency's national co-ordinating agency (Single National Entity)
15 January	Report (CRF and certain parts of the NIR) goes to the European Commission (in the framework of the CO_2 Monitoring Mechanism) and to the European Environment Agency
15 March	Report (corrected CRF and complete NIR) goes to the European Commission (in the framework of the CO_2 Monitoring Mechanism) and to the European Environment Agency
15 April	Report goes to the FCCC Secretariat
May	Initial check by the FCCC Secretariat
June	Synthesis and assessment report I (by the UN FCCC Secretariat)
August	Synthesis and assessment report II (country-specific; by the UN FCCC Secretariat)
September - October	Inventory review by the UN FCCC Secretariat

1.2.2 Overview of inventory planning

Inventory preparation draws on the expertise of *research institutions*, via execution of research projects in the UFOPLAN (environmental research plan) framework. This occurs via work on specific issues, and it takes place via overarching projects, which primarily support a) harmonisation of individual results, for the overall inventory, as well as b) identification and closure of gaps in surveys of emission-relevant activities. In each of the UFOPLANs for the 2002-2009 period, the Single National Entity had a global project on *updating emissions-*

calculation methods, a framework for initiating measures for continuous inventory improvement. Since 2010, measures for continuous inventory improvement have been financed completely via the budget title for expert services. The Federal Environment Agency promised to provide the Single National Entity with funding, from the budget title for expert services (Title 526 02, Chapter 1605), for short-term contracting for purposes of inventory improvement under the responsibility of the Agency. The funding, provided as of 2005, in the interest of emissions reporting, comes in addition to the research funding available from the UFOPLAN.

1.2.3 Overview of inventory preparation and management, including overview of supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

The emissions-reporting process is a regular, annual process. Since it is a decentralised process, carried out by a range of different persons, it can differ for different parts of the inventory. Prior to the introduction of the QSE (in 2005), this process was intensively studied and analysed. As a result of that work, within the overall emissions-reporting process, the QSE differentiates the following main processes, which are described in detail in Chapter 1.3.2:

- Definition of the bases for calculation,
- Data collection,
- Data processing and emissions calculation, and
- Report preparation.

These main processes are broken down into sub-processes (cf. Figure 6).

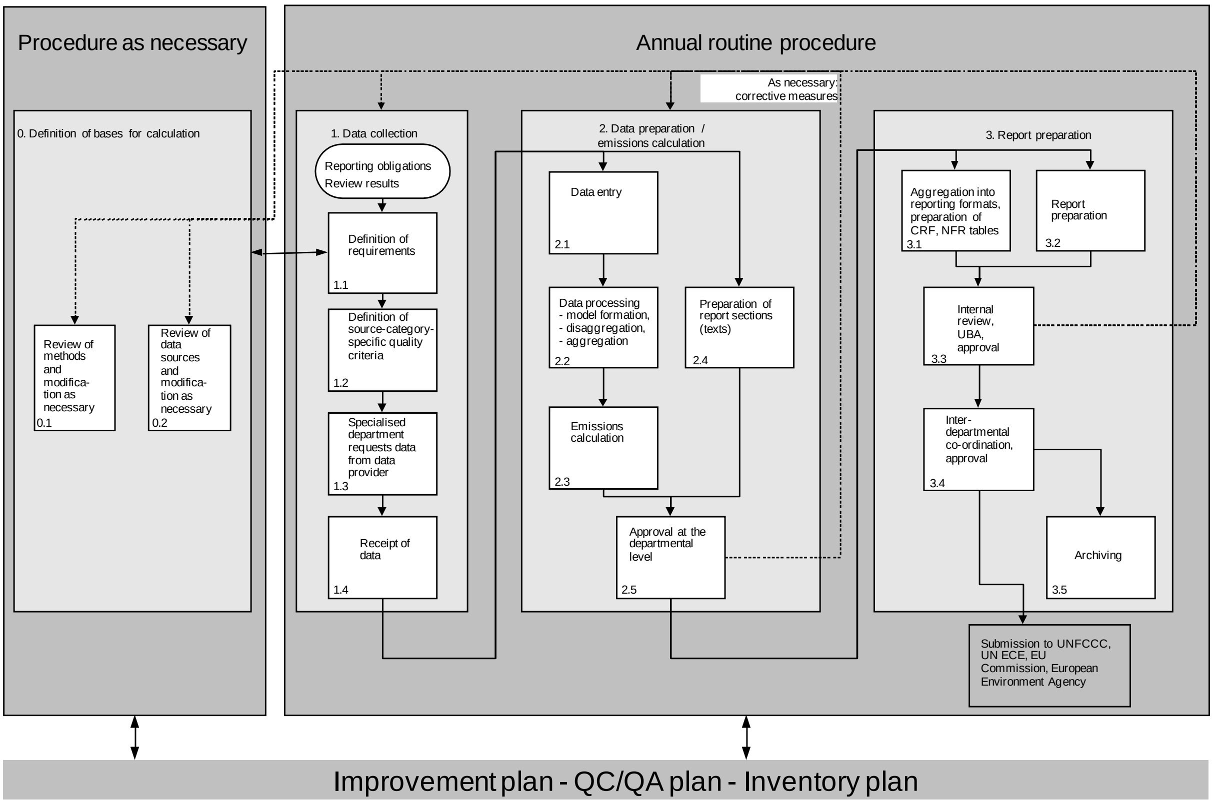


Figure 6: Overview of the emissions-reporting process

Experience has shown that workflow in the inventory planning and preparation process can affect inventory quality, i.e. that the order in which relevant steps are taken is important. That is one of the reasons why the inventory-preparation process is closely tied to quality assurance and control measures. Suitable QC/QA measures have thus been assigned to each sub-process, to ensure that quality assurance not only safeguards the quality of inventory data in its final form, but also safeguards such quality on the pathways leading to that final form. This, in turn, makes it possible to carry out periodical internal evaluations of the inventory-preparation process pursuant to paragraph 15 (d) of the *Guidelines for National Systems*.

The process, including QC/QA measures, fulfills the requirements of paragraphs 14 (a) to (g), with regard to inventory preparation, of the *Guidelines for National Systems*.

The workflow for inventory preparation is described in detail in Chapter 1.3.

The reporting processes address all requirements pursuant to Article 7 of the Kyoto Protocol.

1.3 Inventory preparation

As the overview in Chapter 1.2.3 shows, inventory preparation functions in accordance with a regular, annual scheme. The processes for preparation of greenhouse-gas inventories, KP-LULUCF inventories and National Inventory Reports, and for execution of quality control and quality assurance measures, are very closely linked.

At the same time, the upstream processes for inventory preparation (cf. Chapter 1.3.1.1), including definition of bases for calculation (cf. Chapter 1.3.2.1), and data collection, processing and storage (cf. Chapter 1.3.2), remain distinct from those for quality control and quality assurance (cf. Chapter 1.3.3).

1.3.1 Greenhouse-gas and KP-LULUCF inventories

The upstream processes of inventory preparation and definition of the bases for calculation are identical for greenhouse-gas inventories and for KP-LULUCF inventories.

1.3.1.1 Preliminary/upstream processes

Apart from the sub-processes for emissions reporting, as outlined in Figure 6, certain upstream (preliminary) processes are carried out – in each case, between a pair of emissions-reporting cycles.

The following sub-processes are considered preliminary/upstream processes:

- Continuous review and assurance of data streams from data suppliers to the Federal Environment Agency, via improvement of institutionalisation of the National System;
- Implementation of improvements in inventory planning and inventory preparation;
- Determination of key categories (pursuant to Tier 1, in keeping with Chapter 7.2 of the *IPCC Good Practice Guidance*);
- Calculation and aggregation of uncertainties relative to emissions, using Monte Carlo simulation (pursuant to Tier 1 or Tier 2, in keeping with the *IPCC Good Practice Guidance*);
- Expanded identification of key categories, via Monte Carlo simulation (pursuant to Tier 2, in keeping with Chapter 6.4 of the *IPCC Good Practice Guidance*).

1.3.1.1.1 Improvement of the National System

The National System builds on existing data streams, and it provides for suitable measures to assure long-term data provision where such assurance is lacking (cf. Chapter 1.2.1.2). Consequently, data streams continually have to be reviewed between pairs of reporting cycles.

Where voluntary commitments expire, discussions have to be carried out with the relevant data suppliers in order to secure the commitments' renewal. Where continued data provision is not assured, relevant commitments or co-operation agreements have to be obtained. In cases of any doubt, relevant legal provisions relative to data provision have to be reviewed and implemented.

Existing agreements have to be adapted as necessary to new circumstances and reporting requirements (for example, to changes in reporting procedures). Such efforts help assure the consistent high quality of the National System and the inventory preparation process.

Changes and improvements in the National System, during the current reporting cycle, are described in Chapter 13.

1.3.1.1.2 Implementation of improvements in inventory planning and inventory preparation

Paragraphs 13 and 15(d) of the Guidelines for National Systems (Decision 19/CMP.1) obligate all Annex I countries to strive for continual improvement of inventories and inventory planning.

Wherever possible, the required improvements identified in quality control and quality assurance, and the results of reviews, are implemented between reporting cycles.

A detailed description of the quality control and quality assurance procedures is provided in Chapter 1.6. The improvements achieved for the present report are described in the relevant source-category chapters.

1.3.1.1.3 Determination of key categories (pursuant to Tier 1)

In order to be able to focus the many and detailed activities and capacities required for inventory preparation and improvement on the principal source categories of the inventory, the IPCC has introduced the definition of a "key category". Key categories are source/sink categories that play an especially prominent role in the national inventory because their emissions/removals have a significant influence on the total emissions of direct greenhouse gases – because of their absolute quantities, because of their contribution to the emissions trend over time, because of their uncertainties, or because they have been assessed by an expert as an important category.

The Single National Entity identifies key categories once per year, prior to the emissions-reporting process. Whereas in the reporting framework results are reported for year x, they cannot be taken specifically into account until inventory preparation for the year x+1. A source category's designation as a key category helps decide what calculation method (Tier approach) must be used for the category and, as a result, how detailed emissions modelling for the source category must be. In addition, the key-category selection process is used to identify any source categories to which priority must be given in inventory improvement.

The *IPCC Good Practice Guidance* (2000) specifies the methods to be applied in identifying key categories. These methods identify the relevant key categories with the help of analysis of the inventory for one year with regard to emissions levels for individual source categories (Tier 1 level assessment), time-series analysis of inventory data (Tier 1 trend assessment) and detailed analysis of inventory data with error evaluation (Tier 2 level and trend assessment with consideration of uncertainties).

The key categories have been defined by applying two Tier 1 procedures, Level (for the base year and for the last year reported) and Trend (for the last year reported, as compared to the base year), to German greenhouse-gas emissions. In keeping with IPCC provisions, analyses have taken account of both emissions from sources and removals of greenhouse gases in sinks.

1.3.1.1.4 Calculation and aggregation of uncertainties relative to emissions

Uncertainties are a basic component of emissions inventories; an emissions inventory's uncertainties are determined in order to quantitatively assess the inventory's accuracy. While uncertainties are determined in connection with data gathering, and thus are part of the "data collection" section of the emissions-reporting process, they can be aggregated only after an inventory – or the pertinent emissions-reporting cycle – has been completed.

In calculation and aggregation of uncertainties, uncertainties for activity data and emission factors, which are normally estimated by experts at the lowest source-category level of the CSE, are converted into uncertainties for emissions and then aggregated. Uncertainties pursuant to Tier 1 are aggregated once per year, at the end of the report-preparation cycle for the current report year. Every three years, uncertainties are additionally determined pursuant to the Tier 2 method.

In the current NIR, Germany reports uncertainties that have been calculated pursuant to the Tier 1 method. For uncertainties determination, the individual uncertainties have been estimated, wherever possible to date, by data-supplying experts of the relevant Federal Environment Agency specialised sections and by external institutions.

1.3.1.1.5 Expanded determination of key categories

Aggregated uncertainties serve as a basis for expanded identification of key categories (Tier 2 key-categories determination).

1.3.2 Data collection, processing and storage, including data for KP-LULUCF inventories

1.3.2.1 Definition of bases for calculation

Selection and review of, and (where necessary) changes in, the calculation methods used to determine emissions affect the entire emissions-reporting process. For this reason, the main process "determination of the bases for calculation" must begin with review of the suitability of the methods to be used. The *IPCC Good Practice Guidance* specifies, via use of decision trees, what methods are to be used for the various source categories. In each case, such methods selection depends on whether the group in question is a key category or not. Any use of different – country-specific – methods, instead of the prescribed methods, must be justified in the NIR. In each case, an outline of why the method in question is of equivalent or higher value is to be provided, along with clear documentation.

Another factor that is critical to the success of the overall process is **selection and review of, and (where necessary) changes in, data sources**, since the quality of results of all downstream processes (data preparation, calculation, reporting) cannot be better than that of the primary data used. Data sources may be oriented to the activity data, emission factors or emissions for/of a specific source category. In many cases, the data sources used have been relied on for a number of years. It can become necessary to select new data sources – for example, as a result of required changes in methods, of the elimination of an existing data source, of a need for additional data or of findings from quality checks of previously used data sources.

The suitability of a given data source depends on various criteria. These include:

- Long-term availability,
- Institutionalisation of data provision,
- Good documentation,
- Execution of quality assurance and control measures, by the persons/organisations providing data,
- Identification of uncertainties,
- Representative nature of the data in question, and
- Completeness of the expected data.

In each case, it is vital that the reasons for choosing a particular data source be documented and, where the data source has significant deficits, that suitable measures for improving the data be planned.

Providers of data must always be given requirements relative to quality control, quality assurance and documentation; where research projects are commissioned, this requirement is particularly relevant, since the Federal Environment Agency, as the customer for such services, must be able to influence such projects.

1.3.2.2 Data collection

Data collection and documentation take place under the responsibility of the relevant experts. One way of collecting data is to evaluate official statistics, association statistics, studies, periodicals and third-party research projects. Other ways of obtaining data include carrying out own research projects, applying personally available information and exchanging data via relevant Federal/Länder channels. Often, work results obtained by other means are also reused for the purposes of emissions reporting.

Data collection comprises the following steps:

- Definition of requirements,
- Determination of the source-category-specific quality criteria for the data,
- Requesting of data from data providers (carried out by the relevant experts' group), and
- Receipt of data.

In each case, the National Single Entity (national co-ordinating agency) also requests inventory input from the experts responsible for the source category in question, via the experts' superiors. A master file, specifying the structure for such input, is provided for NIR preparation. The requirements for later data input are provided by the relevant CSE (ZSE) specifications (direct entry or fill-in of the import format). Reporting requirements (including pertinent QC/QA measures), along with the results of all inventory reviews, the databases for the various specific source categories and the current results of key-category identification, are all communicated to the responsible experts via informational events held by the *Federal Environment Agency's Working Group on Emissions Inventories*, via the Federal Environment Agency's intranet and share-point sites for emissions reporting and via an electronic inventory description (cf. Chapter 1.3.3.1.5). On this basis, responsible experts **define requirements** relative to data sources and to calculation methods.

Such requirements influence the upstream process of defining the bases for calculation (review and selection of methods and data sources) – a process which always takes place when requirements have not yet been fulfilled or have changed.

Before any third parties begin with data collection – after the requirements pertaining to data sources and methods have been defined – the **source-category-specific quality criteria for such third-party data should be defined**, in order to support the QC process on the data level.

When a responsible expert **requests data** from a third party able to supply data, the expert is expected to accompany his or her request with a description of the amount of data expected from the prospective data supplier, of the relevant data-quality requirements and of the relevant data-documentation requirements. Upon **receipt of data**, the data are checked for completeness, compliance with quality criteria and currentness. Data validation is carried out by the relevant expert.

1.3.2.3 Data preparation and emissions calculation

The process of data preparation and emissions calculation comprises the following steps:

- Data entry,
- Data preparation (model formation, disaggregation, aggregation),
- Calculation of emissions,
- Preparation of report sections (texts), and
- Approval by the relevant experts.

Report texts are prepared along with the time series for activity data, emission factors, uncertainties and emissions. As a result, the term "data" is understood in a broad sense. In addition to number data, time series, etc., it also includes contextual information such as the sources for time series, and descriptions of calculation methods, and it also refers to **preparation of report sections** for the NIR and documentation of recalculations.

Considerable amounts of **data entry and processing** (processing of data, and emissions calculation) take place in the CSE. This considerably enhances transparency and consistency, and it opens up the possibility of automating required data-level quality-control measures in the CSE (such as checking of orders of magnitude and of completeness, and specification of checking parameters in CalQlator). In cases that lend themselves to such automation, certain QC measures then do not have to be carried out manually. At the same time, plausibility cross-checks, with simplified assumptions, should be applied to results of calculations with complex models.

After all checks have been carried out, and the relevant parties have been consulted where necessary, the **emissions are calculated** in the CSE by means of an automated procedure, based on the following principle:

activity data * emission factor = emission

If upstream calculation routes are also stored in the CSE, these calculations are initiated first, before the actual calculation of emissions takes place.

In each case, the relevant expert responsible for QC also has responsibility for **issuing expert-level approvals**, for written texts and for calculation results, prior to any further use of such texts and results by the Single National Entity. Such issuance normally takes place in connection with transmission to the Single National Entity, and it is carried out via approval of completed QC/QA checklists.

1.3.2.4 Report preparation

Report preparation includes the following steps:

- Aggregation of emissions data for the national trend tables and reporting formats, preparation of data tables for the NFR, export / import of XML files into the CRF reporter,
- Compilation of submitted report texts to form a report draft (NIR), and editing of the complete NIR,
- Internal review of the draft (national trend tables and NIR) by the Federal Environment Agency, followed by approval as appropriate,
- Handover to the BMU, for interdepartmental co-ordination, leading to approval by the co-ordinating committee, followed by the final steps of
- Handover to the UNFCCC Secretariat, the EU Commission and the UNECE Secretariat, and
- Archiving.

Following complete preparation of data, report sections and QC/QA checklists by the responsible experts, and transmission of those materials to the Single National Entity, the materials are reviewed by source-category-specific, specialised contact persons at the Single National Entity, on the basis of a QC checklist. The results of this review are then provided to the relevant responsible experts, to enable these experts to revise their contributions (if necessary, following suitable consultation) accordingly.

Before emissions data can be transferred into the report formats for the Framework Convention on Climate Change (CRF = Common Reporting Format), the Kyoto Protocol and the UN ECE Geneva Convention on Long-range Transboundary Air Pollution (NFR = New Format on Reporting), emissions data from CSE time series (in the data-collection format) **must be aggregated** into the CRF/NFR source-category **report formats**. This is accomplished via hierarchical allocation within the CSE, a process that, in Annex 3, is described in detail for the various key categories. Where no changes with respect to the previous year have occurred, the aggregations are carried out automatically.

Following calculatory aggregation, activity data and emissions are read, via export in XML-file form, into the CRF reporter, which automatically prepares the IPCC CRF reporting tables. Nonetheless, quality control still has to be carried out to ensure that the emissions inventory and the CRF-Reporter tables agree with respect to relevant values and to the implied emission factors calculated by the CRF Reporter. Furthermore, suitable explanatory remarks have to be provided for any recalculations and notation keys.

CO_2 equivalents for greenhouse gases are calculated in accordance with Art. 20 of the *IPCC Guidelines on Reporting and Review* (FCCC/CP/2002/8), on the basis of the GWP published in the *Second Assessment Report* and listed in the table below, which are based on effects of greenhouse gases out to a 100-year time horizon.

Table 3: Global Warming Potential (GWP) of greenhouse gases

Greenhouse gas	Chemical formula	1995 IPCC GWP
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Hydrofluorocarbons (HFC)		
HFC-23	CHF_3	11700
HFC-32	CH_2F_2	650
HFC-41	CH_3F	150
HFC-43-10mee	$C_5H_2F_{10}$	1300
HFC-125	C_2HF_5	2800
HFC-134	$C_2H_2F_4$ (CHF_2CHF_2)	1000
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1300
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
HFC-143	$C_2H_3F_3$ (CHF_2CH_2F)	300
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3800
HFC-227ea	C_3HF_7	2900
HFC-236fa	$C_3H_2F_6$	6300
HFC-245ca	$C_3H_3F_5$	560
Perfluorocarbons (PFC)		
Perfluoromethane	CF_4	6500
Perfluoroethane	C_2F_6	9200
Perfluoropropane	C_3F_8	7000
Perfluorobutane	C_4F_{10}	7000
Perfluorocyclobutane	c-C_4F_8	8700
Perfluoropentane	C_5F_{12}	7500
Perfluorohexane	C_6F_{14}	7400
Sulphur hexafluoride		
Sulphur hexafluoride	SF_6	23900
Additional Greenhouse Gases		
HFC 245fa	*$C_3F_5H_3$ ($CF_3CH_2CHF_2$)*	*950*
HFC 365mfc	*$C_4F_5H_5$ ($CF_3CH_2CF_2CH_3$)*	*890*
NF_3	*NF_3*	*8000*

Source (except for entries in italics): FCCC/CP/2002/8, p.15

At the same time, the report co-ordinator **compiles the checked report texts to produce the draft** of the NIR.

Review and approval, **within the Federal Environment Agency**, of the completed report tables and the NIR, and of the inventory plan to be included in future, are certified via co-signing in the framework of the Federal Environment Agency's **internal co-ordination process**. Then, the materials are **forwarded** to the BMU, for the second approval phase within the framework of **interdepartmental co-ordination**. In a concluding step, the co-ordinating committee approves the report tables and the NIR for submission to the UNFCCC

Secretariat. The ministry arranges for translation of the NIR and for its **submission to the UNFCCC Secretariat**.

The data tables and the related NIR, in the version provided for ministerial co-ordination, are then transferred onto a CD and archived with clear identification information. The content of the CSE database used for calculation purposes is likewise copied and archived. The final version submitted to the Secretariat of the Framework Convention on Climate is also **archived**.

1.3.3 Procedures for quality assurance and quality control (QA/QC), and detailed review of greenhouse-gas and KP-LULUCF inventories

1.3.3.1 The Quality System for Emissions Inventories

The QSE takes account of provisions of the *IPCC Good Practice Guidance*, of national circumstances in Germany and of the internal structures and procedures of the Federal Environment Agency (UBA), the reporting institution. The QSE's procedures are flexible enough to be able to routinely incorporate future changes in requirements. The QSE's scope of application comprises the entire emissions-reporting process.

The QSE covers all participants of the NaSE. Within the Federal Environment Agency, the QSE has been made binding via the agency's in-house directive (UBA-Hausanordnung) 11/2005. Details regarding assurance of the QSE's binding nature for other NaSE participants are provided in Annex 22.1.1.

1.3.3.1.1 Directive 11/2005 of the Federal Environment Agency

In 2005, via its *in-house directive (Hausanordnung) 11/2005*, the Federal Environment Agency established a *Quality System for Emissions Inventories* (QSE), within the Agency. The QSE provides the necessary framework for compliance with good inventory practice and for execution of routine quality assurance. This system is structured in accordance with the requirements of the *IPCC Good Practice Guidance*, and it has been adapted to national circumstances in Germany and to the internal structures and procedures of the Federal Environment Agency, the reporting institution. The in-house directive (Hausanordnung 11/2005) issues binding provisions on relevant competencies within the Agency, lists deadlines for the various inventory-preparation steps and describes the necessary relevant review actions for purposes of quality control / quality assurance.

The directive has fulfilled requirements, pursuant to Paragraph 10 (a) of the *Guidelines for National Systems*, for specification of relevant procedures, and for definition, pursuant to Paragraph 12 (c), of specific responsibilities at the Agency level.

1.3.3.1.2 Minimum requirements pertaining to a system for quality control and assurance

The requirements pertaining to the system for quality control and quality assurance (QC/QA system) and to measures for quality control and quality assurance are defined primarily by Chapter 8 of the *IPCC Good Practice Guidance*.

From those provisions, the Federal Environment Agency has derived its own "General minimum requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting" (cf. Chapter 22.1.2.1). Other National System participants adopted the minimum requirements after representatives of the participating federal ministries approved them in the framework of the National Co-ordinating Committee for the National System of Emissions Inventories (cf. Annex Chapter 22.1.1).

Further information regarding the Federal Environment Agency's necessary organisational measures for implementing these requirements is provided in the following chapters and in a complementary section in the Annex, 22.1.2.1.11.

1.3.3.1.3 Start-up organisation for establishing the Quality System for Emissions Inventories

Within the QSE framework, a concept for a start-up organisation was developed that defines binding responsibilities, for the Federal Environment Agency, for implementation of the necessary QC and QA measures. The defined roles and responsibilities have the purpose of facilitating effective information exchange and directive-conformal execution of QC and QA (cf. Table 4).

Table 4: QSE – Roles and responsibilities

Role	Task	Responsible
Responsible expert at the operational level (FV)	Data collection, entry and calculation, in keeping with the prescribed methods Definition of source-category-specific quality and review criteria Execution of QC measures Decentralised archiving of source-category-specific inventory information	All staff appointed by the head (FGL)
QC/QA section representative (QKV)	QC for data and report sections delivered to the Single National Entity (SNE) Approval of report sections Ensuring that necessary inventory work, QC measures and documentation are carried out at the operational level Definition of specific sectional emissions-reporting responsibilities, and follow-up to ensure they are properly carried out	All responsible heads (Federal Government and the Länder)
Specialised contact person (source-category-specific) in the SNE (FAP)	Facilitation of specialised and technical support (inventory work and reporting) Independent QC/QA for supporting work of the various sections	An appointed staff member of the Single National Entity (SNE)
Report co-ordinator (NIRK)	Co-ordination of supporting textual work, preparation of the NIR from the various relevant contributions, overarching QC and QA for the NIR	An appointed staff member of the Single National Entity (SNE)
CSE co-ordinator (ZSEK)	Overarching QC and QA throughout the entire inventory process Ensuring the integrity of databases Emissions reporting and data aggregation into report formats	An appointed staff member of the Single National Entity (SNE)
QC/QA co-ordinator (QSEK)	Overarching QC and QA throughout the entire reporting process Maintenance and further development of the QSE Management and updating of the QC and QA plans, QC checklists and QSE manual Management and updating of the improvement plan, and management of relevant adoption in the inventory plan	An appointed staff member of the Single National Entity (SNE)
NaSE co-ordinator	Ensuring of on-time, requirements-conformal	An appointed staff

(NaSEK)	reporting Initiation of overarching measures from the inventory plan Selection of institutions and collection of relevant informational materials and legal agreements Ensuring that all inventory information is archived, carrying out central archiving of inventory information Preparation of execution and post-processing of inventory reviews	member of the Single National Entity (SNE)

1.3.3.1.4 *Organisation for establishing the Quality System for Emissions Inventories*

Procedures for QC/QA measures in the QSE are oriented to the emissions-reporting process described in Chapter 1.2.3. At the same time, quality management is directly linked with the various steps in the inventory process. Suitable QC measures, assigned to the various process players, have been allocated to each step of the inventory-preparation process (cf. Figure 7).

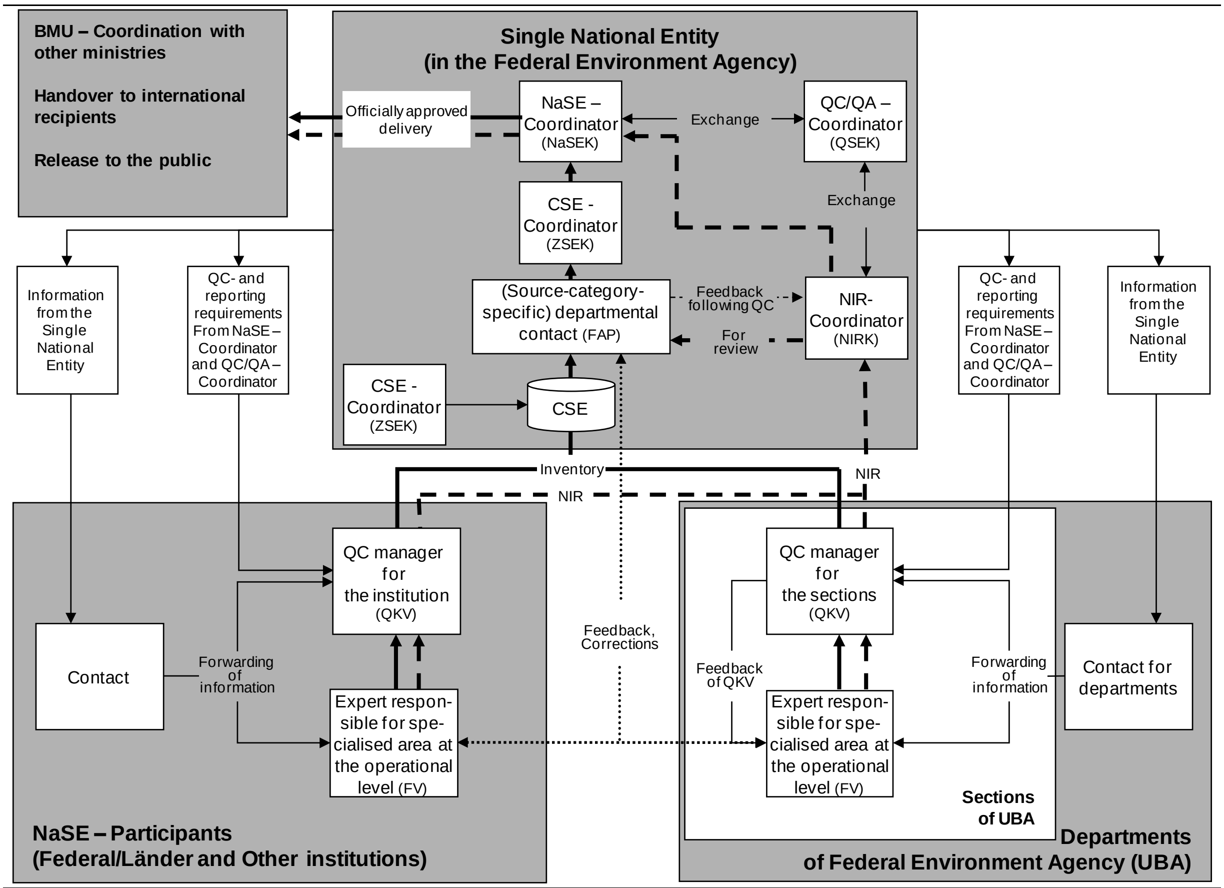


Figure 7: QSE – Roles, responsibilities and workflow

The required quality reviews pursuant to Paragraph 14 (g) of the *Guidelines for National Systems* are provided, in the form of quality checklists and along with data requirements, to the FV, QKV, FAP and NIRK (cf. Table 4). They are completed in the course of the relevant supporting work.

1.3.3.1.5 Documentation in the Quality System for Emissions Inventories

The requirements pertaining to the execution, description and documentation of QC/QA measures, as formulated in connection with the minimum requirements for a QC/QA system (cf. Chapter 22.1.2.1), are largely being fulfilled in conjunction with production of the pertinent inventory contributions. For the QSE, a documentation concept was developed that represents all such measures and related actions in an integrated form tailoured to the specific parties and tasks concerned. The various components of such documentation are shown in Figure 8.

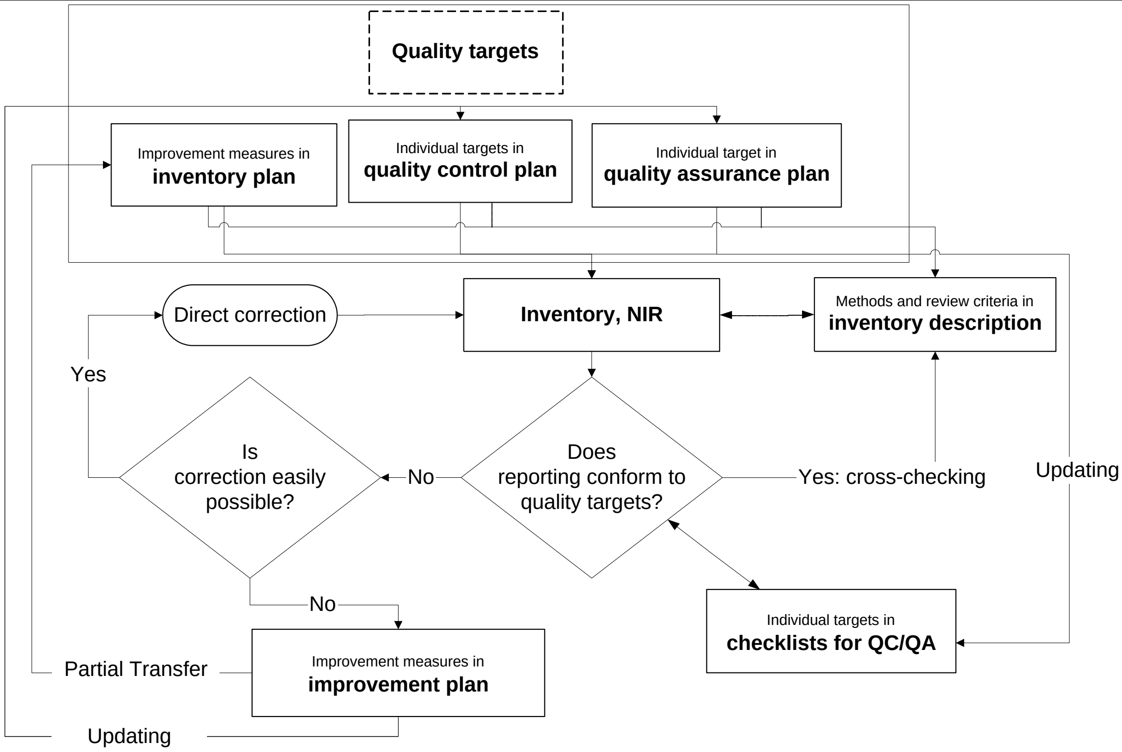


Figure 8: NaSE & QSE – Control and documentation

A general description of the **quality targets** is provided in the QSE handbook; the description is derived from the *IPCC Good Practice Guidance*[12]. In addition, individual operational objectives, relative to quality control and quality assurance, have to be derived for the various source categories from comparison of the requirements from the *IPCC Good Practice Guidance*, the results of independent inventory review and assessment of inventory realities.

Pursuant to the IPCC Good Practice Guidance requirements and Paragraph 12 (d) of the *Guidelines for National Systems*, the necessary QC/QA measures for emissions reporting should be summarised in a QC/QA plan. Such a QC/QA plan is to serve the primary purpose of organising, planning and monitoring such QC/QA measures. To permit transparent, effective control of execution and monitoring of measures for achieving these objectives, the measures are set forth in a **quality control plan (QC plan)** and a **quality assurance plan (QA plan)** with respect to specific roles – and, if necessary – specific source categories. Quality assurance objectives may be focused on the inventory, the reporting process or the QSE itself. Furthermore, the quality assurance plan includes scheduling of quality assurance

[12] For relevant explanations / definitions, see also Annex 3 (Glossary) of the *IPCC Good Practice Guidance*

measures to be performed by independent, external third parties. Both plans may be understood as sets of specifications.

As to their document structure, the QC and QS plans are combined with the **checklists for quality control and quality assurance**, which are used to review and document successful execution of quality controls. In this context, quality checks are actually defined not as checks but as quality objectives; in each case, either compliance with the objectives must be confirmed or non-compliance must be justified. Such QC/QA checklists are to be filled out by NaSE participants[13] along with inventory preparation. They are designed to provide information about the quality of the data and methods on which the inventory is based. The first time the Federal Environment Agency carried out systematic QC/QA, in the form of checklists, and in co-operation with the NaSE participants, was for the 2006 report. Since the 2007 report, these checklists have been used in electronic form. Also as of the 2007 report, in a first step, Tier 1 QC checks have been expanded to include category-specific QC checks in accordance with Tier 2, for key categories. For the 2008, 2009 and 2010 reports, the checklists for the experts involved in the various specialised areas, and for specialised contact persons, have been comprehensively revised. Such revision has been aimed at further enhancing the clarity, practical usefulness and logical structure of the checklists. To ensure the success of the pertinent improvements, a number of persons from the affected group of persons were selected for inclusion in the revision process. No changes were made in content-relevant requirements, which are derived from the IPCC Good Practice Guidance. Just as the checklists have been annually revised and improved, so have the QC and QA plans been continually refined.

Taken together, the two plans and the QC checklists are an instrument for reviewing fulfillment of international requirements, and they make it possible to control inventory quality via initiation of quality assurance measures pursuant to Paragraph 13 of the *Guidelines for National Systems*.

The **improvement plan** documents all potential improvements identified in the framework of the relevant last completed emissions-reporting cycle, as well as the findings that result from independent inventory review. In the plan, such improvements and findings are correlated with feasible corrective measures. The Single National Entity categorises the corrective measures, prioritises them and then, via consultations with the relevant responsible experts, integrates them as necessary within the **inventory plan**. There, they are linked with deadlines and responsibilities. As an annex to the NIR, the inventory plan undergoes a co-ordination and release process. It is thus a binding set of specifications for improvements to be carried out in the coming reporting year.

The Single National Entity also maintains an **inventory description**, a central document record for the various source categories. The description covers all key aspects of inventory preparation. It includes descriptions of all work that pertains to specific source categories and that is relevant to preparation of source-category-specific inventories. The inventory description is really a collection of background information. It is divided into a **paper-form**

[13] These persons include specialised experts (Fachverantwortliche - FV), specialised contact persons (Fachliche Ansprechpartner - FAP), quality control managers (Qualitätskontrollverantwortliche - QKV), the co-ordinator for the national inventory report (Koordinator für den Nationalen Inventar Report - NIRK), the co-ordinator for the National System (Koordinator für das Nationale System - NaSEK), the co-ordinator for the Central System of Emissions (Koordinator für Das Zentrale System Emissionen - ZSEK) and the co-ordinator for the Quality System for Emissions Inventories (Koordinator für das Qualitäts-System Emissionsinventare - QSEK)

inventory description and an **electronic inventory description** (eIB). The two versions are identical in structure. Both are managed by the Single National Entity, and both cover all of the document types currently used in everyday inventory work. The obligation to prepare defined documentation was introduced in the Federal Environment Agency via an in-house directive (cf. Chapter 1.3.3.1.1). It provides the key basis for archiving inventory information pursuant to the provisions of Paragraph 16 (a) of the *Guidelines for National Systems*.

For a range of reasons, the documentation concept, in a departure from Paragraph 17 of the *Guidelines for National Systems*, does not provide for an exclusively central archive. The key reasons for this decision were:

- The body of data that provides the basis for calculating the German inventory is extensive, and non-centralised,
- Responsibility for that data is distributed,
- Confidentiality aspects that, for legal reasons, preclude provision of individual data, for archiving purposes, to a central agency.

The central archive also includes a suitable reference system for relevant, but non-archived data. That system records "who has non-centrally archived what data where", and in what form such data were aggregated for the inventories.

1.3.3.1.6 The QSE handbook

The international requirements for quality assurance and quality control measures in emissions reporting have been set forth, for the National System of Emissions Inventories (NaSE) in Germany, in the "Handbook for quality control and quality assurance in preparation of emissions inventories and reporting under the UN Framework Convention on Climate and EU Decision 280/2004/EC" ("Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU Entscheidung 280/2004/EG". That document, which is binding for the Federal Environment Agency, describes the Quality System for Emissions Inventories (QSE).

The QSE handbook has entered into force via an in-house directive of the Federal Environment Agency (cf. Chapter 1.3.3.1.1). It has been published, along with pertinent, co-applicable documents, in the Federal Environment Agency's intranet.

The pertinent, co-applicable documents include:

- a list of specialised contact persons in the Single National Entity,
- a list of relevant contact persons in the agency's departments,
- a list of responsible persons in the Federal Environment Agency's relevant sections (section contacts – Fachverantwortliche),
- the quality control plan,
- the quality assurance plan,
- the role-specific QC/QA checklists,
- the improvement plan and the inventory plan,
- the requirements for reporting from the Guidelines,
- the results of inventory reviews,
- the available specific data for each source category (inventory description),
- a guide to using the inventory description.

- the results of determination of the key categories (pursuant to Tier 1 and (if necessary) Tier 2),
- the NIR,
- the guide for calculation of uncertainties,
- a form for proposals relative to ongoing improvement of the QSE, and
- a guide to using the QSE checklists.

1.3.3.1.7 Support provided by expert-review groups

In addition to the Federal Environment Agency's own quality control and assurance measures, inventory review by expert review groups provides important impetus for inventory improvement. It is thus in the Single National Entity's own interest to fulfil the provisions of Paragraphs 16 (b) and (c) regarding provision of archived inventory information for the review process and for responding to questions of expert review groups. This relationship has been given priority in the design of the QSE. For this reason, all tabular-form correspondence relative to inventory reviews, along with the pertinent German answers, and together with relevant documents from national QC/QA, is archived in a searchable format.

1.3.3.1.8 Use of EU ETS monitoring data for improvement of GHG-emissions inventories

Monitoring data from European emissions trading will be used to improve the quality of annual national emissions inventories with respect to source categories that include installations subject to reporting obligations under the CO_2 Emissions Trading Scheme (ETS).

The comparisons have confirmed, in principle, the usefulness of such comparisons for verifying individual source categories and identifying data gaps. A formalised procedure, with defined deadlines and workflow, has been agreed for their regular use and for the relevant annual required data exchanges.

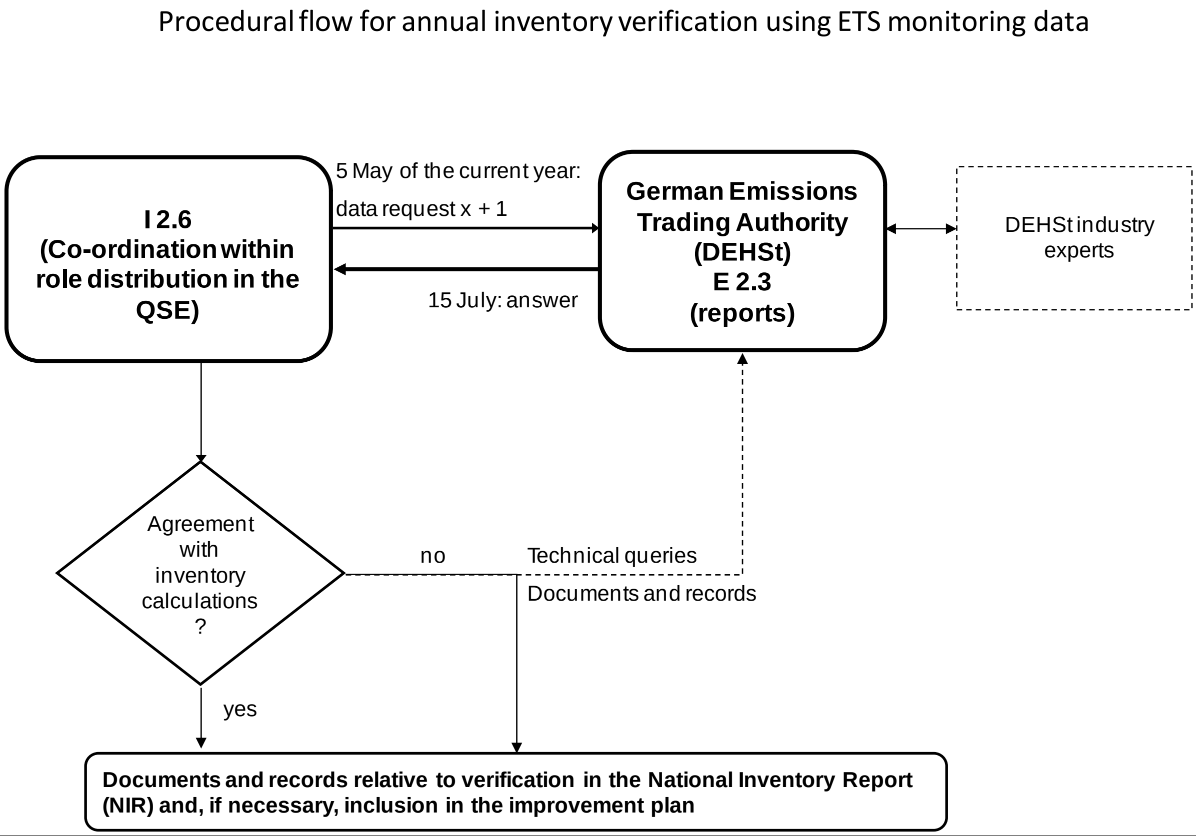


Figure 9: Procedural flow for annual inventory verification using ETS monitoring data

1.4 Short, general description of the methods and data sources used

1.4.1 Greenhouse-gas inventory

1.4.1.1 Data sources

1.4.1.1.1 Energy

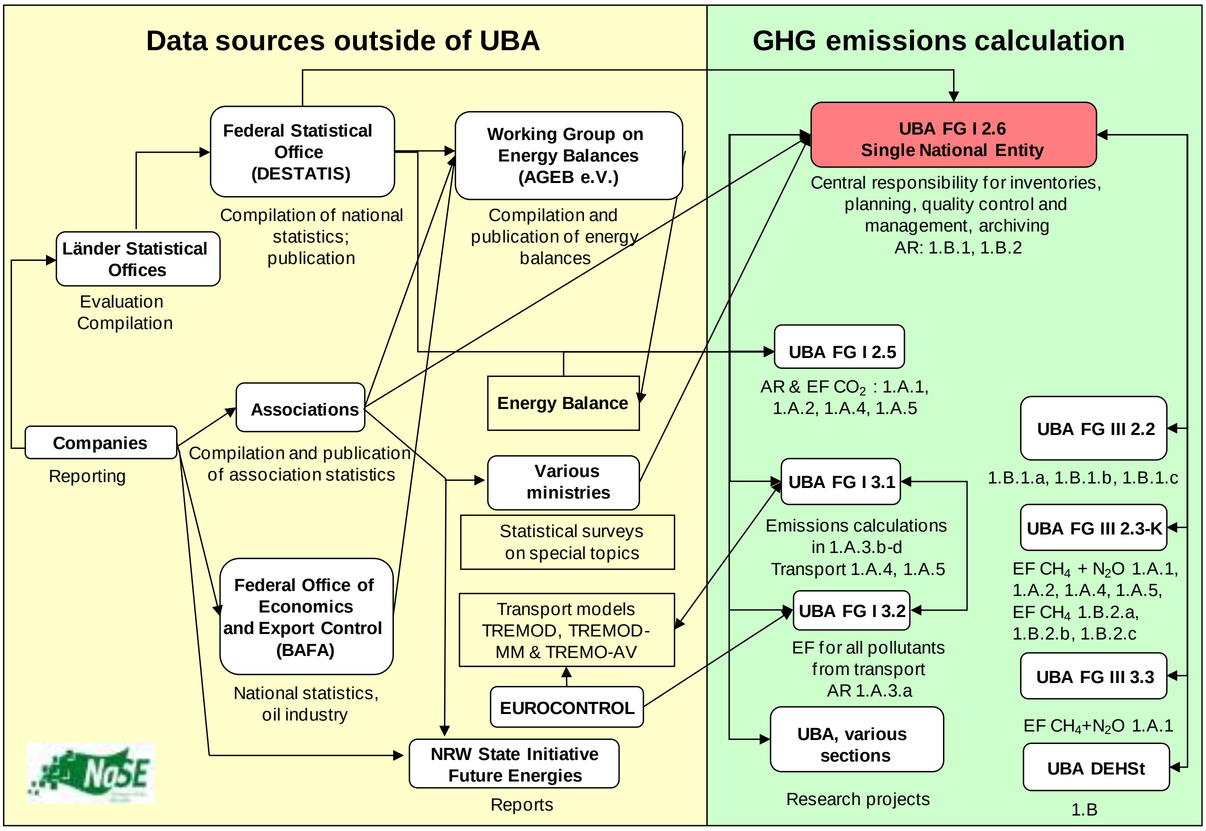


Figure 10: Responsibilities and data flows for calculation of greenhouse-gas emissions in the energy sector

In all likelihood, the most important data sources for determination of activity data for source category 1.A are the *"Energy Balances of the Federal Republic of Germany"* ("Energiebilanzen der Bundesrepublik Deutschland"), hereinafter referred to as: Energy Balance), which are published by the *Working Group on Energy Balances* (Arbeitsgemeinschaft Energiebilanzen - AGEB). An Energy Balance provides an overview of the links within Germany's energy sector, and it supports breakdowns in accordance with fuels and source categories. The data for Energy Balances come from a wide range of other sources.

In commissioning the Energy Balances 2007 – 2012, the BMU obligated the Working Group on Energy Balances (AGEB) to comply with minimum requirements pertaining to quality assurance for the National System. In 2013, the contract for preparation of Energy Balances will again be put to tender. In addition, for the most recent annual Energy Balances, quality reports of the German Institute for Economic Research (DIW) and of Energy Environment Forecast Analysis GmbH Co. KG are available that describe relevant measures for quality assurance and quality control. As of 2012, the Working Group on Energy Balances (AGEB) provides a joint quality report for the Energy Balance (cf. Chapter 18.4.2). Also as of 2012, the AGEB prepares an "Energy-Data Action Plan for inventory improvement" ("Aktionsplan Energiedaten Inventarverbesserung"; cf. Chapter 18.5) that outlines actions to be taken to address the criticism that emerged from the inventory review. This action plan fulfills the action-plan requirement set forth in Paragraph 39 of the 2011 review report (FCCC/ARR/2011/DEU).

Along with the main Energy Balance, a *Satellite Balance of Renewable Energies* (Satellitenbilanz Erneuerbare Energieträger; hereinafter referred to as: Satellite Balance) also appears. This balance describes the growth and use of renewable energies in detail. The Satellite Balance appears together with the Energy Balance.

The *Federal Statistical Office* is another important source of data for determination of activity data. The resources of that office that are used in the present context include the *Fachserien 4 (technical series 4) Reihe (sub-series) 4.1.1, Reihe 6.4,* and, for waste data, Fachserie 19. These data are published relatively promptly after collection (about one year), and they are broken down finely in accordance with various areas of the manufacturing sector. To support further data differentiation, and clarification of details, the Federal Statistical Office provides special evaluations.

For the iron and steel sector, as of the 2012 report, data of the Wirtschaftsvereinigung Stahl German steel industry association are being used. Inter alia, these data replace the so-called "BGS form" (Fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) locally connected to such operations), a section of the "Fachserie 4, Reihe 8.1", publication of which was discontinued as of 31 December 2009.

The series STATISTIK DER KOHLENWIRTSCHAFT ("Coal industry statistics"), especially its annual publication "Der Kohlenbergbau in der Energiewirtschaft der Bundesrepublik Deutschland" ("Coal mining in the energy sector of the Federal Republic of Germany"), is used as an additional data source. In addition, the special evaluations provided by the Bundesverband Braunkohle (DEBRIV; federal German association of lignite-producing companies and their affiliated organisations) are used for differentiation of the different types of raw lignite coal that are burned. Furthermore, DEBRIV provides the necessary data for calculation of fuel inputs for lignite drying.

Yet another data source is the publication "*Petroleum Data*" (Mineralöl-Zahlen) of the Association of the *German Petroleum Industry* (Mineralölwirtschaftsverband; (*MWV*) e.V. (hereinafter also referred to as: MWV Statistics)). This publication contains data on supply and consumption of petroleum in Germany, and it is broken down by source categories. The statistical data as published is very current (publication takes place within just a few months after the relevant survey).

The quantities of secondary fuels used for energy generation (listed under CRF 1.A.2) are taken from the annual report of the German Pulp and Paper Association (Verband der Papierindustrie) and from reports of the German Cement Works Association (Verband der Zementindustrie – VDZ).

The emission factors for source category 1.A were provided by research projects, initiated by the Federal Environment Agency, of the Öko-Institut (Institute for Applied Ecology) and the Franco-German Institute for Environmental Research (DFIU).

For collection of transport emissions data (1.A.3), *Official Mineral-oil Data* (amtliche Mineralöldaten) of the *Federal Office of Economics and Export Control (BAFA)* and *Petroleum Data* (Mineralöl-Zahlen) of the *Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry (MWV)* e.V. are used, in addition to Energy Balance data.

Road-transport emissions are calculated primarily with the TREMOD model ("*Transport Emission Estimation Model*"; currently: Version 5.2, IFEU, 2011)[14]. For calculations carried out in TREMOD, extensive basic data from generally accessible statistics and special surveys are used, co-ordinated, and supplemented. A precise description of the data sources for emission factors is provided by the "Handbook of road-traffic emission factors" ("Handbuch Emissionsfaktoren des Straßenverkehrs"; INFRAS 2010).

For air transports, in addition to data of the aforementioned sources, data of *EUROCONTROL, the European Organisation for the Safety of Air Navigation*, and of the *Federal Statistical Office* are used: Year-specific split factors, determined on the basis of actual aircraft movements, are used to break down fuel consumption and emissions data by national and international air transports. For years as of 2003, the split factors are provided by Eurocontrol. For all earlier years, they are derived via aircraft-movement data (numbers of take-offs and landings) collected by the Federal Statistical Office. The aircraft-movement data collected by the Federal Statistical Office are also used to break down consumption and emissions data in accordance with the different phases of flight. For the first time, further processing of the many different types of input data is being carried out within the newly developed TREMOD-AV module, a separate TREMOD module for air transports. In addition, Eurocontrol provided country-specific consumption and emissions data from the PAGODA model, for the first time. While that data arrived too late for the current report, they were used for verification of our own surveys.

Data on emissions of other mobile sources (in 1.A.4.b & c and 1.A.5.b) are also collected from figures of the Working Group on Energy Balances (AGEB), of BAFA and of the Association of the German Petroleum Industry (MWV). Military transports (1.A.5.b) play a special role in this context; all of the consumption data for those transports are taken from the Official Mineral-oil Data of BAFA, since such data are no longer listed separately in the Energy Balances.

Data for source categories of category 1.B.1 are taken from publications of Statistik der Kohlenwirtschaft e.V. (coal-industry statistics), the Federal Ministry of Economics and Technology (BMWi), the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations, Deutsche Montan Technologie GmbH (DMT), the German Society for Petroleum and Coal Science and Technology (DGMK) and Interessenverband Grubengas e.V. (IVG; association for the pit-gas sector).

The publication "Statistik der Kohlenwirtschaft" (coal-industry statistics) is especially important in this context. It is processed with the help of federal and Land (state) ministries, including their authorities (such as supreme state mining authorities), and with use of reports and expert opinions of the "Landesinitiative Zukunftsenergien" NRW ("NRW State Initiative for Future Energies"; here, the AG Grubengas mine-gas working group). Inventory preparation is co-ordinated with the support of the Association of the German hard-coal

14 To make it possible to derive and assess reduction measures, energy consumption and CO_2 emissions for the various vehicle categories are also calculated with TREMOD. The resulting values are subsequently checked against total consumption and total CO_2 emissions.

mining industry (Gesamtverband Steinkohle; formerly, Gesamtverband des deutschen Steinkohlebergbaus - GVSt).

Data for source categories in category 1.B.2 are taken from publications of the *Federal Statistical Office*, the Association of the German Petroleum Industry (MWV), the German Society for Petroleum and Coal Science and Technology (DGMK), the Association of the petroleum and natural-gas industry (Wirtschaftverband Erdöl und Erdgasgewinnung e.V. – WEG), the German Technical and Scientific Association for Gas and Water (DVGW), the Federal association of the German gas and water industry (Bundesverband der deutschen Gas- und Wasserwirtschaft – BDEW; gas statistics) and the German Emissions Trading Authority (DEHSt). Processing in this area now takes account of responses (statements of position) of the WEG.

1.4.1.1.2 Industrial processes

Activity data for the mineral industry are obtained primarily from association statistics. The data for the cement industry (2.A.1) were provided by the German Cement Works Association (Verband der Zementindustrie – VDZ), especially by that association's research institute, as well as by the Federal association of the German cement industry (Bundesverband der Deutschen Zementindustrie e.V. - BDZ). For the most part, the data in question consist of data published in the framework of CO_2 monitoring under the industry's voluntary climate-protection commitment. The figures for lime and dolomite-lime production (2.A.2) are collected by the German Lime Association (BVK) on a per-plant basis and then provided annually in aggregated form. Use of limestone and dolomite (2.A.3) is reported in other source categories (included elsewhere), and the relevant data sources are mentioned in the pertinent categories in each case. The total quantity of soda ash production (2.A.4.a) is determined via surveys of the Federal Statistical Office, while soda ash use (2.A.4.b) is determined via assessment by experts of the Federal Environment Agency. The production quantities for bitumen paper and bitumen roof sheeting (2.A.5) are provided by the VDD industry association for bitumen paper and bitumen roof sheeting. Production quantities of asphalt for road paving (2.A.6) are provided by the German asphalt association (Deutscher Asphaltverband - DAV). Glass-production figures (2.A.7.a Glass) are taken from the regularly published annual reports of the Federal glass industry association (Bundesverband Glasindustrie), although relevant orientational figures on glass recycling are taken from other statistics. Production trends in the ceramics industry (2.A.7.b Ceramics) are determined via official statistics and via conversion factors provided by the Federal association of the German brick industry (Bundesverband der Deutschen Ziegelindustrie).

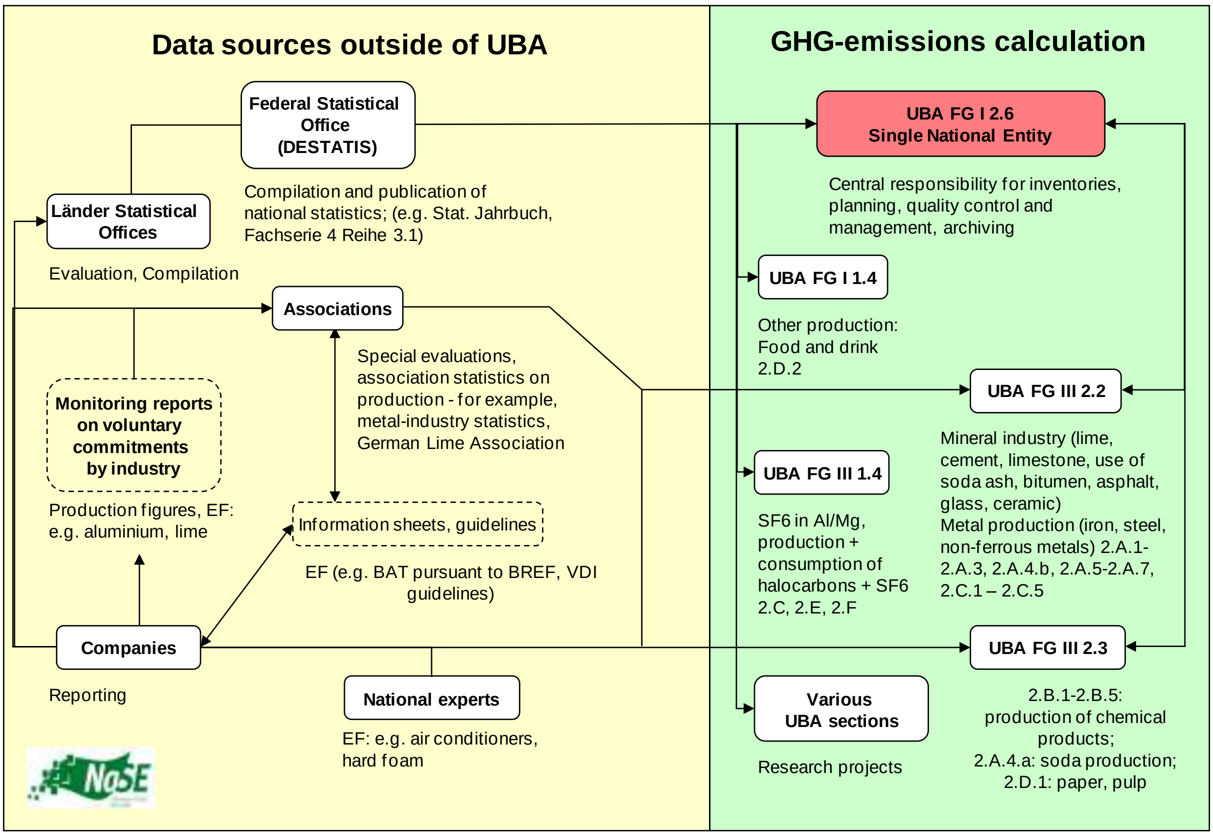


Figure 11: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of industrial processes

A range of different sources are used to determine emission factors for the mineral industry. The emission factor used for calculation of emissions from cement-clinker production (2.A.1) is based on a calculation of the German Cement Works Association (VDZ) carried out by aggregating plant-specific data. CO_2 emissions from lime production (2.A.2) and from soda-ash use (2.A.4.b) are calculated with the help of stoichiometric factors. Soda ash production (2.A.4.a) via the Solvay process is considered CO_2-neutral with regard to the raw materials used. The emission factors for production and laying of bitumen paper and bitumen roof sheeting (2.A.5), and for production of asphalt for road paving (2.A.6) refer only to NMVOC, and they have been taken from research reports. The CO_2-emission factors for various types of glass (2.A.7.a) have been derived from glass-composition data, while CO_2-emission factors for the ceramics industry (2.A.7.b) have been derived, by Federal Environment Agency experts, from raw-material inputs.

The activity data for source category 2.B Chemical industry are determined from activity data of the *Federal Statistical Office*, of the *Mineralölwirtschaftsverband* Association of the German Petroleum Industry and directly from figures of industry associations and producers. The latter group (industry data) is confidential. The relevant emission factors have been determined by experts in the Federal Environment Agency, via research projects or by the pertinent producers. Until 2008, activity data for 2.B.1 Ammonia production and 2.B.2 Nitric acid production were collected by the *Federal Statistical Office*. Since 2009, data for ammonia and nitric-acid production have been collected by producers themselves – plant-specifically, on the basis of an agreement with the chemical industry and for the entire time series as of 1990. These data are forwarded to the association, which aggregates them and forwards them to the Federal Environment Agency. For this purpose, in addition to determining the applicable activity data, the producers also determine the applicable emissions for 2.B.1 and the applicable emission factors for 2.B.2. Until the mid-1990s, plant-by-plant activity data were supplied for 2.B.3 Adipic acid production. The default emission factor for N_2O was applied to that data. Now, plant operators are supplying emissions data directly to the Federal Environment Agency, on a confidential basis. For the area of adipic-acid production, data delivery has also been assured for the long term, via an agreement from 2009. Producers in Germany find the IPCC's default emission factors for NO_X, CO and NMVOC rather puzzling. This is the reason why emissions of these substances have not been reported to date. Since there is only one calcium carbide (2.B.4) producer in Germany, the relevant data are confidential. The Federal Environment Agency obtains these data directly from the producer. Under 2.B.5 Other, greenhouse-gas emissions from several different production processes are reported: coke burn-off in catalyst regeneration, transformation losses and production of carbon black. Emissions of precursor substances are reported for production of sulphuric acid, titanium dioxide and organic substances. The activity data have been obtained via research projects, data of the Federal Statistical Office and publications of the Association of the German Petroleum Industry. The emission factors have been obtained from experts' assessments, research projects and default figures in the IPCC Guidelines.

The activity data for the metal industry (2.C) are provided by the *Federal Statistical Office* and the relevant associations (Steel Institute VDEh, Wirtschaftsvereinigung Metalle (metals industry association) and Gesamtverband der Aluminiumindustrie (aluminium industry association). The emission factors for the metals industry (2.C) are normally calculated by experts in the Federal Environment Agency; in some cases, IPCC default values are used as well.

One exception in this regard is the source category Ferroalloys (2.C.2); for it, activity data from statistics of the U.S. Geological Survey are used, while the relevant emission factors are taken from the results of a research project (in some cases, IPCC default values are also used).

In the area of Other production: Pulp and paper production (2.D.1), data from the production report of the German Pulp and Paper Association (Verband Deutscher Papierfabriken VDP) are used. In the area of Other production: Food and beverages (2.D.2), data of the Federal Food Industry Association (Bundesvereinigung der Deutschen Ernährungsindustrie; BVE), of the Federal Statistical Office (Statistisches Bundesamt) and of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) are used. The emission factors have been obtained from a research project that was completed in 2008.

In the area of production of halocarbons and SF_6 (2.E), data are obtained from *producers' figures and surveys of producers*. For the most part, activity data are researched in the framework of research projects, directly in accordance with the inventory's requirements. In some cases, producers supply only emissions data. Only small numbers of companies are involved in the various sub- source categories, and thus data in these areas are confidential.

The activity data for consumption of halocarbons and SF_6 (2.F) are determined from figures of producers and associations, from surveys of the Federal Statistical Office and of other federal authorities and with the help of calculation models. In individual cases, producers provide emissions data directly. The data are classified into several sub - source categories.

Furthermore, a distinction is made between production, use and disposal emissions. The data in some parts of 2.F are also confidential.

Emission factors for source categories 2.E and 2F are obtained in part from national and international fact sheets and directives or via surveys of experts; where necessary, IPCC default values are used.

More detailed pertinent information regarding emission factors is presented in the descriptions of methods for the various source categories.

1.4.1.1.3 Solvent and other product use

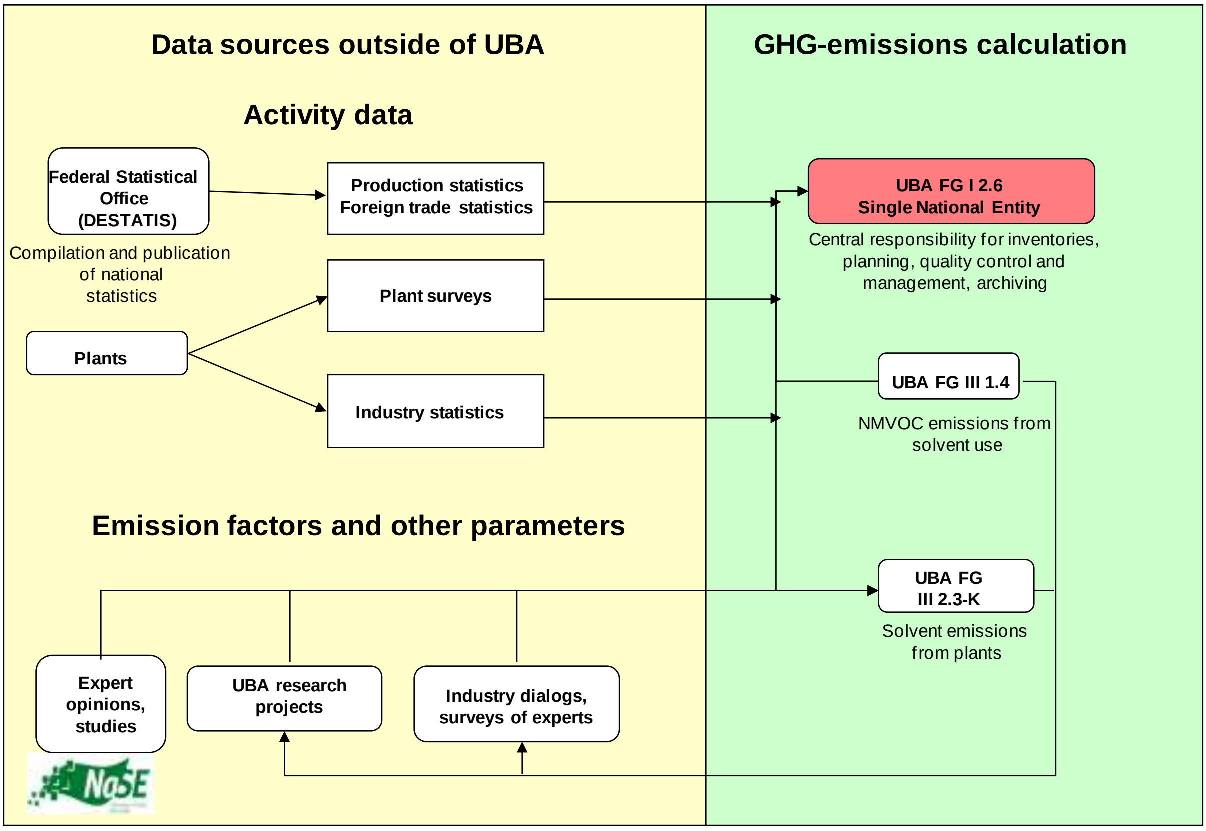


Figure 12: Responsibilities and data flows for calculation of greenhouse-gas emissions from use of solvents and other products

The Federal Environment Agency's Section (FG) III 1.4 *Substance-related Product Issues* is responsible for calculating NMVOC emissions from the area of solvent and other product use. With regard to the sub - source category of solvent emissions from plants, the Federal Environment Agency's Section for *Substance-related Product Issues* is supported by the agency's Section III 2.1, *General Aspects, Chemical Industry, Combustion Plants* in the framework of the latter section's "global responsibility". The Federal Environment Agency has not yet specified internal responsibilities for determining N_2O emissions from products.

Activity data are drawn mainly from published statistics of the Federal Statistical Office, especially from its statistics on production and foreign trade. The activity data are supplemented with industry statistics and information supplied by experts. For N_2O emissions, research-project results and companies' figures are used.

Emission factors, along with other parameters that enter into calculation of emissions from solvent and other product use, are taken from national studies, experts' opinions and research projects directly commissioned by the Federal Environment Agency; in some cases, they are also based on information provided by experts in the context of dialogs with industry.

1.4.1.1.4 Agriculture

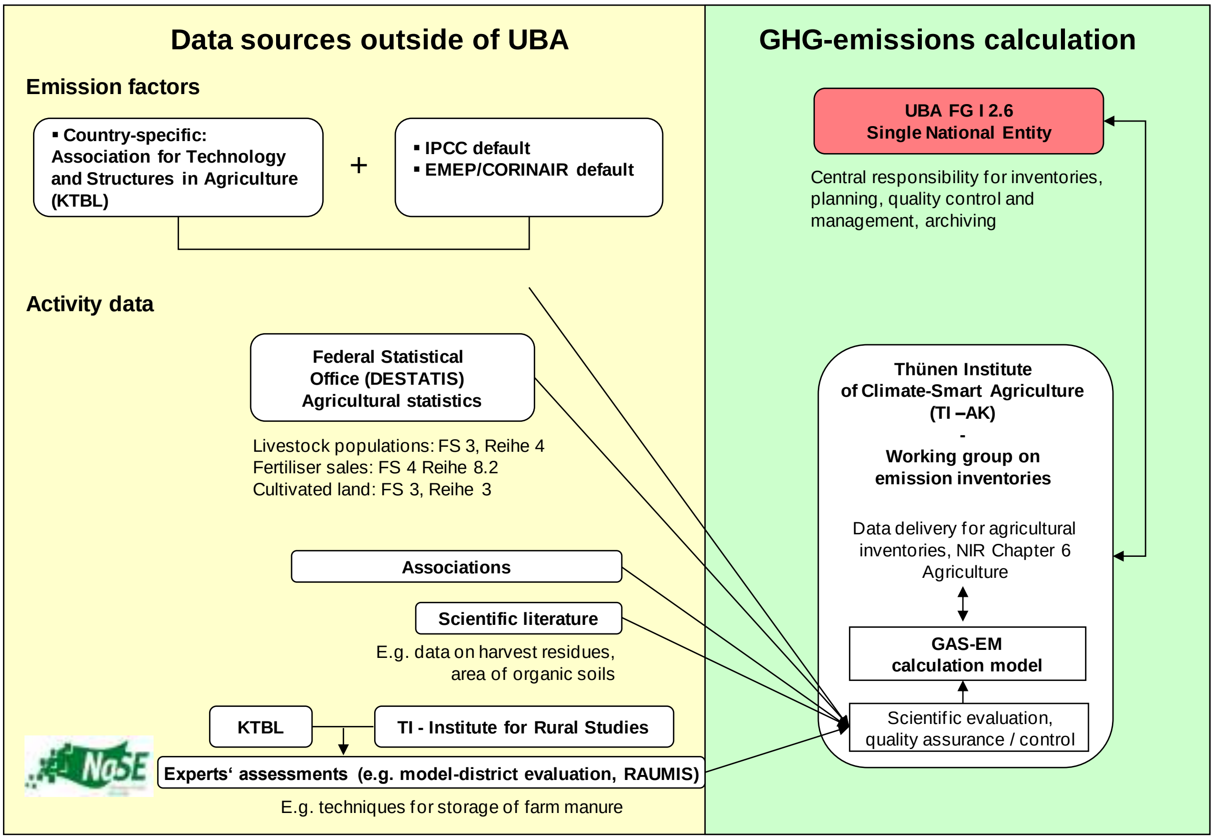


Figure 13: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of agriculture

Emissions calculations for source category 4 (Agriculture) are carried out by the von Thünen Institute (TI). For calculation of agricultural emissions in Germany, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) initated a suitable joint project, in the framework of which the former Federal Agricultural Research Institute (FAL) developed a modular model for relevant spread-sheet calculation (GASeous Emissions, GAS-EM) (DÄMMGEN et al, 2002 & HAENEL et al. 2012). The BMU and BMELV now have a framework ministerial agreement in place for management of relevant data and information exchange and for operation of a joint database at the UBA and the FAL.

Agricultural statistics of the Federal Statistical Office are another important data source for calculation of agricultural emissions. Animal statistics have been obtained from the *Federal Statistical Office* (*FEDERAL STATISTICAL OFFICE,* FS3 R4); other Fachserien (technical series) provide data on amounts of fertiliser sold and agricultural land under cultivation. In some areas, such data are supplemented by figures from the pertinent literature (for example, crop residues and recommended fertiliser quantities). Additional data are available from experts' assessments (for example, an evaluation of model districts with regard to techniques for storing farm fertilisers).

In many areas, calculations for the agriculture sector are based on highly differentiated activity data obtained via national data sources. Also in many areas, such data are combined with the standard emission factors given in the 1996b and 2006 IPCC Guidelines or the EMEP/EEA manual of the United Nations Economic Commission for Europe (UN ECE).

1.4.1.1.5 Land-use changes and forestry

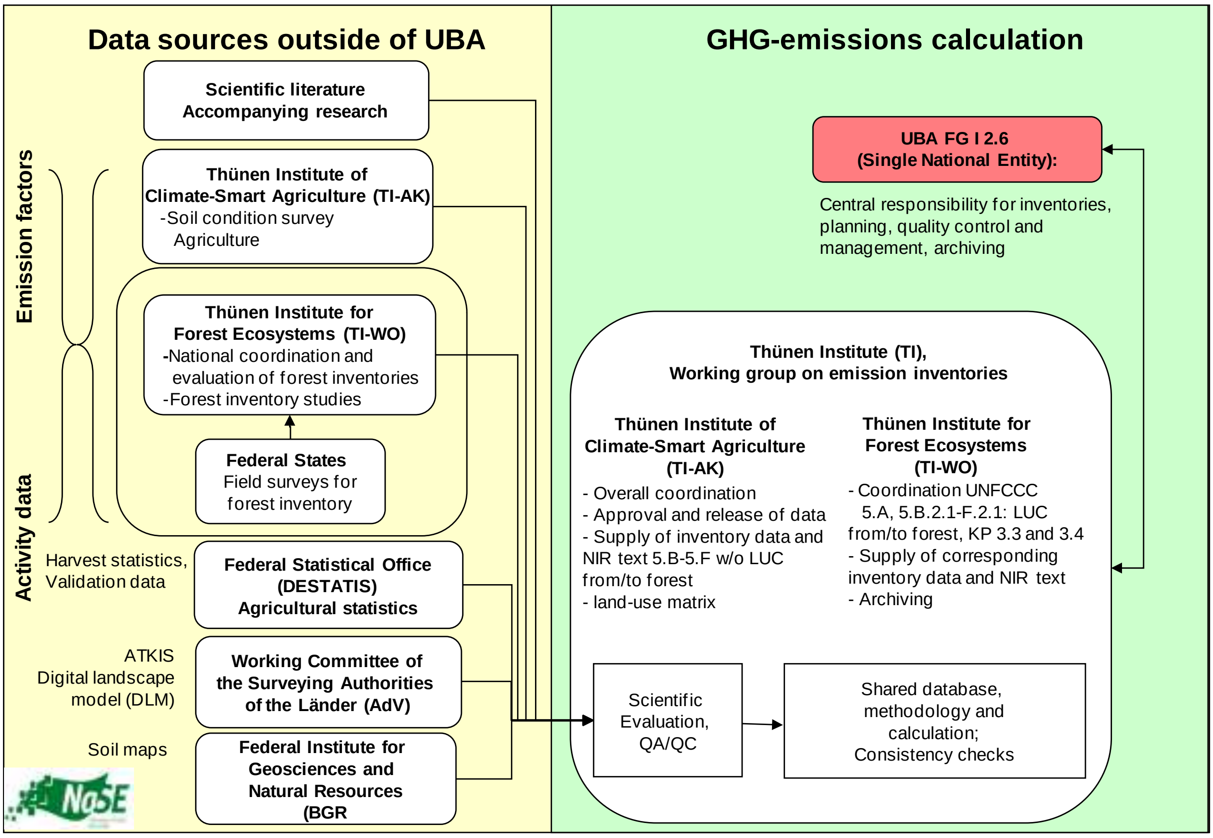


Figure 14: Data flows for calculation of greenhouse-gas emissions from the areas of land-use changes and forestry (LULUCF) and KP-LULUCF

In the 2012 Submission, a consistent, unified method was introduced for taking account of land-use changes in the LULUC sector and the forestry sector. The method expands the existing sample-based system for determining forest-land areas, and land-use changes to and from forest land, for all land-use categories and change types.

Soil carbon stocks are estimated with the help of soil maps (differentiated to show usages) and soil-profile data provided by the Federal Institute for Geosciences and Natural Resources (BGR), while use-change-related changes in these stocks are estimated on the basis of changes in the mean stocks per land-use category.

Changes in biomass carbon stocks are estimated on the basis of harvest statistics, the main survey on soil use (Bodennutzungshaupterhebung) and specific factors given in the pertinent scientific literature (and used in conjunction with area data). Emissions from liming of soils are determined with the help of data, taken from Federal fertiliser statistics, on domestic sales of mineral fertilisers that contain lime and other nutrients. The fertiliser industry is legally required to disclose its sales.

Projects for improvement of activity data, and especially for determination of country-specific emission factors for carbon and nitrogen, and for CO_2, CH_4 and N_2O – for example, the project "Organic Soils" (since 2009), the agricultural soil survey (Bodenzustandserhebung Landwirtschaft; since 2011) and others – will help validate and improve national estimates of emissions and removals.

1.4.1.1.6 Waste and wastewater

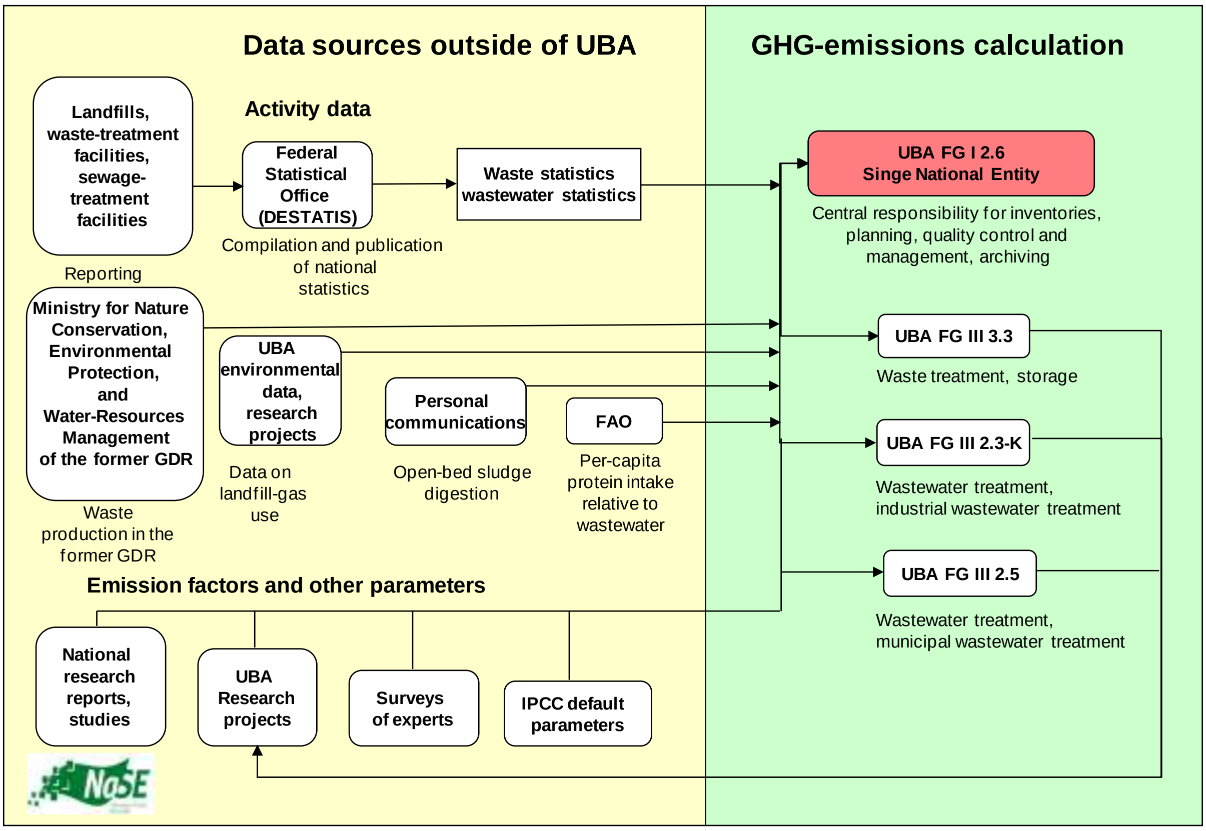


Figure 15: Data flows for calculation of greenhouse-gas emissions from the area of waste and wastewater

Federal Environment Agency Section FG III 3.3 *Waste treatment, waste storage* is responsible for selecting the methods, parameters and data for calculating emissions from the waste sector. In recalculation of landfill emissions in 2003 (development of the Tier 2 method for the Federal Republic of Germany), and in refinement of the Tier 2 method in 2006, the Federal Environment Agency was supported by a research project (ÖKO-INSTITUT, 2004b).

Activity data in the waste sector are drawn mainly from published data of the Federal Statistical Office, which provides detailed, disaggregated time series. The section on waste provides precise information as to what statistical series and sources were used. The Federal Statistical Office has not published any data on amounts of waste produced in the former GDR. In this area, an official source of the former GDR's ministry for nature conservation, environmental protection and water-resources management was used. The calculations relative to landfill-gas use are based on data from the Energy Balances and from Fachserie 19 of the Federal Statistical Office. The database for landfill-gas use was updated in the framework of the 2010 In-Country Review. Statistical data on gas collection at landfills in the follow-on care phase are now collected. Such data became available for the first time for the present report.

The emission factors and other parameters that enter into calculation of emissions from waste landfilling, from mechanical-biological waste treatment and from composting were taken from national studies and research reports conducted/prepared in research projects commissioned directly by the Federal Environment Agency. IPCC default parameters were also used for this purpose. Selected experts were also consulted regarding a few of the relevant parameters (for example, half-life selection). The relevant chapter presents the sources for the various parameters, in detail.

The Federal Environment Agency's Section for *General Aspects, Chemical Industry, Combustion Plants* (III 2.1) is responsible for selecting the methods, parameters and data for calculating emissions from the industrial wastewater / sewage sludge handling sector (6.B.1). The Federal Environment Agency's Section III 2.5 *Monitoring Methods, Waste Water Management* is responsible for selecting the methods, parameters and data for calculating emissions from the municipal wastewater handling sector (wastewater and sewage sludge) (6.B.2).

Activity data in the wastewater sector are drawn mainly from published data of the Federal Statistical Office, which provides detailed, disaggregated time series. The section on wastewater provides precise information as to what technical series and sources were used. The data on per-capita protein intake are taken from FAO data.

The emission factors and other parameters that enter into calculation of emissions from wastewater treatment were taken from national studies and research projects commissioned directly by the Federal Environment Agency. IPCC default parameters are also used. Various experts were consulted directly regarding a few parameters and methodological issues (for example, production of CH_4 emissions in aerobic wastewater-treatment processes).

1.4.1.2 Methods

The methods used for the individual source categories are outlined in the overview tables for the various source categories and in summary tables 3s1 and 3s2 of the CRF reporting tables. In addition, detailed descriptions are provided in the relevant source-category chapters.

A distinction is made between calculations made with country-specific ("CS") methods and calculations made, in the various source categories, with IPCC calculation methods of varying degrees of detail (of varying "Tiers")[15]. The manner in which a calculation is assigned to the various IPCC methods depends on the pertinent source category's share (expressed as equivalent emissions) of total emissions. Such assignment is carried out via an instrument known as "key-category analysis" (cf. Chapter 1.5 in this regard).

NMVOC emissions from solvent use, converted into indirect CO_2, are calculated on the basis of a product-consumption approach pursuant to the IPCC Guidelines 1996.

1.4.2 KP LULUCF activities

The data sources and methods used for KP reporting do not differ from the data sources and methods used for reporting for source categories 5.A-5.F in the UNFCCC framework. There

15 Tier 1 refers to the simpler calculation methods that may be used with fewer input data, whereas Tier 2 and Tier 3 require more differentiated input data and hence generally lead to more accurate results.

are thus no differences with regard to the present purpose. Cf. also Chapter 1.4.1.1.5 and Chapter 7.2 and Annex Chapter 19.5.

1.5 Brief description of key categories

1.5.1 Greenhouse-gas inventory (with and without LULUCF)

The key categories were defined by applying two Tier 1 procedures, Level (for the base year, for 1990 and for 2011) and Trend (for 2011, as compared to the base year), to German greenhouse-gas emissions. In addition, the Tier 2 method was used. In keeping with the IPCC specifications for the Tier 1 method, analysis focussed both on emissions from sources and on removals of greenhouse gases in sinks. The analyses are first carried out solely for emissions from the sources listed in Annex 1 of the UN Framework Convention on Climate Change and, then, in a second step, for storage of greenhouse gases in sinks. All specified key categories result either from level analysis, or from trend assessment, or from Tier-2 key-category analysis on the basis of current uncertainties determination. No new key categories have been added as a result of assessment of qualitative aspects (explanations regarding this aspect are provided in Annex Chapter 17.1.2).

For the 2013 report, the Tier 1 method identified 37 source categories, out of a total of 120 source and sink categories studied, as key categories. Only 23 of these were identified, by both trend and level analysis, as key categories. In addition, 6 source categories were identified as key categories solely by trend analysis, and 8 source categories were so identified solely by level analysis. Via the Tier 2 method, 8 additional key categories were identified (cf. Table 8).

Ultimately, 45 key categories were defined. These are summarised in Table 5.

Table 5: Number of source categories and key categories

Category	**120**		
			Key categories
by Level	Level & Trend	Trend	
8	23	6	**37 (Tier 1)** **+8 (Tier 2)** **45 (total)**

Table 7 provides an overview of the results of Tier-1 key-category analysis. Table 8 shows the additional key categories identified via Tier 2 analysis. Annex 1 (Chapter 17) of this report presents detailed explanations of the key-category analysis carried out.

Only few changes have occurred with respect to the results obtained in the previous year. The number of key categories pursuant to Tier-1 analysis has decreased to 37, from a former level of 39. The following source categories are no longer key categories: CO_2 emissions from railway transport (1.A.3.c) and CH_4 emissions from commerce, trade and services (commercial and institutional sources) (1.A.4.a). The number of key categories pursuant to Tier 2 analysis has increased by one: CO_2 emissions from the Residential sector (1.A.4.b) has been added as a new key category pursuant to Tier 2.

Germany uses all recommended procedures for identifying and evaluating source categories. The IPCC Guidelines require 95% of emissions from sources / removals in sinks to be classified in key categories. In keeping with the fact that Germany identifies key categories by combining the results of all analysis procedures and evaluations, emission-causing activities accounting for about 98 % of the inventory have been identified as key categories.

1.5.2 Inventory with KP-LULUCF reporting

As a result of the analysis, as described in the previous chapter, of the UNFCCC inventory, CO_2 emissions / removals in the categories *Forest Land* (5.A), *Cropland* (5.B) and *Grassland* have been identified as key categories. For these categories, additional detailed analyses were carried out, in line with the methodological specifications set forth in chapter "5.4 methodological choice – identification of key categories" of the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC, 2003). As a result, the sub-categories listed in Table 6 were identified as key categories for the KP-LULUCF inventory pursuant to Article 3.3. The key factors in such selections were the relevant emissions-contribution levels and emissions trends. With the help of Table 5.4.4, the activities selected in accordance with Article 3.4 were then correlated with these categories. Under this article of the Kyoto Protocol, Germany has selected only the category "forest management". These results, as well as the criteria used for the selection, are presented in CRF Table NIR.3 (Table 342 in Chapter 17.1.4)).

Table 6: Results of KP-LULUCF key-category assessment

IPCC Source Categories	Emissions / Sinks of	1990	2011	Key category assessment
5.A.1 Forest Land remaining Forest Land	**CO_2**	**74,155.8**	**27,952.8**	●
5.A.1 Forest Land remaining Forest Land	CH_4	0.4	0.1	-
5.A.1 Forest Land remaining Forest Land	N_2O	0.2	0.2	-
5.A.2 Land converted to Forest Land	**CO_2**	**6,485.1**	**4,836.3**	●
LIME CROPLAND	CO_2	1,158.9	1,775.9	-
5.B.1 Cropland remaining Cropland	**CO2**	**22,255.7**	**23,433.3**	●
5.B.1 Cropland remaining Cropland	N_2O	IE	IE	**IE**
5.B.2 Land converted to Cropland	CO_2	5,217.5	3,423.3	-
5.B.2 Land converted to Cropland	N_2O	0.6	0.7	-
5.C.1 Grassland remaining Grassland	**CO_2**	**11,707.6**	**10,325.5**	●
5.C.2 Land converted to Grassland	CO_2	380.1	1,557.1	-
5.D.1 Wetlands remaining Wetlands	CO_2	2,050.7	2,020.7	-
5.D.2 Land converted to Wetlands	CO_2	182.5	107.4	-
5.E.1 Settlements remaining Settlements	CO_2	1,600.4	1,665.3	-
5.E.2 Land converted to Settlements	CO_2	707.3	590.7	-
5.F.1 Other Land remaining Other Land	CO_2	0.0	0.0	-
5.F.2 Land converted to Other Land	CO_2	0.0	0.0	-
5.G Other	CO_2	116.8	64.3	-

Table 7: Key categories for Germany pursuant to the Tier 1 method

IPCC Source Categories	Activity	Emissions of	Level						Trend		Emis-sions Base Year	Emis-sions 2011
			Base Year	Base Year + sinks	LEVEL 1990	1990 + sinks	LEVEL 2011	2011 + sinks	2011	2011 + sinks		
1A1a Public electricity and heat production	All fuels	CH_4	-	-	-	-	-	-	●	●	185.8	1,864.2
1A1a Public electricity and heat production	All fuels	CO_2	●	●	●	●	●	●	●	●	339,017.9	314,159.6
1A1a Public electricity and heat production	All fuels	N_2O	●	-	-	-	-	-	-	-	3,568.9	2,631.9
1A1b Petroleum Refining	All fuels	CO_2	●	●	●	●	●	●	●	●	20,005.9	18,380.0
1A1c Manufacture of Solid Fuels and Other Energy Industries	All fuels	CO_2	●	●	●	●	●	●	●	●	64,393.8	17,006.6
1A2a Manufacturing Industries and Construction: Iron and Steel	All fuels	CO_2	●	●	●	●	●	●	●	●	34,742.0	34,323.0
1A2e Manufacturing Industries and Construction: Food Processing	All fuels	CO_2	-	-	-	-	-	-	●	●	1,989.2	190.7
1A2f Manufacturing Industries and Construction: Other	All fuels	CO_2	●	●	●	●	●	●	●	●	137,298.8	78,190.5
1A3b Transport: Road Transportation	All fuels	CO_2	●	●	●	●	●	●	●	●	150,358.3	147,867.4
1A3e Transport: Other Transportation	All fuels	CO_2	●	●	●	●	●	●	-	-	4,751.7	4,098.1
1A4a Other Sectors: Commercial/institutional	All fuels	CO_2	●	●	●	●	●	●	●	●	63,949.6	33,429.9
1A4b Other Sectors: Residential	All fuels	CO_2	●	●	●	●	●	●	●	●	129,474.0	81,918.8
1A4c Other Sectors: Agriculture/Forestry/Fisheries	All fuels	CO_2	●	●	●	●	●	●	●	●	11,059.8	5,970.9
1A5 Other: Include Military fuel use under this category	All fuels	CO_2	●	●	●	●	-	-	●	●	11,811.1	1,202.1
1B1a Fugitive Emissions from Fuels: Coal mining and handling	Solid fuels	CH_4	●	●	●	●	-	-	●	●	18,415.2	2,612.3
1B1c Fugitive Emissions from Fuels: Other (Abandoned Mines)	Solid fuels	CH_4	-	-	-	-	-	-	●	●	1,806.8	15.1
1B2b Fugitive Emissions from Fuels: Natural gas	Gaseous fuels	CH_4	●	●	●	●	●	●	-	-	6,966.1	5,372.5
2A1 Mineral Products: Cement Production	Clinker production	CO_2	●	●	●	●	●	●	●	●	15,145.8	13,130.8
2A2 Mineral Products: Lime Production	Limestone and dolomite	CO_2	●	●	●	●	●	●	-	-	5,867.6	4,926.6
2B1 Chemical Industry	Ammonia production	CO_2	●	●	●	●	●	●	●	●	5,745.0	7,450.0
2B3 Chemical industry	Adipic acid production	N_2O	●	●	●	●	-	-	●	●	18,804.6	521.6
2B5 Chemical Industry	Other	CO_2	●	●	●	●	●	●	●	●	6,888.2	9,211.8
2C1 Metal Production: Iron and Steel Production	Steel (integrated production)	CO_2	●	●	●	●	●	●	-	-	22,711.9	16,350.0
2C3 Aluminium Production	0	PFCs	-	-	-	-	-	-	●	●	1,551.7	81.5
2E Production of Halocarbons and SF6	Production of HCFC-22	HFCs	●	●	●	●	-	-	●	●	4,218.5	41.4
2F Industrial Processes	Consumption of Halocarbons and SF6	HFCs	-	-	-	-	●	●	●	●	C	C
2F Industrial Processes	Consumption of Halocarbons and SF6	SF_6	●	●	●	●	-	-	●	●	C	C
3D Total Solvent and Other Product Use	0	N_2O	-	-	-	-	-	-	●	●	1,924.6	287.9

IPCC Source Categories	Activity	Emissions of	Level: Base Year	Level: Base Year + sinks	Level: LEVEL 1990	Level: 1990 + sinks	Level: LEVEL 2011	Level: 2011 + sinks	Trend: 2011	Trend: 2011 + sinks	Emis-sions Base Year	Emis-sions 2011
4A1 Enteric Fermentation	Dairy cattle	CH_4	●	●	●	●	●	●	-	-	16,002.7	11,677.4
4A1 Enteric Fermentation	Non-dairy cattle	CH_4	●	●	●	●	●	●	-	-	12,229.0	7,996.3
4D1 Agricultural Soils	Direct soil emissions	N_2O	●	●	●	●	●	●	●	●	29,140.6	26,360.9
4D3 Agricultural Soils	Indirect emissions	N_2O	●	●	●	●	●	●	●	●	16,539.7	14,195.7
5A Forest Land	0	CO_2		●		●		●		●	-80,640.9	-32,789.1
5B Cropland	0	CO_2		●		●		●		●	28,632.1	28,632.5
5C Grassland	0	CO_2		●		●		●		-	11,327.5	8,768.4
6A Solid Waste Disposal on Land	Managed Waste Disposal on Land	CH_4	●	●	●	●	●	●	●	●	38,598.0	11,046.0
6B Wastewater Handling	Domestic and Commercial Wastewater	CH_4	-	-	-	-	-	-	●	●	2,226.2	60.9

Table 8: Key categories for Germany identified solely via the Tier 2 approach

IPCC Source Categories	Activity	Emissions of
1.A.4.b Other Sectors: Residential	All fuels	CO_2
4.B.1.a Manure Management: Other	Dairy cattle	CH_4
4.B.1.a Manure Management: Other	Dairy cattle	N_2O
4.B.1.a Manure Management: Swine	Swine	CH_4
4.D.2 Agricultural Soils	Pasture, range and paddock manure	N_2O
5.D Wetlands		CO_2
5.E Settlements		CO_2
6.B Wastewater Handling	Domestic and Commercial Wastewater	N_2O

1.6 Information regarding the quality assurance and quality control plan , the inventory plan (including verification) and management of confidential information

1.6.1 Quality assurance and quality control procedures

1.6.1.1 QC/QA plan

Pursuant to the IPCC Good Practice Guidance requirements, the necessary QC/QA measures for emissions reporting should be summarised in a QC/QA plan. Such a QC/QA plan is to serve the primary purpose of organising, planning and assuring the proper execution of such QC/QA measures.

Organisation:

A general description of the manner in which the quality assurance and control process is organised – with regard to both establishment and workflow – is provided in Chapter 1.3.3.1. That section also describes the principles by which QC/QA measures are controlled, as well as the sorts of documents and records kept in the process.

Planning:

The requirements for quality assurance and quality control measures in emissions reporting are described in detail in the "Handbook for quality control and quality assurance in preparation of emissions inventories and reporting under the UN Framework Convention on Climate and EU Decision 280/2004/EC" ("Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU Entscheidung 280/2004/EG" (Federal Environment Agency, 2007b, unpublished). The most important specifications set forth in the handbook consist of quality reviews carried out primarily during inventory preparation.

Execution:

The quality checks are carried out with the help of checklists (for the relevant content, cf. Chapters 1.3.3.1.5 and 22.1.2.1.11). These lists currently comprise some 100 role-specific individual targets and some 50 optional targets.

Currently, some 50 Federal Environment Agency and external staff, in various functional roles, and in four layered, cumulative QC/QA review levels, are involved in emissions reporting. The review levels are represented, in each case, by the relevant expert (Fachverantwortlicher – FV), his superior, the quality control manager (Qualitätskontrollverantwortlicher – QKV), a specialised contact person, within the Single National Entity, for the relevant source category (Fachlicher Ansprechpartner – FAP) and, finally, the co-ordinators responsible for achieving a consistent overall result comprising the NIR, the inventory, the QSE and uncertainties estimates.

In inventory preparation, role-specific QC/QA reviews are linked with general quality targets (cf. Chapter 22.1.2.1.10.3) and individual process steps (cf. Chapter 1.2.3), so that final evaluation can take account of such targets and steps. As a whole, the reviews cover the entire inventory-preparation process.

Subsequent evaluation of the checklists identifies source categories that need to be reviewed – and, possibly, revised – with regard to fulfillment of specific inventory requirements. Such fulfillment is achieved via addition of pertinent further information. The great majority of all identified review requirements are added to the binding inventory plan. The inventory plan undergoes internal and interdepartmental approval processes and is then published in aggregated form.

1.6.1.2 Inventory plan

For preparation of the inventory plan, the QC/QA checklist results for all source categories are evaluated. Those results are combined with any results of improvement activities mentioned in the NIR (cf. Chapter 10.4.1), with evaluations of results of the various review procedures of the UNFCCC and the EU Commission and with any other requirements for improvement. The inventory plan comprises a range of individual measures that are to be implemented by the various roles within the QSE (FV, QKV, FAP, ZSEK, QSEK and NaSEK; cf. the role concept within QSE, Chapter 1.3.3.1.3) and by the Federal German ministries involved in emissions reporting (cf. Chapter 1.2.1.4). In the interest of clarity, the measures as shown in the table are not grouped in accordance with pertinent areas of responsibility (such as federal ministries, the Federal Environment Agency or the roles FV, QKV, FAP, NaSEK, etc), with emissions parameters (AR, EF, emissions, etc.) or with sources of individual measures. The relevant individual measures have been combined to yield the overarching measures shown in Table 9. The inventory plan is regularly updated, within an ongoing process.

Regularly, as inventory-plan measures are implemented, large numbers of the included individual measures are processed to the point where they can be removed from the list.

Table 9: Inventory plan 2013

Category (CRF code)	Planning for inventory improvement / required actions
4.A.+B, 6.B.2	Check whether requirements of IPCC Good Practice Guidance pertaining to selection of calculation method and to procedures for applicable methods changes are fulfilled or if it´s necessary to adjust already existing calculation methods/modells.
1.A.3.c, 2.A.7.(b), 6.B.1	Check whether there are any gaps in the available data for time series as of 1990.
1.A.3.e.ii, 2.A.5, 6.B.2	Check whether the source category is completely covered by the relevant data source and whether the defined data sets for EF and AR are consistently delimited.
1.A.3.b, 1.A.3.e.ii, 1.A.4.c.iii, 2.A.6, 6.B.2	Check whether uncertainties have been determined and are complete.
1.A.2.e, 1.A.2.f.b+c, 1.A.3.a.ii, 1.A.3.b+c+d.ii+e.ii, 1.A.4.c.ii+iii, 1.A.5.b, 1.C.1.b, 6.B	Check whether obligations pertaining to keeping of records and documentation are fulfilled and whether the relevant documents are complete and meaningful.
1.A.1, 1.A.3.b, 2.A.6, 2.C.2, 5, 5 (III), 5.A.(f), 5.B-F, 6.B.2	Check whether data suppliers and contracted supporting entities are carrying out suitable routine quality controls, and whether the emissions-reporting requirements defined by the Single National Entity have been provided to such suppliers and entities and are being fulfilled.
1.A.2.f, 1.A.3.e.ii, 1.A.4.iii, 1.A.5.b, 2.A.1+2+4+6+7b, 6.B	Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.
1.A., 1.A.3.d, 1.B.2.b, 4.+5., 6, 6.B.2	Check whether it was possible to take pointers from inventory reviews and inventory plan into account.
1.A.2.f(a+b), 1.A.3.b, 1.A.4, 5., 6.A.1, 6.B.2, 6.D.2	Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.
1.A.3.d, 1.A.3.e.ii, 5.B-D, 6.B.2	Check whether the EF are plausible and complete (have no gaps and are completely documented).
1.A.2.f.(b+c), 1.C.1.b, 4.(b), 4.B, 4.D, 5.A-C	Check whether the AR are plausible and complete (have no gaps and are completely documented).
6.B.2	Check whether data has been entered into the CSE correctly, including whether all numbers, units and conversion factors have been correctly entered and properly integrated.
1.A.2.f.(a-d), 2.A.6, 2.A7.(b), 6.B	Check whether the NIR source category has been completely and logically described in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).
1.A.2.e+f, 1.A.3.d, 1.A.3.e.ii, 1.A.4,	Various types of required action.

1.A.4.a+c.ii, 1.A.5.b, 1.B.2, 1.B.2.d, 2.A.5, 4.A+B+D, 5.A., 6.B	
1.A.2.b, 1.A.2.e, 1.A.3.e, 1.A.3.e.i, 1.B.1, 1.B.2.b, 1.B.2.c.(a), 2.A.4.(b), 2.A.5, 3.D.1+4, 6.B.2	Check whether pertinent responsibilities need to be updated.
1.A.1, 1.A.2.f, 1.A.3.e, 1.B.2, 1.B.2.a.v, 1.B.2.d, 1.C.1.b, 2.A.6, 5.A-C+D	Initiated research projects for inventory improvement.

In the following, additional information relative to the inventory plan is provided, in accordance with various Review Teams' recommendations to the effect that transparency be enhanced.

The first inventory plan was published together with the 2007 Submission. Since then, some 2,500 items for action or improvement have been addressed within the quality system. Since that total is too unwieldy to be presented in any clear manner, we simply provide an overview of the development of the IP over the past 4 years (2010-2013).

As of the end of the 2013 reporting year, the inventory plan comprises some 1,100 items for action or improvement. Those items span about 160 source categories.

Some 111 new items for improvement have been identified in connection with the 2013 reporting round. A total of 750 of the existing improvement items have been successfully addressed (last year: 540). The focuses of the completed improvements include the areas of review results, documentation and verification. The focuses of the 336 improvement items that are still open or still undergoing processing (last year: 435) include documentation, verification and QC with regard to data suppliers. If one takes into account the number of repetitions that necessarily result via recurrence of checklist results of past years, then the number of open improvement items decreases to an actual figure of 254.

The overviews in Table 10 and Table 11 present detailed information on the improvement items – those that have been successfully addressed and those that are still open. The tables include the review results from the years 2006-2010, the statements made in the NIR relative to planned improvements in 2011 to 2013, the other improvement items of 2008 to 2013 and the CHKL results from 2010 to 2013.

Detailed information regarding individual improvements, with respect to source categories, priorities, deadlines, responsibilities, gases, fuels, quality targets, needs for action, etc., cannot be provided here, due to the sheer scope of the information involved. With regard to successfully addressed Review results, more-detailed excerpts from the inventory plan are provided in Table 310 (Compilation of the review recommendations that have been successfully addressed and that are documented in the IP), while information relative to statements made in the NIR regarding planned improvements is provided in Table 311 (Summary of the planned improvements mentioned in the NIR source-category chapters).

Table 10: Inventory plan – Needs for action/improvement that have been successfully addressed

Key category	Category (CRF code)	Planning for inventory improvement / required actions	Source	Source reference, report year
Energy	1.A	Check whether requirements of IPCC Good Practice Guidance pertaining to selection of calculation method and to procedures for applicable methods changes are fulfilled or if it´s necessary to adjust already existing calculation methods/modells.	ARR	2008
Industrial Processes	2.B.5, 2.E.3, 2.F.1+6		S&A I, NIR, CHKL	2006, 2010, 2012
Agiculture	4.B		Other	2009
Energy	1.A.2	Check whether the data source (s) used will be available throughout the long term.	CHKL	2011
Agiculture	4.A.(a), 4.B.(a)		CHKL	2010
LULUCF	5		Other	2008
Waste	6.D.(b)		CHKL	2010
Energy	1.A.3.c	Check whether there are any gaps in the available data for time series as of 1990.	CHKL	2010
Industrial Processes	2.C.2+3		CHKL	2010-2011
Agiculture	4.A.(b), 4.D		CHKL	2010-2011
LULUCF	5.A.(b)		CHKL	2012
Waste	6.A.1	Check whether the source category is completely covered by the relevant data source and whether the defined data sets for EF and AR are consistently delimited.	NIR	2012
Energy	1.A.2, 1.A.3.a.ii, 1.A.3.b+c, 1.A.3.e.ii, 1.A.5.	Check whether uncertainties have been determined and are complete.	CHKL	2010-2012
Industrial Processes	2.A.5, 2.C.1-3		CHKL, NIR	2010-2011
LULUCF	5, 5(III+IV), 5.A.(c+f), 5.B-F		Other, CHKL, NIR	2008, 2010-2011
Waste	6.A.1		CHKL	2011
Energy	1.A, 1.A.1+2, 1.A.3.a.ii, 1.A.3.b+c, 1.A.3.d.ii, 1.A.3.e, 1.A.4, 1.A.5.a+b, 1.B.1+2, 1.C.1.b	Check whether obligations pertaining to keeping of records and documentation are fulfilled and whether the relevant documents are complete and meaningful.	CHKL	2010-2012
Industrial Processes	2.C.1-3, 2.D.1+2		CHKL	2010-2011
Agiculture	4.A.(a), 4.B.(a)		CHKL	2010
LULUCF	5, 5(III+IV), 5.A-F		CHKL, Other	2008, 2010
Waste	6.A.1, 6.B.2, 6.D.		CHKL	2010-2011
Energy	1.A.2, 1.A.3.a.ii, 1.A.3.b+c, 1.A.3.d.ii, 1.A.3.e.ii, 1.A.4.c.ii, 1.A.5.b, 1.C.1.b	Check whether data suppliers and contracted supporting entities are carrying out suitable routine quality controls, and whether the emissions-reporting requirements defined by the Single National Entity have been provided to such suppliers and entities and are being fulfilled.	CHKL	2010-2011
Industrial Processes	2.C.2		CHKL	2011
Agiculture	4, 4.A., 4.B., 4.D		CHKL, Other	2008, 2010-2011
LULUCF	5, 5(III), 5.A.(f), 5.B-F		CHKL, Other	2008, 2010, 2012
Waste	6.B.2		CHKL	2010-2011
Alle	Alle	Check whether requirements for	ARR	2008

Key category	Category (CRF code)	Planning for inventory improvement / required actions	Source	Source reference, report year
Energy	1, 1.A, 1.A.1+2, 1.A.3.a-e, 1.A.4, 1.A.4.c.iii, 1.A.5.a+b, 1.B.1+2, 1.C.1.a	cross-checking and verification of data and their underlying assumptions have been fulfilled.	ARR, Eu-Rev, S&A I, CHKL, NIR	2006-2008, 2010-2012
Industrial Processes	2.A.2, 2.A.4.(a), 2.A.7., 2.B.1, 2.C.1-3, 2.D.2,		CHKL	2010-2012
LULUCF	5(III), 5.B-F		CHKL	2010, 2012
Waste	6.A.1		CHKL	2011
Alle	Alle	Check whether it was possible to take pointers from inventory reviews and inventory plan into account.	ARR, IRR	2006, 2009-2010
Energy	1, 1.A, 1.A.1.a, 1.A.2, 1.A.2.a, 1.A.2f, 1.A.3.b-d, 1.B.1+2, 1.BU.1, 1.C.1		ARR, IRR, SL	2006, 2008-2010
Industrial Processes	2, 2.A.1-4, 2.B.1-3, 2.C.1-4, 2.E, 2.F		ARR, IRR, CHKL	2006, 2008-2010
Solvents	3.A – 3.D		ARR	2008
Agiculture	4, 4.A-B, 4.D		ARR, IRR, NIR	2006, 2008-2010, 2012
LULUCF	5, 5.A-D		ARR, IRR, SL	2006, 2008-2010
Waste	6, 6.A, 6.B, 6.B.2, 6.C, 6.D		ARR, IRR	2006, 2008-2010
Energy	1.A, 1.A.1+2, 1.A.2.a+f, 1.A.3.b+d, 1.A.4, 1.B.1.a, 1.B.2	Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.	ARR, EU-Rev, S&A I, CHKL	2006-2008, 2010-2011
Industrial Processes	2, 2.A.5+6, 2.B.2+5, 2.C.1, 2.D.1.(b), 2.F.1		EU-Rev, CHKL	2007, 2010-2011
Agiculture	4, 4.D		ARR	2008
LULUCF	5.A.2, 5.B.1, 5.C.1		EU-Rev	2007
Waste	6.A.1, 6.B.2		EU-Rev, CHKL	2007, 2011
Energy	1.A.1, 1.A.2, 1.A.4, 1.A.5.a	Check whether the EF are plausible and complete (have no gaps and are completely documented).	EU-Rev, S&A I	2006, 2007
Industrial Processes	2.B.1, 2.C.4, 2.F		EU-Rev, NIR	2007, 2011
Agiculture	4.B, 4.B.(b)		EU-Rev, NIR	2007, 2012
LULUCF	5.C.2		EU-Rev	2007
Alle	Alle	Check whether the AR are plausible and complete (have no gaps and are completely documented).	Other	2008
Energy	1.A.1; 1.A.2; 1.A.4; 1.A.5.a, 1.B.1c		EU-Rev, S&A I, NIR, CHKL	2006, 2007, 2011-2012
Industrial Processes	2.A.7.(a)		NIR	2011-2012
Agiculture	4.B+D		NIR	2011
Waste	6.A.1, 6.D.2		NIR	2011-2012
Waste	6.B.2	Check whether data has been entered into the CSE correctly,	CHKL	2011

Key category	Category (CRF code)	Planning for inventory improvement / required actions	Source	Source reference, report year
		including whether all numbers, units and conversion factors have been correctly entered and properly integrated.		
Energy	1.A.2.f.(a+c), 1.B.1.c, 1.B.2.a	Check whether the NIR source category has been completely and logically described in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	ARR, CHKL	2008, 2011-2012
Industrial Processes	2.A.6, 2.C, 2.C.2+3, 2.D.1.(b)		EU-Rev, CHKL	2007, 2010-2011
Energy	1, 1.A.1+2+4	Check whether any recalculations are required. If they are they must be documented in a logical manner.	EU-Rev, S&A I	2006, 2007
Industrial Processes	2		EU-Rev, S&A I	2006, 2007
Agiculture	4		S&A I	2006
Waste	6, 6.D		S&A I, EU-Rev	2006, 2007
Alle	Alle	Various types of required action.	Other	2010
Energy	1.A., 1.A.3.a+b+e, 1.B.1		NIR, Other, CHKL	2009-2011
Industrial Processes	2.A.5, 2.C.1, 2.D.1		CHKL, NIR	2010-2012
Solvents	3.A+B, 3.D.1+4+5		CHKL	2010
Agiculture	4.		NIR	2011
LULUCF	5, 5.A-D		ARR, NIR	2008, 2011
Energy	1.A.2.d, 1.A.3.e.i	Check whether pertinent responsibilities need to be updated.	CHKL	2010
Industrial Processes	2.A.6, 2.B.5.(e), 2.D.1		CHKL	2010-2012
Waste	6.B.2		CHKL	2010
Energy	1.A.3.c+d, 1.B.1.c, 1.B.2	Initiated research projects for inventory improvement.	NIR	2011-2012
Industrial Processes	2.A.2		NIR	2011
Agiculture	4.B		NIR	2012
LULUCF	5.A+E		NIR	2011-2012
Waste	6.A.1, 6.D.1		NIR	2011-2012

Table 11: Inventory plan – Needs for action that are still open or still undergoing processing

Key category	Category (CRF code)	Planning for inventory improvement / required actions	Source	Source reference, report year
Agiculture	4.A.+B	Check whether requirements of IPCC Good Practice Guidance pertaining to selection of calculation method and to procedures for applicable methods changes are fulfilled or if it´s necessary to adjust already existing calculation methods/modells.	NIR	2012, 2013
Waste	6.B.2		CHKL	2013
Energy	1.A.3.c	Check whether there are any gaps in the available data for time series as of 1990.	CHKL	2013
Industrial Processes	2.A.7.(b)		CHKL	2013
Waste	6.B.1		NIR	2013
Energy	1.A.3.e.ii	Check whether the source category is completely covered by the relevant data source and whether the defined data sets for EF and AR are consistently delimited.	CHKL	2011
Industrial Processes	2.A.5		CHKL	2012
Waste	6.B.2		CHKL	2011
Energy	1.A.3.b, 1.A.3.e.ii, 1.A.4.c.iii	Check whether uncertainties have been determined and are complete.	CHKL	2010, 2012
Industrial Processes	2.A.6		CHKL	2012
Waste	6.B.2		CHKL	2011, 2013
Energy	1.A.2.e, 1.A.2.f.b+c, 1.A.3.a.ii,	Check whether obligations pertaining to keeping of records and documentation are fulfilled	CHKL	2010-2013

Key category	Category (CRF code)	Planning for inventory improvement / required actions	Source	Source reference, report year
	1.A.3.b+c+d.ii +e.ii, 1.A.4.c.ii+iii, 1.A.5.b, 1.C.1.b	and whether the relevant documents are complete and meaningful.		
Waste	6.B		CHKL	2011-2013
Energy	1.a.1, 1.A.3.b	Check whether data suppliers and contracted supporting entities are carrying out suitable routine quality controls, and whether the emissions-reporting requirements defined by the Single National Entity have been provided to such suppliers and entities and are being fulfilled.	CHKL	2010, 2012
Industrial Processes	2.A.6, 2.C.2		CHKL	2012
LULUCF	5, 5 (III), 5.A.(f), 5.B-F		CHKL	2010, 2012
Waste	6.B.2		CHKL	2012
Energy	1.A.2.f, 1.A.3.e.ii, 1.A.4.iii, 1.A.5.b	Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.	CHKL	2011, 2013
Industrial Processes	2.A.1+2+4+6 +7b		CHKL, NIR	2012, 2013
Waste	6.B		CHKL	2010-2013
Energy	1.A., 1.A.3.d, 1.B.2.b	Check whether it was possible to take pointers from inventory reviews and inventory plan into account.	ARR, IRR	2006, 2010
Agiculture&LULUCF	4.+5.		ARR	2010
Waste	6, 6.B.2		ARR, CHKL	2008 - 2010, 2013
Energy	1.A.2.f(a+b), 1.A.3.b, 1.A.4	Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.	NIR, CHKL	2012, 2013
LULUCF	5.		NIR	2013
Waste	6.A.1, 6.B.2, 6.D.2		CHKL	2012, 2013
Energy	1.A.3.d, 1.A.3.e.ii	Check whether the EF are plausible and complete (have no gaps and are completely documented).	CHKL	2012
LULUCF	5.B-D		NIR	2011, 2013
Waste	6.B.2		CHKL	2013
Energy	1.A.2.f.(b+c), 1.C.1.b	Check whether the AR are plausible and complete (have no gaps and are completely documented).	NIR, CHKL	2013
Agiculture	4.(b), 4.B, 4.D		NIR	2011, 2012
LULUCF	5.A-C		NIR	2011, 2012
Waste	6.B.2	Check whether data has been entered into the CSE correctly, including whether all numbers, units and conversion factors have been correctly entered and properly integrated.	CHKL	2013
Energy	1.A.2.f.(a-d)	Check whether the NIR source category has been completely and logically described in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	CHKL	2012, 2013
Industrial Processes	2.A.6, 2.A7.(b)		CHKL	2013
Waste	6.B		CHKL	2011, 2013
Energy	1.A.2.e, 1.A.2.f, 1.A.3.d, 1.A.3.e.ii, 1.A.4, 1.A.4.a+c.ii, 1.A.5.b, 1.B.2, 1.B.2.d	Various types of required action.	CHKL, Other, NIR	2010-2013
Industrial Processes	2.A.5		NIR	2012
Agiculture	4.A+B+D		NIR	2011, 2012
LULUCF	5.A.		NIR	2011
Waste	6.B		Other	2013
Energy	1.A.2.b, 1.A.2.e, 1.A.3.e, 1.A.3.e.i, 1.B.1, 1.B.2.b, 1.B.2.c.(a)	Check whether pertinent responsibilities need to be updated.	CHKL	2013
Industrial Processes	2.A.4.(b),		CHKL	2013

Key category	Category (CRF code)	Planning for inventory improvement / required actions	Source	Source reference, report year
	2.A.5			
Solvent & Other	3.D.1+4		CHKL	2013
Waste	6.B.2		CHKL	2013
Energy	1.A.1, 1.A.2.f, 1.A.3.e, 1.B.2, 1.B.2.a.v, 1.B.2.d, 1.C.1.b	Initiated research projects for inventory improvement.	NIR	2011-2013
Industrial Processes	2.A.6		NIR	2012
LULUCF	5.A-C+D		NIR	2012

1.6.2 *Activities for verification*

1.6.2.1 Procedure for using monitoring data from European emissions trading

In efforts to fulfil mandatory quality criteria, a need has been seen – especially within the EU – to use data from the EU Emissions Trading Scheme (EU ETS) to improve greenhouse-gas emissions inventories. All Member States are now called upon to use ETS data to improve the quality of their annual national emissions inventories.

A reliable database from emissions trading, showing relevant annual emissions, is available for the period since ETS monitoring commenced. This data can be used, in aggregated form, to draw source-category-specific conclusions regarding the completeness and consistency of certain parts of emissions inventories. In addition, it provides a basis for reviewing emission factors used and for verifying activity data. Since emissions calculations for all components are all based on the same activity data, such verification is of significance for all reported emissions inventories.

Emissions-trading data required for improvement of inventory data subject to reporting are available in electronic form, in the installations database of the German Emissions Trading Authority (DEHSt). In 2005, agreement was reached regarding a general procedure for individual data queries related to inventory preparation. In the main, this procedure involves direct communication between the Single National Entity and the German Emissions Trading Authority's section E 2.3.

Monitoring data from European emissions trading will be used to improve the quality of annual national emissions inventories with respect to source categories that include installations subject to reporting obligations under the CO_2 Emissions Trading Scheme (ETS). To make it possible to use this "resource" on a regular basis, a formalised procedure for the pertinent required annual data exchanges, including deadlines and defined workflows, has been agreed.

In a research project (ÖKO-INSTITUT, 2006b), allocation rules were developed that make it possible to compare data from verified emissions reports with data from the inventories' database, on a year-by-year basis. The comparisons, which have been carried out only once to date, have confirmed, in principle, the usefulness of such comparisons for verifying individual source categories and identifying data gaps. A follow-on project begun in 2011, "D.E.N.K.", is studying whether the allocation rules can be improved and the relevant procedure could be further automated. It has become clear that the data the ETS provides for inventory calculations are resources-critical and time-critical. When discrepancies occur in existing aggregates that fulfill requirements for confidentiality of business and operational secrets, the underlying data sets for individual operational steps have to be checked. At an international workshop held within the project framework, experts of other countries confirmed that issue's importance for the German situation. The number of ETS data sets is so large – 35,000 – that the limits of capacities for checking such sets (instead of automatically using the pertinent aggregates) are being reached. Consequently, it will not be possible to bring the procedure used in this area into line with the procedures used in other countries.

1.6.2.2 Workshop on the National System (Peer Review)

In November 2004, the Federal Environment Agency held a first workshop on the National System of Emissions Inventories. This created a forum that significantly promoted inclusion of associations and other independent organisations, as well as supporting implementation of Paragraph 15 (b) of the *Guidelines for National Systems*, which requires that inventories be reviewed by third parties (peer review).

In May 2009, a second workshop on the National System was held, with the purpose of facilitating another review of the inventories by independent third parties, pursuant to Paragraph 15 (b) of the *Guidelines for National Systems*. That second workshop focussed on specific source categories within the inventory. The selected areas included "N_2O from product use", "emissions from non-energy-related use of fossil fuels" and "SF_6 emissions from the photovoltaics industry". The persons invited to the discussion of inventory areas included experts from the various sectors, industry representatives and independent experts. For example, with regard to the area of use of N_2O, the invited participants included sellers of industrial gases, and representatives of the Berufsverband deutscher Anästhesisten (BDA; Professional Association of German Anaesthetists) and of the Federal Institute for Materials Research and Testing (BAM). With regard to the area of non-energy-related uses, discussions were held with representatives of the Association of the German Chemical Industry (VCI) and of affected chemical producers. Participants with a focus on photovoltaics production included representatives of producers, industrial-gas sellers, systems builders, universities and research establishments. The topics were comprehensively and intensively discussed. The workshop contributed significantly to overall improvement of the data and of the quality of reporting.

In May 2011, an international experts' workshop on the German LULUCF-reporting system took place. That workshop reviewed the methodological changes made as a result of the In-Country Review of September 2010. All of the recommendations made by experts in that framework have been fully implemented.

In April 2012, a discussion was held with the Federal Statistical Office regarding the topic of natural gas statistics. The participants in the technical discussion included representatives of the Federal Statistical Office, the Federal Environment Agency (UBA) and of the German Association of Energy and Water Industries (BDEW), as well as representatives of various gas companies and the German Institute for Economic Research (DIW; Working Group on Energy Balances (AGEB)). In preparation for revision of the national Energy Balance, the discussion focussed on the available natural gas statistics. In the process, measures were approved that will directly improve the Energy Balance and, thus, will improve the emissions inventory. In addition, agreement was reached on additional study that will be carried out in order to verify the available statistical data.

1.6.2.3 Cross-Country Review on fluorinated gases

In February 2011, a group of experts met in Vienna for a cross-country review focussing on reporting on F gases. The participating countries included the UK, Austria and Germany. After basic presentations of data collection in the three countries, the various individual areas of application concerned were considered in detail and compared in terms of data sources, precision, emission factors and other criteria. In the process, it emerged that, of the three countries, Germany has the most extensive specialised knowledge resources and presumably is thus best able to assess the completeness and plausibility of the available data.

One of the key results that emerged from the cross-country review is that all three countries have to commit high levels of manpower to reporting on F gases. Any reduction in such resources commitments would mean that reporting would no longer be IPCC-conformal.

As a result of the meeting, a report was prepared that has entered into German reporting regarding F gases.

1.6.3 Handling of confidential information

When the Federal Statistical Office began providing data in connection with the entry into force of the 3rd SME Relief Act (Mittelstandsentlastungsgesetz 3; MEG 3), the Federal Environment Agency received access to data subject to statistical secrecy.

In addition, from associations and companies, the Single National Entity receives activity data, emission factors and emissions data that reflect operational and business secrets and that are otherwise confidential.

In storing and using such data, therefore, the Single National Entity must take special precautions, and apply special procedures, to protect the confidentiality of the data.

In particular, it must provide for strict separation (both spatial and in terms of staff assignments) of statistical work / analysis and any enforcement of legal provisions pertaining to the installations for which data are collected.

The Single National Entity and the affected sections of the Federal Environment Agency have taken various measures for the purpose of fulfilling these requirements. For example, as a basic rule, persons charged with enforcement of laws in a specific area are never permitted to carry out specialised tasks relative to emissions reporting in the same area.

In 2008, the Single National Entity commissioned a legal study with the aim of precisely assessing the requirements and possibilities pertaining to use and management of data for emissions reporting. The results entered into revision and refinement of the Single National Entity's concept for handling confidential data.

Previously, access to the Central System on Emissions (CSE) database was already limited to a specified group of authorised persons. That measure represents the key precaution for dealing with confidential data. In particular, it makes it practicable to separate - in terms of the persons involved - the tasks of data analysis and legal control. In addition, in 2009 a special access-restricted area was set up, on a central server of the Federal Environment Agency, for confidential electronic data that are not centrally stored in the CSE (for example, energy data subject to statistical confidentiality, emissions-control declarations, data relative to large combustion plants, information about production processes, etc.).

Furthermore, data provided by the *Federal Statistical Office* are placed on a password-/access- protected server (i.e. available only for specifically authorised persons) at the *Federal Statistical Office*.

1.7 General estimation of uncertainties

1.7.1 Greenhouse-gas inventory

The IPCC Good Practice Guidance (GPG, 2000) characterises determination of uncertainties as a key element of any complete inventory. As a result of the GPG's focus on continual inventory improvement, uncertainties in the inventories play an important role. Uncertainties information is used primarily as an aid for improving the precision of inventories, as well as for selecting methods and carrying out recalculations for inventories. The declared aim is to minimise uncertainties to the greatest possible degree, in order to maximise the inventories' accuracy. Annex I countries must thus first quantify the uncertainties for all source categories and sinks, in order to enhance their assessment of inventory quality – which assessment, in turn, is the key to effective inventory planning.

Uncertainties are quantified for emission factors and activity data; in some cases, they are also quantified for emissions.

In general, two methods for determining uncertainties are differentiated. The Tier 1 method combines, in a simple way, the uncertainties in activity data and emission factors, for each source category and greenhouse gas, and then aggregates these uncertainties, for all source categories and greenhouse-gas components, to obtain the total uncertainty for the inventory. The Tier 2 method for uncertainties determination is the same, in principle, but it also considers the distribution function for uncertainties and carries out aggregation using Monte Carlo simulation. In the Tier 2 method, this process also necessarily includes determining a probability density function for both parameters. Ideally, these functions can be determined via statistical evaluation of individual data items (such as measurements for a large number of facilities). In many cases, few relevant values are available, however, and thus the uncertainty must be determined on the basis of experts' assessments.

Research project 202 42 266 (UBA, 2004) determined uncertainties in keeping with the Tier 1 and Tier 2 methods, pursuant to Chapter 6 of the GPG. Since then, the resulting database has been continually improved, and the uncertainties data for the greenhouse-gas inventory have been further improved for the 2009 report. In the current NIR, Germany reports uncertainties that have been calculated pursuant to the Tier 1 method. The uncertainties for the activity data, emission factors and emissions data used were taken from the CSE database. They are based on estimates of experts in relevant departments of the Federal Environment Agency and at external institutions. In cases in which uncertainties information is not yet available in complete form, as an expert's estimate, pertinent figures are added from other sources (such as relevant technical literature), in the framework of a Tier 1 calculation.

Germany determines uncertainties in keeping with the Tier 2 method every 3 years, and it should normally have reported Tier-2-level uncertainties again this year. Last year, however, Germany extensively revised its calculation algorithms, and it made a change of methods for such uncertainties calculation. Now, in order to improve the consistency of the pertinent results, such uncertainties are no longer calculated via a separate procedure – they are calculated via a procedure integrated directly within the Central System of Emissions (CSE).

While initial results have already been obtained with this new approach, neither they nor the basic change in methods have yet been verified. The necessary review for such verification will be carried out in 2013; it was not possible for it to begin earlier. For these reasons, in a departure from earlier planning, the results of Tier 2 uncertainties determination will be reported as part of the next report, i.e. the NIR 2014.

1.7.1.1 Tier 1 approach for uncertainties determination

In the Tier 1 method, in keeping with Chapter 6 of the GPG, uncertainties are determined on the basis of the uncertainties for AR (activity data), EF and EM, as determined on the lowest sub-category level (primarily by responsible experts of the Federal Environment Agency), and as listed in the CSE. Where asymmetric uncertainties figures are yielded, the larger of the two relevant values is used, under the assumption of a normal distribution, as both the upper boundary and the lower boundary. In each sector, the uncertainties for the individual time series are aggregated to form a total uncertainty for the sector pursuant to the IPCC Good Practice Guidance. In Formula 6.3, sinks are taken into account as emissions quantities ($|x_i|$ in Formula 6.3). A similar approach applies for determination of the combined uncertainties within the inventory (Column H in Table 6.1 of the IPCC Good Practice Guidance, Formula G * |D| / sum |D|).

1.7.1.2 Tier 2 approach for uncertainties determination

The uncertainties analysis pursuant to Tier 2 will only be completed in time for the final Submission.

1.7.1.3 Results of uncertainties assessment

In general, uncertainties for activity data can be assumed to be smaller than those for emission factors. In particular, the uncertainties are smaller for activity data derived from fuel use and based on the Federal Energy Balance. On the other hand, uncertainties for activity data derived from disaggregated fuel use normally increase as the relevant disaggregation increases.

- Pursuant to the results from an R&D project (RENTZ et al, 2002), the uncertainties in emission factors for indirect greenhouse gases in stationary combustion systems (CRF 1.A.1) are relatively small, as a result of regular monitoring of such emissions. Higher uncertainties are listed for N_2O emission factors, since N_2O emissions are not normally monitored. The same applies to the emission factors for CH_4.
- The uncertainties in the Transport source category (primarily CRF 1.A.3) can generally be considered to be small, since precise relevant data on fuel use and vehicle fleets are available, due to taxation obligations, and since that category's emission factors have been very finely modelled and are normally determined via measurements. Some uncertainties may arise via systematic measuring errors or wrong disaggregation.

- In the source category Fugitive emissions from fuels (CRF 1.B), the uncertainties for the activity data for oil and natural gas (CRF 1.B.2) are low, as a result of the fuels' being subject to taxation. Flaring of natural gas represents the only exception. The activity data for Coal mining (CRF 1.B.1) are also well-represented by production volumes. By contrast, the uncertainties for emission factors for fugitive emissions are likely to be higher. On the one hand, this results from the many different technical factors that affect fugitive emissions in transport, storage and processing of oil and natural gas. On the other hand, fugitive CH_4 emissions from coal mining have thus far been taken into account only as lump sums.
- Considerable uncertainties are seen in many areas in the category of industrial processes (CRF 2). Activity rates based on production figures that must be reported to the Federal Statistical Office can be subject to uncertainties, especially as a result of discrepancies between reporting structures and relevant industry definitions. Activity rates determined from association information are subject to uncertainties that correlate, in each case, with the degree to which the relevant industrial sector is represented in the association in question. For emission factors, uncertainties – which can be considerable, depending on the greenhouse gas in question – result, understandably, from the factors' strong dependence on technology, in combination with extensive technological diversification. Furthermore, equipment-specific emission factors often are tied to business secrets, particularly in sectors with few market players (for example, manufacturing of chemical products (CRF 2.B)), and this tends to make operators hesitant to publish such data or leads them to provide information in consolidated form. In addition, uncertainties can be higher for complex processes in which non-combustion-related activities generate emissions, if relevant emissions-generating processes are inadequately understood and the relevant contributions of pertinent individual activities are not known.
- In the area of production of alcoholic beverages, within the area of Food and drink production (CRF 2.D.2), the activity-rate uncertainties must be considered very small, since production of such beverages is subject to taxation regulations that require very precise determination of production volumes. On the other hand, statistics for sectors with large numbers of small and medium-sized enterprises (such as baked-goods production) tend to be significantly less precise, and thus the activity data for such sectors are subject to higher uncertainties. The uncertainties for the relevant emission factors are also larger, due to the sectors' extensive technological diversification.
- The uncertainties for emissions parameters for the source categories Managed waste disposal in landfills (CRF 6.A.1, 6.D) and Industrial wastewater treatment (CRF 6.B.1) are presumed to be high. This applies especially to the areas of composting, MBT and waste landfilling, which have high waste-type diversity that tends to reduce the reliability of data for the relevant emissions parameters. The reasons for the higher uncertainties seen for activity data include the fact that the underlying statistical data make use of non-standardised waste and recycling definitions. The general assumptions relative to the uncertainties of activity data also apply to thermal treatment of waste.

Pursuant to Tier 1, the inventory's total uncertainty figures for 2011 are 6.3 % (level) and 6.5 % (trend).

Nitrous oxide emissions overall account for a major share of total uncertainty, and that share is defined noticeably by nitrous oxide from agricultural soils (4.D).

The CO_2 emissions of the sector Combustion of fuels (1.A) contribute another important share of the total uncertainty. The predominating components of that share include solid fuels in the sector Public electricity and heat production (1.A.1.a) and mobile sources (1.A.3), especially road transports (1.A.3.b) and combustion in the residential, commercial and institutional sectors (1.A.4.a/b).

Significant contributions to the total uncertainty have also come from the areas of a) CO_2 sinks and sources of the LULUCF sector and b) methane emissions from waste storage (6.A) and from animal husbandry (enteric fermentation, 4.A).

Detailed information about the applicable uncertainties is provided in Annex 7 (cf. Chapter 22).

1.7.2 KP LULUCF inventory

Since the same data and methods are used, under both UNFCCC and KP, for reporting for source categories 5.A-5.F, the uncertainties for the two reporting areas are comparable. The information provided in the previous chapter and in the relevant source category chapters (cf. Chapters 11.3.1.5 and 7.2.5) applies.

1.8 General review of completeness

1.8.1 Greenhouse-gas inventory

Completeness information for the various individual source categories is presented in CRF Tables 9(a) und 9(b), which, in turn, are summarised in NIR Chapter 21 (Table 377 and Table 378). The following are differentiated in Germany:

- Source-specific emissions and sinks that do not occur (NO – not occurring),
- Source-specific emissions and sinks that are not estimated in Germany, either because they are not quantitatively relevant or because the necessary data for estimates are lacking (NE – not estimated), and
- Source-specific emissions and sinks that are completely accounted for, pursuant to the latest scientific findings, for Germany (All or Full), or that are partly accounted for (Part).

The following section touches on a few source-category-specific approaches for improving the completeness of the inventory.

All combustion-related activities (1 A) from the area of energy are recorded in full. At certain points, the Energy Balance of the Federal Republic of Germany is supplemented if it is evident that complete coverage is not achieved in selected sub-sections (such as the non-commercial use of wood, secondary fuels). In some source categories, separation of combustion-related and non-combustion-related emissions from industry requires further verification. In general, avoidance of duplicate counting is an important part of quality assurance for such categories, however.

In the area of industrial processes, some use is made of production data from association statistics and of manufacturers' information. In the interest of the inventory's completeness and reliability, where emissions reporting is based on such sources, checking of source-category definitions and data-collection methods will continue to receive priority.

The "Not Estimated" (NE) emissions, which are still reported, consist primarily of non-calculated emissions that, pursuant to IPCC GPG (2003, p.1.11), do not have to be calculated by a reporting country, since those emissions are listed in Appendices 3a.2, 3a.3 and 3a.4..

Some of the emissions data available to the Federal Environment Agency are confidential, due to data-protection requirements, and thus are reported only in aggregated form – although they are reported completely.

An agreement covering provision of data to the Single National Entity by the German Emissions Trading Authority (DEHSt) has been concluded in order to assure the regular exchange of data.

1.8.2 KP LULUCF inventory

Since, for reporting for source categories 5.A-5.F, the data and methods used for reporting under UNFCCC do not differ from those used for reporting under KP, the information provided in the previous chapter applies.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

Table 12 below shows the total emissions, as determined for this inventory, of direct and indirect greenhouse gases and of the acid precursor SO_2. The reference figure defined, in keeping with results of review of the initial report carried out in 2007[16] and of reporting in 2006 pursuant to Article 8 of the Kyoto Protocol – and independently of any further possible improvements in the basic data – for reduction obligations under the Kyoto Protocol is 1,232,429.543 Gg CO_2 equivalent. Pursuant to its obligations under the Kyoto Protocol and EU burden sharing (Council Decision 2002/358/EC), Germany's reduction obligations amount to 21 %. Table 13 shows the annual progress achieved, with respect to 1990, for each pertinent year. With the exception of HFCs, significant reductions in emissions have been achieved for all the emissions calculated here. In total, greenhouse-gas emissions, calculated as CO_2 equivalents, decreased by 25.6 % compared to the aforementioned reference figure.

[16] "Report of the review of the initial report of Germany", FCCC/IRR/2007/DEU, of 12 December 2007 published at: http://unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php

Table 12: Emissions of direct and indirect greenhouse gases and SO_2 in Germany since 1990

Emissions development (Gg)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Net CO_2 emissions / removals	1,005,890	895,151	856,337	871,823	877,524	854,680	853,256	791,974	834,511	807,118
CO_2 emissions (not including LULUCF)	1,041,914	930,781	891,400	864,716	870,739	847,397	845,761	783,734	826,063	798,058
CH_4	5,236	4,411	3,576	2,833	2,709	2,582	2,553	2,453	2,399	2,326
N_2O	280	257	199	197	195	200	205	205	177	184
HFCs (CO_2 equiv.)	4,592	7,012	7,623	8,640	8,708	8,742	8,843	9,443	8,963	9,177
PFCs (CO_2 equiv.)	2,627	1,780	792	695	550	484	472	338	285	230
SF_6 (CO_2 equiv.)	4,642	6,779	4,269	3,480	3,398	3,334	3,115	3,065	3,194	3,316
CO	12,402	6,599	4,854	3,695	3,616	3,516	3,433	3,051	3,495	3,304
NMVOC	3,131	1,808	1,394	1,146	1,134	1,071	1,016	929	1,055	1,006
NO_X	2,877	2,175	1,925	1,574	1,559	1,481	1,404	1,305	1,329	1,288
SO_2	5,292	1,718	653	477	487	469	469	419	444	445

Table 13: Changes in emissions of direct and indirect greenhouse gases and SO_2 in Germany, since the relevant reference years

Emissions change with respect to the reference year / previous year (%)	Reference year	Reference year through 2010	Reference year through 2011	With regard to the previous year (2010 – 2011)
Net CO_2 emissions / removals	*1990*	-17	-19.8	-3.3
CO_2 emissions (not including LULUCF)	*1990*	-20.7	-23.4	-3.4
CH_4	*1990*	-54.2	-55.6	-3.1
N_2O	*1990*	-36.8	-34.2	+4.1
HFCs (CO_2 equivalent)	*1995*	+27.8	+30.9	+2.4
PFCs (CO_2 equivalent)	*1995*	-84.0	-87.1	-19.5
SF_6 (CO_2 equivalent)	*1995*	-52.9	-51.1	+3.8
Total emissions with respect to EU burden-sharing[17]	***Defined base year***	**-23.4**	**-25.6**	**-2.9**
CO	*1990*	-71.8	-73.4	-5.5
NMVOC	*1990*	-66.3	-67.9	-4.6
NO_X	*1990*	-53.8	-55.2	-3.0
SO_2	*1990*	-91.6	-91.6	+0.1

All detailed tables relative to discussion of trends are presented in Annex Chapter 22.3.

Trends, taking account of changes with respect to the previous year of the report period

With regard to the previous year, 2010, total emissions decreased by 2.9 %. This resulted from a decrease in CO_2 emissions and slight decreases in releases of methane; emissions of nitrous oxide and F gases (overall) increased slightly.

2.1 Description and interpretation of trends in aggregated greenhouse-gas emissions

Through 2011, Germany continued to fulfill its obligation to reduce greenhouse-gas emissions, in the framework of EU burden-sharing, with its total reduction reaching 25.6 % in that year. The individual greenhouse gases contributed to this development to varying degrees (cf. Table 1). Among the direct greenhouse gases, emissions of those gases that predominate in terms of quantity were markedly reduced, with the strongest reductions

[17] Established base-year emissions of 1,232,430 Gg CO_2 equivalent, not including CO_2 from LULUCF. Cf. Chapter 0.2

occurring for methane. The main reasons for these developments are found in the following areas:

- Transition from use of solid fuels to use of liquid and gaseous fuels, which have lower emissions, in the period since 1990;
- Growing use of renewable energies, and growing, related, use of substitutes for fossil fuels;
- Increased plant (installation) efficiencies;
- Changes in animal-housing methods, and reductions of livestock populations;
- Fulfillment of legal regulations in the waste-management sector;

Such areas are considered in greater detail in the discussion below of trends for the various individual greenhouse gases. The global economic crisis, which had its first impact in Germany at the end of 2008, had a significant effect on emissions, as did the partial economic recovery that occurred in 2010 and the renewed economic slowdown of 2011.

Releases of carbon dioxide – the great majority of which are caused by stationary and mobile combustion processes – predominate in the overall picture of greenhouse-gas emissions. Due to a disproportionately large decrease in emissions of the other greenhouse gases, the proportion of total greenhouse gases attributable to CO_2 emissions has increased since 1990 (cf. Table 2). All other greenhouse gases together account for only slightly more than one-tenth of greenhouse-gas emissions. Germany's range of greenhouse-gas emissions is typical for a highly industrialised country.

2.2 Description and interpretation of emission trends, by greenhouse gases

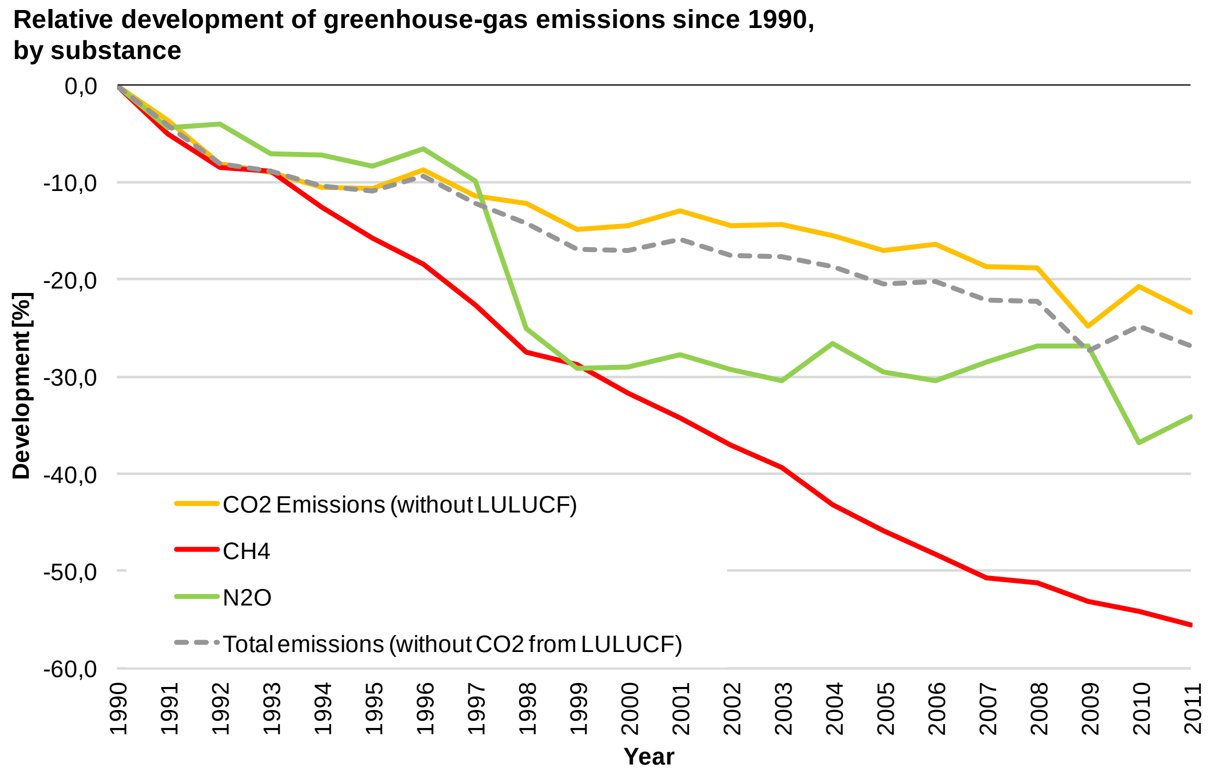


Figure 16: Relative development of greenhouse gases in comparison to their levels in 1990

Figure 16 shows the relative development of emissions of the various greenhouse gases since 1990. In the discussion, it must be remembered that the development of each of these greenhouse gases as shown here is largely dominated by specific developments in a single source category.

2.2.1 Carbon dioxide (CO_2)

The reduction in CO_2 emissions is closely linked to trends in the energy sector. The sharp emissions reduction in this area seen in the early 1990s was primarily the result of restructuring in the new German Länder, including related conversions to cleaner fuels and decommissioning of obsolete facilities. The changes in the fuel mix have continued, to a somewhat lesser degree, through the current report year.

Use of gases, primarily natural gas, as substitutes for solid and liquid fuels is also reflected in emissions trends for stationary combustion systems. While CO_2 emissions from liquid fuels decreased by about one-fourth, with respect to their levels in 1990, and emissions from solid fuels decreased by almost half, emissions from gaseous fuels increased by nearly fifty percent.

When these emissions trends are viewed at the level of individual source categories, a highly consistent picture emerges. In comparison to 1990 levels, emissions in all source categories of energy-related emissions decreased by a total of nearly 236 million t CO_2.

Comparable, but specific (when seen at the detailed level), developments took place in the transport sector. CO_2 emissions increased slightly from 1990 to 1999. Since then, they have fallen significantly below their outset level, to just under 156 million t, as a result of: decreases in consumption; consumers' shifting of fuel purchases to other countries; substitution of diesel fuel for petrol; and increasing use of biodiesel. Diesel fuel's share of total fuel consumption in road transports has increased sharply throughout the entire period in question. In 1990, nearly 2/3 of all road-traffic emissions were still being caused by petrol consumption. Now, the relationship is nearly reversed, and diesel emissions predominate.

Trends, taking account of changes with respect to the previous year of the report period

With respect to the previous year, total emissions decreased especially as a result of strong weather-related decreases in the residential (-22.4%) and commercial and institutional (-10.7%) sectors. Changes in all other sectors remained largely within the normal annual fluctuation ranges.

As a result of weather factors, emissions in the residential sector decreased considerably with respect to the previous year.

2.2.2 Nitrous oxide N_2O

Since 1990, N_2O emissions have decreased by about 34.2 %. The main emissions areas/sources include agriculture – use of nitrogen-containing fertilisers, and animal husbandry; the chemical industry; and use of fossil fuels. Smaller amounts of emissions are caused by wastewater treatment and product use of N_2O (for example, as an anaesthetic). Industry has had the greatest influence on emissions reductions, especially in the area of adipic acid production in 1997 and 2009. Via technological reduction measures, the chemical industry's emissions have been reduced by about 80%, with respect to 1990. Since 1999, emissions trends have been strongly influenced by economic trends in the chemical industry sector. From 2009 to 2010, emissions from adipic acid production decreased drastically as a result of one producer's installation of a second redundant waste-gas-treatment system.

Trends, taking account of changes with respect to the previous year of the report period

With respect to the previous year, total emissions increased, led by considerably higher emissions from the agricultural sector (+5.8%). Emissions trends varied widely from sector to sector, however, as a result of economic factors. In the chemical industry and residential sectors, and in the source category "solvent and other product use", nitrous oxide emissions decreased considerably. In the road transport sector, they increased markedly, however.

2.2.3 Methane (CH_4)

Methane emissions are caused mainly by animal husbandry in agriculture, waste landfilling and distribution of liquid and gaseous fuels; energy-related and process-related emissions, and emissions from wastewater treatment, play an almost negligible role. Methane emissions have been reduced by 55.6 % since 1990. This trend has been primarily the result of environmental-policy measures (waste separation, with intensified recycling and increasing energy recovery from waste) that has decreased landfilling of organic waste. A second important factor is that use of pit gas from coal mining, for energy recovery, has increased, while overall production of such gas has decreased (via closure of hard-coal mines). Emissions in this area have decreased by nearly 80 % since 1990. Yet another reason for the emissions reductions is that livestock populations in the new Federal Länder have been reduced, with reductions occurring especially in the first half of the 1990s. Repairs and modernisations of outdated gas-distribution networks in that part of Germany, along with improvements in fuel distribution, have brought about further reductions of total emissions.

Trends, taking account of changes with respect to the previous year of the report period

In comparison to the previous year, emissions decreased by 3.1 %. That development is due primarily to further reductions of landfill emissions.

2.2.4 F gases

Figure 17 shows emissions trends for so-called "F" gases for the period 1995-2011. HFC emissions increased primarily as a result of intensified use of HFCs as refrigerants in refrigeration systems and of increasing disposal of pertinent systems. This more than offset emissions reductions resulting from their reduced use in PUR installation foams. The emissions reductions for PFCs were achieved primarily through efforts of primary aluminium producers and semiconductor manufacturers. The SF_6 emissions reduction until 2003 is due primarily to decreasing use of the gas in automobile tyres since the mid-1990s. In this area, efforts to increase environmental awareness have been successful, resulting in emissions reductions of over 100 t and greenhouse-gas reductions of 2.5 million t of CO_2 equivalents. Similar success has been achieved with soundproof windows, for which production use of SF_6 has been reduced to nearly zero since 1995. The majority of current and future emissions of this substance (will) result from open disposal of old windows. Emissions from electricity-transmission facilities have also decreased considerably. Important new emissions sources include welding, production of solar cells and production of optical glass fibre. SF_6

emissions have also decreased in recent years. At the same time, as indicated, increasing emissions must be expected in the next few years as a result of increasing disposal of old soundproof windows.

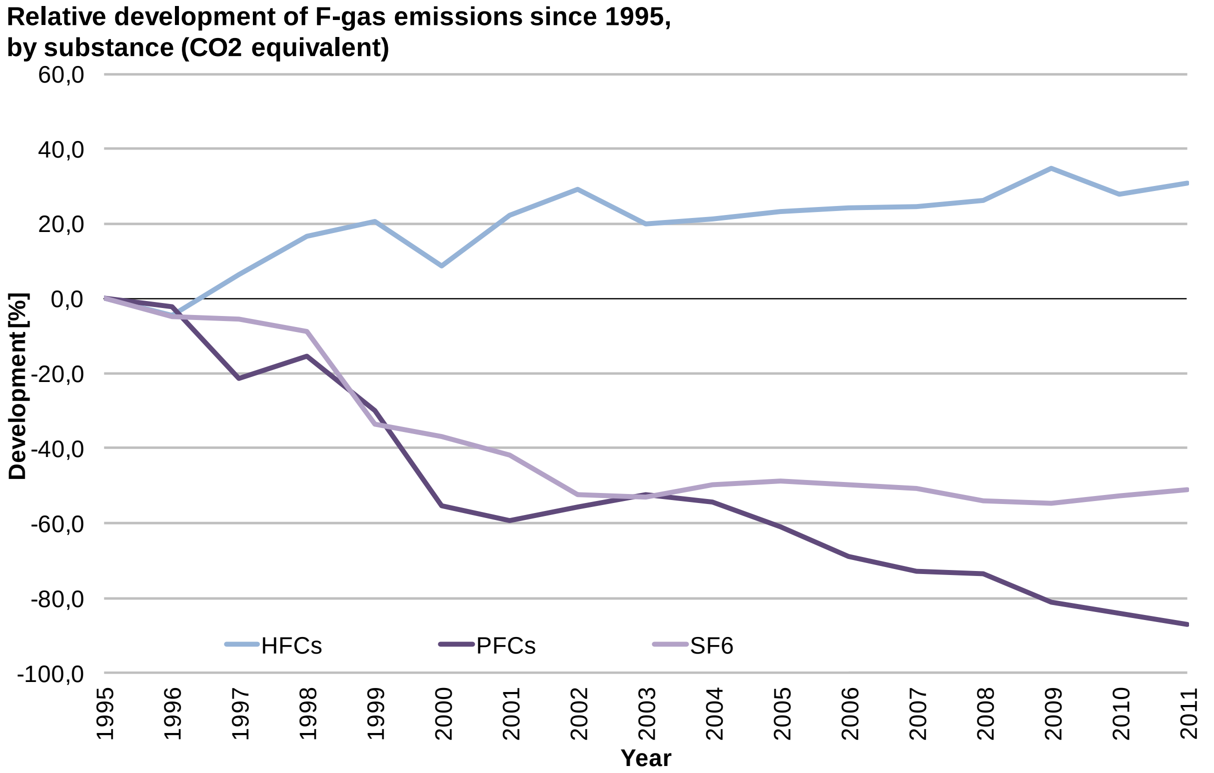


Figure 17: Relative development of F gases in comparison to relevant 1995 levels

2.3 Description and interpretation of emissions trends, by source categories

Energy

In the category of energy-sector emissions, which have been decreasing, combustion-related emissions are governed primarily by CO_2 emissions from stationary and mobile combustion systems (cf. also the results of the key-category analysis). On the other hand, emissions of other greenhouse gases are negligible in this sector. The situation is different solely for emissions that are not combustion-related (source category 1.B.). In this area, CO_2 emissions are very low, while emissions trends are clearly shaped by CH_4 emissions caused by distribution of liquid and gaseous fuels. On the whole, energy-related emissions of all greenhouse gases have decreased by 25.6 % since 1990. The transport-related emissions included in greenhouse-gas emissions have decreased by slightly more than 4.5 % during the same period, meaning they have decreased somewhat less than emissions from stationary combustion systems have. For combustion-related emissions, this has been achieved through fuel changeovers and higher energy and technical efficiencies, as well as through increasing use of zero-emissions energy sources. For distribution emissions, it has resulted from increased use of pit gas, modernisation of gas-distribution networks and introduction of vapour-recovery systems in fuel distribution.

Table 385 in the Annex shows the relevant emissions changes, in comparison to the previous year in each case, for the period since 1990. For CO_2 from the energy sector, for example, it is clear that largely temperature-related fluctuations over time – especially variations in winter temperatures – influence heating patterns. Such fluctuations thus affect energy consumption for space heating, thereby having a major impact on annual trends in energy-related emissions.

Industrial processes

In the area of emissions from industrial processes, carbon dioxide and nitrous oxide are the predominant greenhouse gases. Relatively noticeable changes in emissions of F gases, on the other hand, have no major impacts on overall trends, because such emissions account for only a small share of total emissions. Methane emissions also play an insignficant role in this context.

Emissions from industrial processes are closely tied to production levels. CO_2 emissions trends, in particular, reflect economic trends in the mineral, chemical and metal-producing industries.

The trend for N_2O emissions has been decoupled from production ever since adipic acid producers' emissions-reducing measures began taking effect. From 2009 to 2010, emissions from adipic acid production decreased drastically as a result of one important producer's installation of a second redundant waste-gas-treatment system. Overall since 1990, N_2O emissions have decreased to about one-sixth of their outset level.

Since 1990, emissions for the totality of all industrial processes and greenhouse gases, in GG equivalents, have been reduced by about 26.4 %. In comparison to the previous year, a slight increase of 0.9 % has occurred. With respect to the previous year, emissions increased slightly in 2011, as a result of higher emissions in the mineral industries, although the increases in that sector were largely offset by slight decreases in the metal-producing sectors.

Solvent and other product use

Since 1990, emissions in the area of solvent and product use have decreased by nearly 60.0 %. Among the emissions tallied in the present context, indirect CO_2 emissions from use of solvents (NMVOC) predominate (those emissions accounted for a share of about 2/3). Emissions from use of N_2O as an anaesthetic have decreased by nearly half since 1990.

Agriculture

The decrease in agricultural emissions since 1990, amounting to over 20.0 %, is due primarily to reductions in livestock populations, although it is also due to reductions in emissions from agricultural soils and from fertiliser use.

Land use, land-use changes and forestry

The reduction in greenhouse-gas removals via land-use changes and forestry is due primarily to a reduction of the sink function in the category "Forest Land remaining Forest Land". The decrease in forests' function as a sink is due to increasing harvesting of wood for various uses.

Waste and wastewater

The most significant emissions reduction, at 66.7 %, occurred in the area of waste emissions. In that area, intensified recycling of recyclable materials ("yellow sack" for recyclable materials, Ordinance on Packaging, etc.), and the ban, in effect since June 2005, on landfilling of biodegradable waste, have reduced annual quantities of landfilled waste. All in all, these factors have reduced landfill emissions by over 71 %. Emissions from wastewater treatment, which also belong to this source category, are produced in considerably lower quantities than landfill emissions are. Nonetheless, they also decreased sharply.

Table 14: Changes in greenhouse-gas emissions in Germany, by source categories, since 1990 / since the relevant previous year

Emissions change with respect to 1990; change in %	**1990**	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
1. Energy	0.0	-11.6	-16.1	-19.2	-18.8	-21.1	-21.1	-26.3	-22.7	-25.5
2. Industrial processes	0.0	2.8	-17.8	-16.4	-15.5	-13.3	-16.3	-23.4	-27.1	-26.4
3. Solvent and other product use	0.0	-20.6	-35.0	-54.2	-53.7	-56.5	-59.5	-63.7	-57.9	-59.9
4. Agriculture	0.0	-13.8	-13.6	-18.8	-20.5	-21.8	-18.6	-20.9	-22.3	-20.0
5. Land use, land-use changes & forestry										
CO2 (net sink)										
N2O & CH4	*0.0*	*-2.1*	*-1.6*	*-0.4*	*0.1*	*-0.9*	*-0.5*	*1.7*	*2.6*	*3.3*
6. Waste	0.0	-7.6	-35.3	-50.5	-53.8	-56.9	-59.7	-62.2	-64.5	-66.7

Emissions change, in each case with respect to the previous year; change in %	**1990**	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
1. Energy	0.0	-0.5	-0.2	-1.9	0.6	-2.9	0.0	-6.7	5.0	-3.6
2. Industrial processes	0.0	-1.9	3.6	-4.0	1.0	2.7	-3.4	-8.5	-4.8	0.9
3. Solvent and other product use	0.0	0.2	-8.1	-6.5	1.1	-6.0	-7.0	-10.3	15.8	-4.7
4. Agriculture	0.0	2.9	-0.2	-1.4	-2.1	-1.6	4.2	-2.8	-1.8	2.9
5. Land use, land-use changes & forestry										
CO2 (net sink)										
N2O & CH4	*0.0*	*-1.3*	*0.6*	*0.2*	*0.5*	*-1.0*	*0.4*	*2.2*	*0.9*	*0.7*
6. Waste	0.0	-3.6	-4.5	-6.7	-6.6	-6.8	-6.5	-6.1	-6.1	-6.3

Figures do not include CO_2 from LULUCF

The relevant detailed data are presented in Table 386 in Annex Chapter 22.3.

2.4 Description and interpretation of trends in emissions of indirect greenhouse gases and of SO_2

The relative development of emissions of indirect greenhouse gases and SO_2 are graphically depicted, in each case as time series since 1990, in Figure 18 and in Table 13. Over this period, considerable reductions of emissions of these pollutants have been achieved. For example, emissions of SO_2 have been reduced by over 91 %, those of CO by over 73 %, those of NMVOCs by about 68 % and those of NO_X by about 55 %.

The vast majority of emissions of sulphur dioxide, nitrogen oxide and carbon monoxide are caused by stationary and mobile combustion processes. In the category of NMVOC emissions, however, solvent use is the most important emissions factor.

A range of different factors are responsible for this trend. These factors, which differ in the significance and extent of their relevance, include:

- As a result of Germany's reunification in 1990, emissions from the territory of the former GDR in particular made the starting level relatively high.
- In the years that followed, obsolete industrial facilities in the eastern part of Germany were decommissioned. They were replaced, in the great majority of cases, with state-of-the-art new facilities. Non-decommissioned old installations were extensively retrofitted with emissions-reduction and efficiency-enhancing equipment.
- In addition, fuel mixes were changed – in eastern Germany in particular, local-lignite fractions were reduced in favour of energy carriers such as natural gas and petroleum, which produce fewer emissions.
- In the traffic sector, newer vehicles equipped with pollutant-reducing technology were introduced.
- In the years since 1990, the immission-protection provisions of the former Federal Republic of Germany have become legally binding for eastern Germany. Following the expiration of provisional rulings, applicable laws have been repeatedly adapted in keeping with technological progress.
- Established legal regulations and market-economic incentives have led to thriftier use of energy and raw materials.
- International legislation, particularly from the European Community, has had an emissions-reducing effect (e.g. the NEC Directive).
- Increasing use of zero-emissions energy sources (electricity/heat from solar and wind systems, and from geothermal systems) has also had an impact on emissions of indirect greenhouse gases, especially in recent years.

Descriptions of the emission calculations for these pollutants, along with additional, detailed parameters influencing the emissions trends for the various individual air pollutants involved, are provided by the Web site of the Federal Environment Agency[18].

[18] http://www.umweltbundesamt.de/emissionen/index.htm and directly in the Informative Inventory Report (IIR): http://iir-de.wikidot.com/

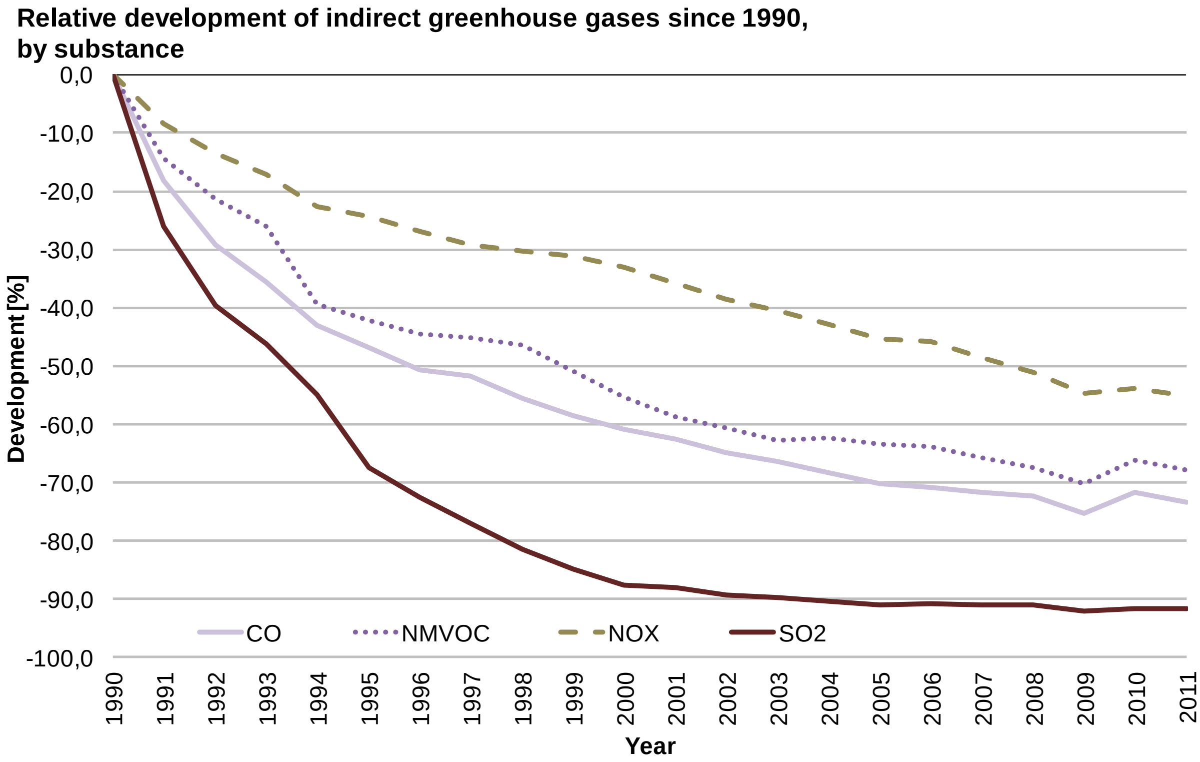


Figure 18: Emissions trends for indirect greenhouse gases and SO_2

2.5 Description and interpretation of emissions trends with regard to the KP-LULUCF inventory, for aggregated emissions and by activity and greenhouse gas

Germany reports under KP-LULUCF Article 3 (3), and it reports in the area of forest management with regard to the selected additional activities pursuant to Article 3 (4) Kyoto Protocol. It reports emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide.

Under Article 3.3, it is reporting removals of -5,633.58 Gg CO_2 equivalent for the year 2011. The removals consist of 5,772.26 Gg CO_2 equivalent of CO_2 removals via afforestation and reforestation and 138.68 Gg CO_2 equivalent of emissions from deforestation. In the deforestation category, emissions of 138.64 Gg CO_2, and of 0.04 Gg CO_2 equivalent of N_2O, are being reported.

Under Article 3.4, it is reporting removals of -27,681.89 Gg CO_2 equivalent. The removals are composed of CO_2 removals via afforestation and reforestation, amounting to -30,301.83 Gg CO_2 equivalent, and emissions of 2,619.94 Gg CO_2 equivalent. Under Article 3.4, it is also reporting CO_2 removals of -27,748.47 Gg CO_2, N_2O emissions of 65.27 Gg CO_2 equivalent and CH_4 emissions of 1.33 Gg CO_2 equivalent.

Table 15: Emissions in 2010 and 2011 for the KP-LULUCF activities afforestation and deforestation, pursuant to Article 3.3, and for forest management, pursuant to Article 3.4.

Source category	Emissions, 2010 [Gg CO_2 equivalent]	Emissions, 2011 [Gg CO_2 equivalent]
KP 3.3 Afforestation/Reforestation	-5,699.817	-5,772.264
KP 3.3 Deforestation	111.611	138.683
KP 3.4 Forest Management	-27,697.207	-27,681.889

On afforestation areas, a removals increase of -72.45 Gg CO_2 equivalent was determined for the period from 2009 to 2010. In the deforestation category, a slight emissions increase of 27.07 Gg CO_2 equivalent was seen. On the other hand, removals in connection with forest management decreased slightly from 2010 to 2011. The decrease amounts to 15.32 Gg CO_2 equivalent (cf. Table 15).

3 ENERGY (CRF SECTOR 1)

3.1 Overview (CRF Sector 1)

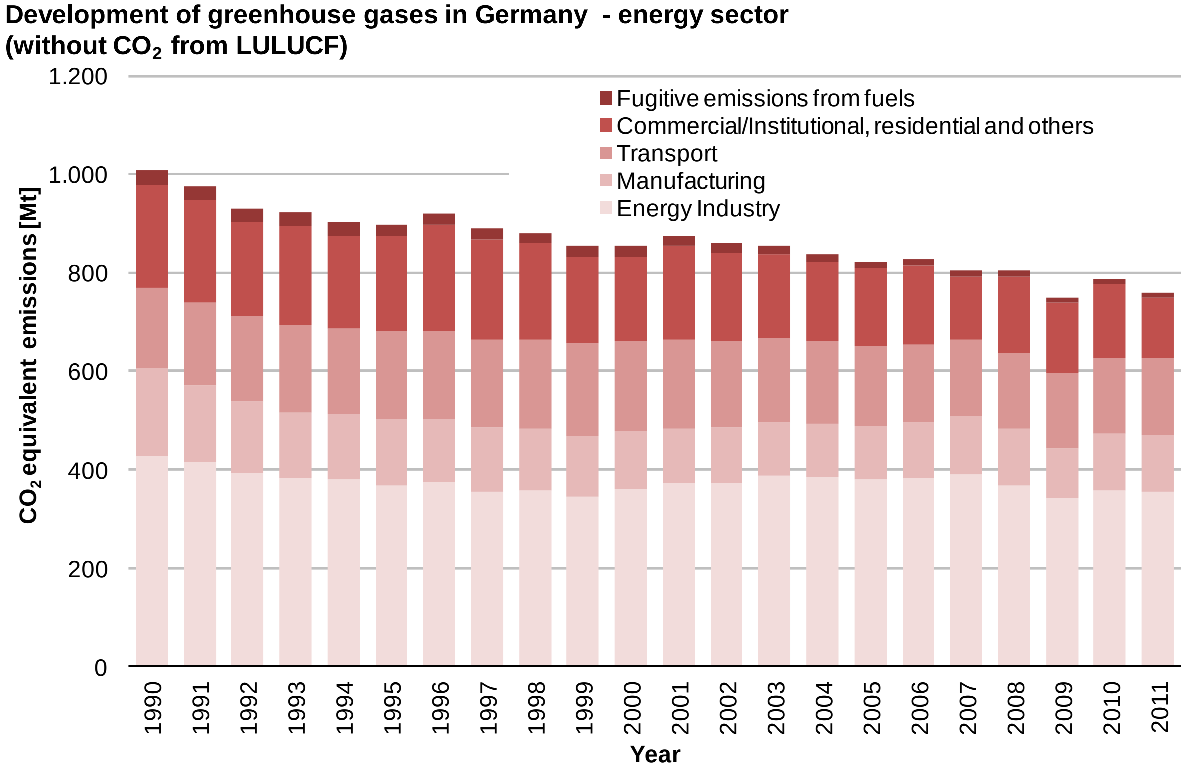


Figure 19: Overview of greenhouse-gas emissions in CRF Sector 1

For determination of activity data from combustion, different models are used for mobile and stationary sources. The model used for stationary sources is the "Balance of Emissions Causes" ("Bilanz der Emissionsursachen" – BEU), while the model used for mobile sources is the "Transport Emission Estimation Model" (TREMOD). In both models, combustion-related activities are determined and then recorded in the "Central System of Emissions" (CSE) emissions database.

Within the CSE, relevant emissions are then calculated by multiplying these combustion-related activities by the pertinent emission factors (as taken from the list of CO_2-emission factors in the National Allocation Plan). In the process, complete oxidation of the carbon contained in the fuels is assumed.

3.2 Combustion of fuels (1.A)

The activity data for stationary combustion are calculated in the "Balance of Emissions Causes" (BEU) model. The database for this model, which was developed by the Federal Environment Agency, consists of the Energy Balance of the Federal Republic of Germany. The Energy Balance is described in detail in Chapters 18.1 through 18.4.

With the help of additional statistics, and of various assumptions, these data are then further disaggregated and supplemented for the relevant energy-transformation and final-consumption sectors. Relevant criteria for this work include permits under immissions-control laws, technologies and differentiation between certain fuels. The model consists of two parts:

a sub-model for the old German Länder, covering the years 1987-1994, and a sub-model for all of Germany, covering the years as of 1995. The model for all of Germany has been revised and, in the reports of two research projects (FKZ 203 41 142: ÖKOINSTITUT, 2005 and 204 41 132: ÖKOINSTITUT / DIW, 2007) comprehensively documented. Since 2009, relevant calculations have been carried out with the help of a database-supported system of the BEU that is based on MESAP software and that was developed in the framework of the research projects FKZ 204 42 203/03 and FKZ 360 16 010 (GICON, 2008), via an approach similar to that used for the sub-model for Germany. Data for the new German Länder, for the period 1990-1994, have already been entered into the CSE. The manner in which those data were obtained is described in detail in Chapter 19.1.1.

The following Energy Balance lines are used for determination of emissions-relevant fuel inputs from stationary sources:

A: Transformation inputs (Energy Balance lines 9 through 19)

1. **Public thermal power stations** (line 11) are plants whose operators are sited within the public utlity sector. This category also includes industrial plants which operate their power stations together with electricity utility companies, as joint-venture power stations. The fuel input for electricity generation is reported here. This line of the Energy Balance also includes the fuel input in public thermal power stations attributable to electricity production.
2. **Industrial thermal power stations** (line 12) comprise the following operator groups:
   - Power stations in the hard-coal-mining sector,
   - Power stations in the lignite-mining sector,
   - Power stations in the petroleum-processing sector (refinery power stations),
   - Power stations that generate single-phase power for Deutsche Bahn AG (German Railways) (until 1999, the relevant input amounts for Deutsche Bahn power stations were reported under 1A2f (EB line 12); as of 2000, they have been reported together with public power stations under 1A1a (EB line 11)),
   - Industrial power stations (quarrying, other mining, manufacturing industry).
3. **Hydroelectric, wind-power, photovoltaic systems and other similar systems** (line 14) comprises all systems/plants that generate electricity from biogas, landfill gas, sewage-treatment gas or solid or liquid biomass and feed the electricity into the public grid. Since no cut-off limit applies for such systems, this category includes very small systems in the residential and commercial/institutional sectors.
4. **Thermal (CHP) power stations** (line 15): only the fuel input which can be allocated to district heat generation is given. Adding lines 11 and 15 together produces the total fuel input in public thermal power stations. The district heat generated is fed into the public heating grid. These stations also supply industrial customers with process heat.
5. **District heating stations** (line 16): here, the fuel input for the public district heat supply, from heating stations, is given. The facilities are often used to cover peak loads in district heating networks in which the basic load is met by thermal power stations.

B: Energy consumption in the transformation sector (Energy Balance lines 33 through 39)

6. Lines 33 to 39 and the total line 40 (**Energy consumption in the transformation sector**) include the fuel input for heat generation which is needed to operate the transformation stations. No distinction is made here with regard to the type of heat generation involved. This means that fuel inputs for heat generation in combined

heating and power stations, steam and hot water boilers and process firing installations are combined. There is an inconsistency in the Energy Balance with respect to summing-up for lignite pits and briquette plants. Since 1980, this own consumption has been listed together with production-related transformation inputs of briquette plants, in line 10. As a result, the emissions-causing inputs within own consumption can no longer be read out of the Energy Balance; they must be calculated from the transformation input. The fuel inputs used to generate heat in combined heat and power generation stations, together with fuel inputs used for electricity generation by the power stations of hard coal pits, lignite pits and refinery power stations, combine to form the total fuel input in such plants. Deduction, from the total listed in line 40, of fuel inputs for heat generation in power stations leaves the quantity of fuel used in process firing installations, steam and hot water boilers.

C: Final energy consumption (Energy Balance lines 46 through 67)

7. **Final energy consumption by industry** (line 60 of the Energy Balance) refers to the fuel used for heat generation which is required for both production purposes and space heating. Here as well, no distinction is made with regard to the type of heat generation involved. Hence, a part of the final energy consumption in these source categories, together with industrial power stations' fuel input for generating electricity, constitutes the total fuel input in such facilities.
8. The data on **Final energy consumption in the residential sector** (line 66 of the Energy Balance) comprise fuel inputs for heat generation and include the application areas of heating, water heating and cooking.
9. The data on **final energy consumption in the commercial/institutional sector and by other consumers** (line 67 of the Energy Balance) comprise fuel inputs used for hot water production, space heating and process-heat generation in this sector/area.

The Energy Balance data scheme is no longer able to accommodate all of the diverse requirements of national and international energy and emissions reporting. For example, the Energy Balance combines fuel inputs

- In facilities with different requirements under immission protection legislation (e.g. large furnaces, medium-sized furnaces, small furnaces, waste incineration plants);
- In plants that operate according to different technical principles (e.g. steam turbine power stations, gas turbine power stations, combustion-engine stations);
- That exhibit regional peculiarities (e.g. different individual mining regions have different qualities of crude lignite);
- With different source-category allocations in national and international emissions reporting;
- That are listed in different Energy Balance lines, in keeping with their intended purpose (for electricity or heat generation), but are used in a single facility group (e.g. steam turbine power stations).

These characteristics have impacts on emissions behaviour. In order to make allowance for the various differing requirements that thus arise, the Energy Balance data in the model *Balance of Emission Causes* (BEU) are disaggregated, using additional statistics as well as the Federal Environment Agency's own calculations. The following Figure 20 provides an overview of the relevant structure:

Balance of emission causes (BEU)
The source categories include: • Public thermal power stations, • Hard coal mining, • Lignite mining, • Deutsche Bahn AG (until 1999), • Petroleum oil refineries, • District heating stations, • Other energy transformation • Quarrying of non-metallic minerals, other mining and manufacturing industry (further sub-classification of process combustion), (The residential, commercial/institutional and other consumers sectors are listed and analysed directly within the CSE, outside of the BEU model.)
The types of facilities involved include: • Steam turbine power stations, • Gas turbine power stations, • Gas and steam turbine power stations, • Motor power stations, • Boiler furnaces (excluding power station boilers), • Process furnaces (sub-classified into 12 processes).
By fuels/energy sources: • About 40 different fuels
On the basis of immission protection legislation provisions, the following are differentiated: • Facilities under the 13th BImSchV, • Facilities under the 17th BImSchV, • Facilities under the 1st BImSchV, • Installations under the Technical Instructions on Air Quality Control (TA Luft)

Abbreviations:

BImSchV Ordinance on the Execution of the Federal Immission Control Act,

TA-Luft First General Administrative Provision on the Federal Immission Control Act (Clean Air Directive)

Figure 20: Characteristics of the Federal Environment Agency's structure of the Balance of Emissions Causes (BEU), for disaggregation of the Energy Balance

The BEU model is designed to provide a data structure that can be used in meeting a range of different reporting obligations. In particular, finer disaggregation has been needed for determination of emissions of "classical" air pollutants.

Despite the conversion of the Energy Balance to the classification of industrial sectors (WZ 93) and altered grouping of energy resources from the year 1995 onwards, it has been possible to fit the data within the outlined basic structure; this has facilitated preparation of consistent time series. As of 2008, the "WZ 2008" classification of industrial sectors has been used, in energy statistics, instead of the "WZ 2003" classification. Collection of activity data for process combustion, from individual statistics, is now being carried out and recorded in keeping with the key for this transition (STATISTISCHES BUNDESAMT (FEDERAL STATISTICAL OFFICE) 2008: "Umsteigeschlüssel WZ 2003 auf WZ 2008" (key for the change from WZ 2003 to WZ 2008))

The structure and the characteristics of the Balance of Emissions Causes (BEU) were presented and described in the 2011 National Inventory Report – in Figure 20 and in Tables 16 through 22 (in tabular form). Since there have been no structural changes in the BEU since then, here we simply refer to that source, which assigns the structural elements of the BEU to the database of the Central System of Emissions (CSE), via unique names.

With regard to determination of activity data from waste incineration and co-combustion of waste in combustion systems in the sectors Public electricity and heat generation (1.A.1) and Manufacturing (1.A.2), energy statistics and the Energy Balance have both showed considerably smaller waste quantities than have the waste statistics of the Federal Statistical Office (STATISTISCHES BUNDESAMT, FS 19 Reihe 1). With a view to recording all fuel quantities as completely as possible, the Federal Environment Agency (UBA), in the framework of a research project of its own, thoroughly evaluated fuel inputs in energy statistics and waste statistics. In that study, the waste quantities in the sectors Public energy generation (1.A.1.a), Mining (1.A.1.c) and Manufacturing (1.A.2) were compared in a breakdown by individual economic sectors. To enable comparison of the two sets of statistics, waste quantities from waste statistics were allocated to the same fuel groups used in energy statistics: solid biomass, other petroleum products, sewage sludge, household and settlement waste and industrial waste. Industrial waste and household waste were classified in keeping with the Ordinance on the European Waste Catalogue (AVV), with industrial waste including all waste with waste-classification numbers beginning with the numbers 01 through 19.

The result shows that in recent years the fuel quantities recorded in energy statistics have continually increased. The reasons for this include the fact that in recent years more and more solid biomass (primarily waste and scrap wood) and processed settlement waste have been used for energy generation. Overall, the relevant fuel quantities in energy statistics are still smaller, however, than those in waste statistics. In particular, the category public energy generation is not yet being completely covered by energy statistics. For that reason, the activity data for household/municipal and industrial waste are taken from the Energy Balance and then supplemented with the difference relative to waste statistics. In the Energy Balance, waste wood is listed as solid biomass, and not as waste. Consequently, to prevent double counting, in waste statistics it has to be deducted from the listed inputs for waste-incineration and combustion systems.

With regard to waste composition, as of the NIR 2006 the fossil and biogenic fractions of household / municipal waste are listed separately, in a ratio of 1:1. That split factor has been confirmed via a published research project, "Use of biogenic waste fractions for energy generation" ("Nutzung der Potenziale des biogenen Anteils im Abfall zur Energieerzeugung") (UBA, 2011; Förderkennzeichen (funding reference number) 3707 33 303). The existing assumptions relative to the biogenic fraction of sewage sludge have been retained. The biogenic fractions of industrial waste vary widely by industrial sector and installation type. Accordingly, for the sector Manufacturing (1.A.2), and for the sectoral classifications iron and steel, paper, cement and lime, detailed substitute-fuel data continue to be used that are provided by the associations German Iron and Steel Institute (VDEh), German Pulp and Paper Association (VDP), the German Lime Association (BV Kalk) and the German Cement Works Association (VDZ).

Figure 21 schematically shows all important sources of data on use of waste as fuel inputs for energy generation.

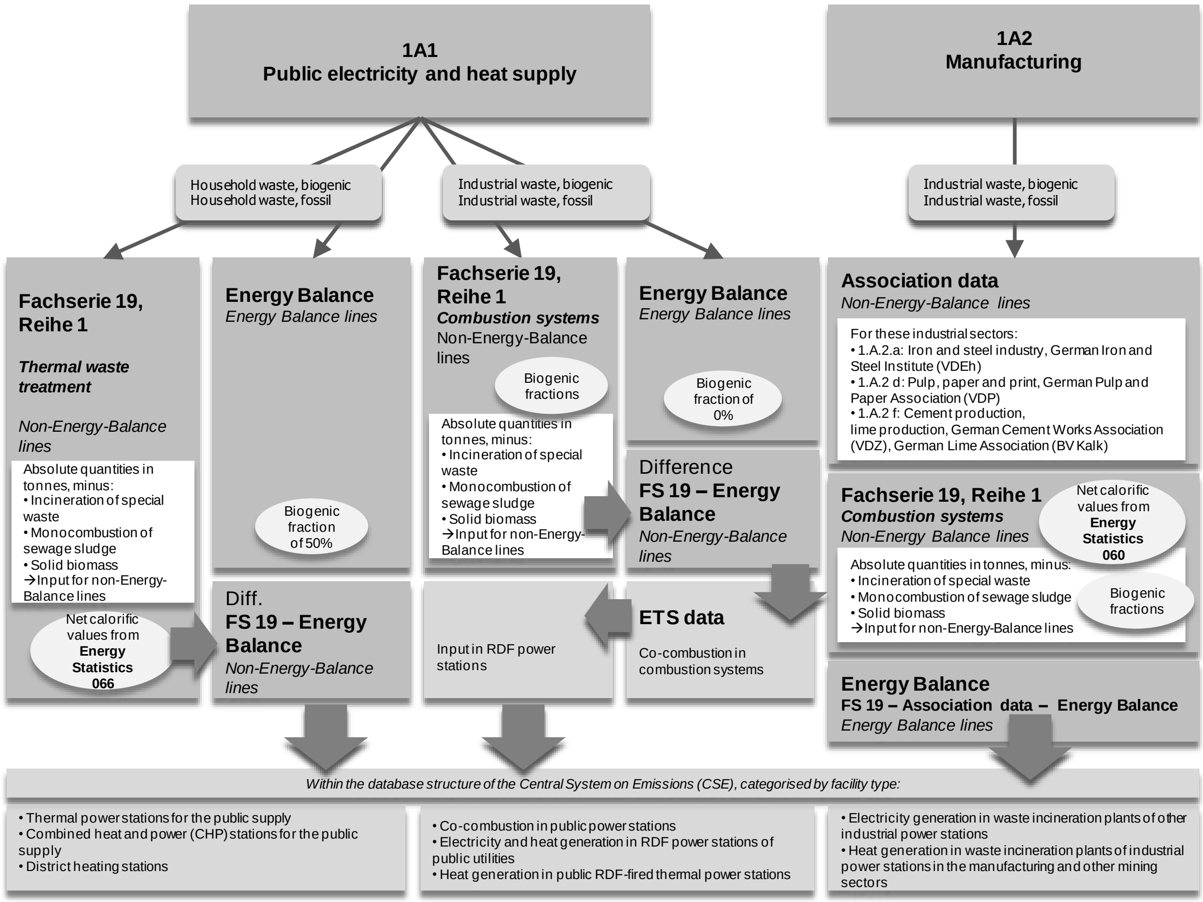


Figure 21: Sources of data, in the context of the inventory of greenhouse-gas emissions, on use of waste as fuel inputs for energy generation

3.2.1 Verification of the sectoral approach for CRF 1.A

3.2.1.1 Comparison with the CO_2 Reference Approach

Reporting on combustion-related CO_2 emissions is centrally important within the context of international climate protection, because such emissions account for such an important proportion of total emissions. To this end, industrialised countries routinely adopt the source-category-specific approach, which addresses the level of individual energy consumption sectors and therefore permits greater differentiation in analysis of emissions structures. To provide a simplified and comparative approach, the IPCC has developed the *Reference Approach*. The CO_2 emissions calculated via that approach, on the basis of primary energy consumption (domestic fuel inputs), have to be compared with the emission results obtained via the *Sectoral Approach*.

The Reference Approach was carried out for all years as of 1990. In each case, the basis for relevant calculations has consisted of the National Energy Balances on primary energy consumption, which have been published for years through 2010. For 2011, only a provisional Balance is currently available.

The results of the Reference Approach are compiled in Table 16. In Figure 22 and Figure 23, they are compared with other available data sets, such as data of the IEA and of individual German Länder. The average discrepancy between the results obtained with the *Reference Approach* and those obtained with the *Sectoral Approach*, for all years under consideration, is 0.4 %. The individual discrepancies vary throughout a range of - 1.2 % (2010) to +1.6 % (2003).

3.2.1.2 Verification with other data sets available for Germany

Below, for verification purposes, the results of the detailed source-category-based calculation of energy-related CO_2 emissions for Germany, carried out in accordance with the specifications of the *IPCC Good Practice Guidance* (2000), are compared with other available (for Germany) national and international data records on energy-related CO_2 emissions for the years 1990 to 2010. For 2011, these comparative data are not yet available.

In the comparison, the calculation results are compared with data:

- From the IEA (source-category-specific approach and Reference Approach)
- From the CO_2 calculations performed at Länder level.

Table 16 and Figure 22 compare the results of the approaches for calculating CO_2 emissions, throughout the different years involved. The key development trends emerge in all calculation approaches, including the Reference Approach, albeit at differing levels. In Figure 23, the relative discrepancies in the data records are depicted in order to illustrate these level differences.

Nevertheless, on the whole, these comparisons confirm the CO_2 emissions calculated for Germany. On an average for the years 1990 to 2009, the total national energy-related emissions calculated with the *Sectoral Approach* (cf. UBA (CRF 1.A)) differ as follows from the relevant comparative data sets:

- IEA (detailed Sectoral Approach): IEA (SA)) 0.1 %
- IEA (Reference Approach: IEA (RA)) 1.2 %
- National Reference Approach (UBA (RA)) 0.4 %
- Results of the Länder[19] 1.0%

[19] Difference with respect to UBA (CRF 1.A), incl. CO_2 from international air transports (CRF 1.C.1.a);

Table 16: Comparison of CO_2 inventories with other independent national and international results for CO_2 emissions

Results, difference	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
IEA statistics, SA (sectoral approach)	**949.7**	**924.8**	**886.5**	**879.9**	**868.5**	**867.8**	**896.5**	**865.8**	**858.9**	**826.9**
How IEA (SA) differs from UBA (CRF 1.A)	-2.9	-2.1	-1.3	-1.1	-0.3	-0.2	0.5	0.5	0.5	-0.2
IEA statistics, RA (reference approach)	**970.9**	**939.8**	**900.3**	**886.6**	**875.4**	**875.8**	**901.5**	**876.1**	**870.6**	**835.1**
How IEA RA differs from UBA (CRF 1.A)	-0.7	-0.5	0.2	-0.4	0.5	0.7	1.0	1.7	1.9	0.8
How IEA RA differs from UBA RA	-0.6	-0.4	0.1	-0.9	-0.1	1.0	0.9	1.3	1.4	0.2
Results of the Länder (energy)	**981.7**	**963.2**	**917.1**	**912.5**	**890.5**	**893.7**	**914.6**	**890.5**	**887.7**	**861.7**
How the Länder results (energy) differ from UBA	-0.8	0.7	0.6	1.0	0.5	1.0	0.7	1.4	1.8	1.7
Reference Approach UBA (RA)	**976.5**	**943.3**	**899.7**	**894.4**	**876.0**	**867.4**	**893.1**	**865.1**	**858.5**	**833.1**
How UBA RA differs from UBA (CRF 1.A)	-0.1	-0.1	0.2	0.5	0.6	-0.3	0.1	0.4	0.5	0.5
Sectoral approach UBA (CRF 1.A)	**977.7**	**944.4**	**898.3**	**889.8**	**871.1**	**869.9**	**892.4**	**861.3**	**854.5**	**828.5**
International air transports	*12.0*	*11.9*	*13.1*	*14.1*	*14.7*	*15.3*	*16.0*	*16.5*	*17.1*	*18.4*
Results, difference	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
IEA statistics, SA (sectoral approach)	**825.0**	**843.3**	**830.7**	**839.8**	**840.8**	**809.0**	**820.9**	**796.3**	**800.1**	**747.1**
How IEA (SA) differs from UBA (CRF 1.A)	-0.3	-0.8	-0.6	0.9	2.8	0.7	1.6	1.4	1.8	1.9
IEA statistics, RA (reference approach)	**841.8**	**870.3**	**844.4**	**846.8**	**842.6**	**818.8**	**819.8**	**802.0**	**800.6**	**751.3**
How IEA RA differs from UBA (CRF 1.A)	1.7	2.4	1.1	1.8	3.1	1.9	1.4	2.1	1.9	2.4
How IEA RA differs from UBA RA	1.1	1.9	0.3	0.2	1.6	0.6	-0.1	1.9	2.6	3.2
Results of the Länder (energy)	**863.1**	**887.6**	**864.5**	**859.6**	**847.4**	**835.7**	**841.6**	**818.7**	**824.6**	**772.0**
How the Länder results (energy) differ from UBA	1.9	2.2	1.2	1.0	1.0	1.1	1.1	1.0	1.6	1.8
Reference Approach UBA (RA)	**832.7**	**854.1**	**842.2**	**845.3**	**829.8**	**814.2**	**821.0**	**787.3**	**780.4**	**727.9**
How UBA RA differs from UBA (CRF 1.A)	0.6	0.5	0.8	1.6	1.5	1.4	1.6	0.2	-0.7	-0.8
Sectoral approach UBA (CRF 1.A)	**827.8**	**849.7**	**835.4**	**832.1**	**817.5**	**803.2**	**808.3**	**785.6**	**785.8**	**733.4**
International air transports	*19.5*	*19.1*	*19.0*	*19.4*	*21.2*	*23.1*	*24.2*	*25.1*	*25.4*	*24.7*
Results, difference	**2010**									
IEA statistics, SA (sectoral approach)	**761.6**									
How IEA (SA) differs from UBA (CRF 1.A)	-1.2									
IEA statistics, RA (reference approach)	**770.0**									
How IEA RA differs from UBA (CRF 1.A)	-0.1									
How IEA RA differs from UBA RA	1.2									
Results of the Länder (energy)	**NA**									
How the Länder results (energy) differ from UBA	NA									
Reference Approach UBA (RA)	**761.1**									
How UBA RA differs from UBA (CRF 1.A)	-1.2									
Sectoral approach UBA (CRF 1.A)	**770.6**									
International air transports	24.5									

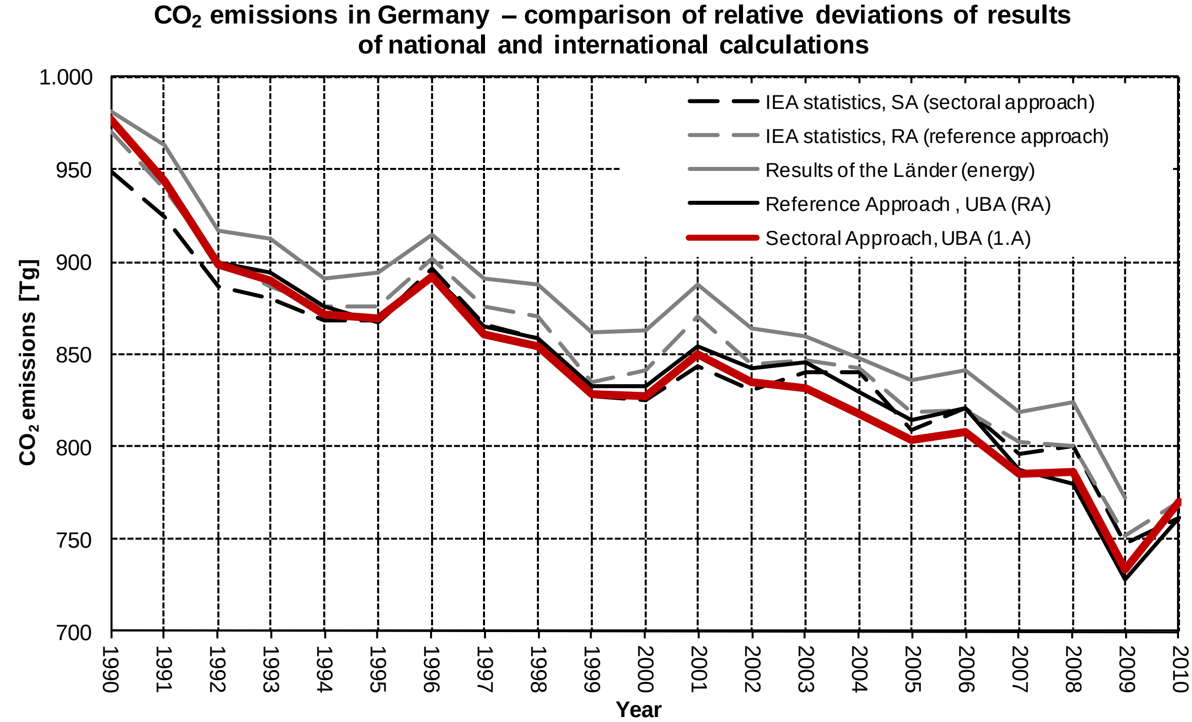


Figure 22: CO_2 emissions in Germany – comparison of results of national and international calculations

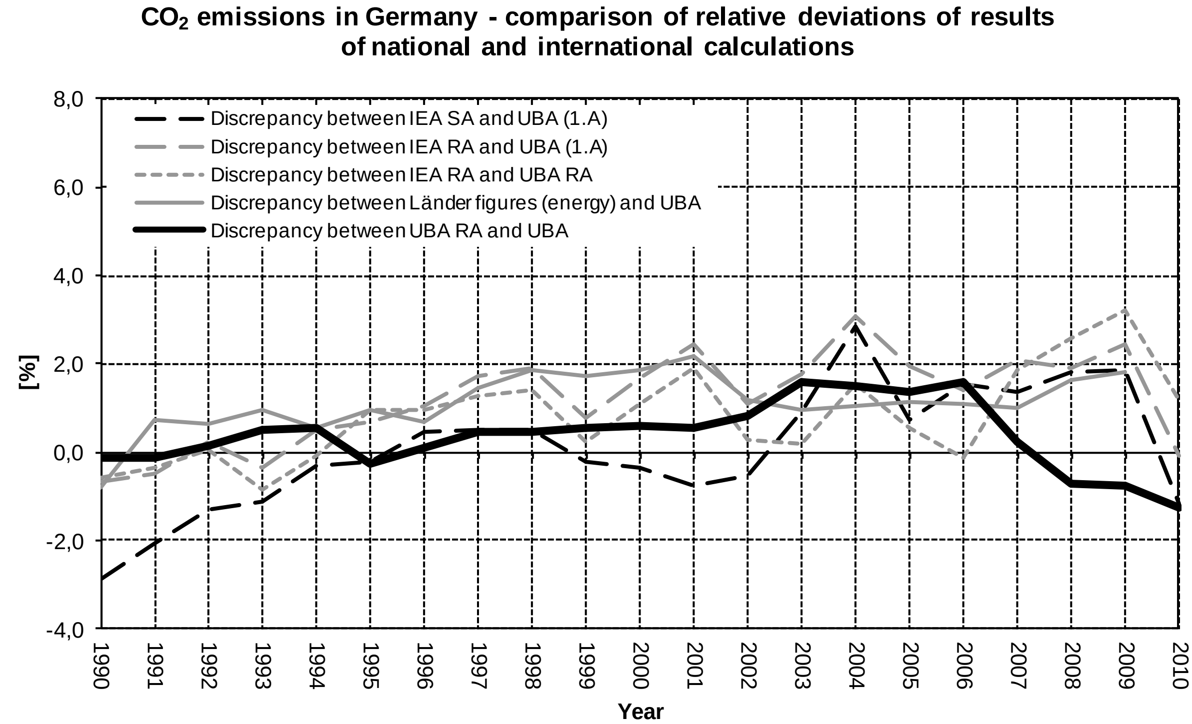


Figure 23: CO_2 emissions in Germany – comparison of relative discrepancies of national and international calculations

3.2.1.2.1 *Comparison with the IEA results*

The data used are data published annually, in updated form, by the IEA (most recently: OECD/IEA 2012). Since the method for determining, processing and applying the basic data used for this purpose currently is not precisely comparable with the national procedure in Germany at present, and relevant addition methodological information is lacking – particularly information with regard to the detailed data used – this comparison is provided only for reasons of completeness.

In spite of this restriction, the comparison with the results obtained with IEA's Sectoral Approach confirm the data obtained via the national, detailed method: the average deviation for (currently) 21 years is 0.1 %, while the pertinent individual deviations vary throughout a range of -2.9 % (1990) to 2.8 % (2004).

The results of the Reference Approach used by the IEA differ from those of the Reference Approach carried out in Germany by 0.8 %, over a 21-year average.

3.2.1.2.2 Comparison with the data obtained for the individual Länder

The German Länder publish data on their own CO_2 emissions (cf.: http://www.lak-energiebilanzen.de/sixcms/detail.php?template=liste_cobilanzen). Regarding the relevant procedures, responsible institutions and methodological descriptions, we call the reader's attention to that Web site and to the pertinent more detailed remarks in the NIR 2009.

The following section presents a comparison, for energy-related CO_2 emissions, of a) available Länder results published to date in the Balance of Emissions Causes (BEU) and b) inventories calculated at the national level. One difficulty hampering the comparison is that pertinent information for the individual Länder is not always available in the form of complete time series. Gaps in the time series were closed primarily via interpolation. Since data for 2010 are currently available for only a few German Länder, the comparison is limited to the period 1990 to 2009.

A significant aspect of the comparison is that the methods used in the Energy Balances of the Länder, and for the CO_2-emissions calculations based on those balances, do not correct for the fuel used in international air transports. For this reason, the a) results of the German Länder (states) have to be compared with b) the total energy-related emissions (1.A) in the national inventory, plus the emissions, reported as memo items, for international air transports (1.C.1.a).

Table 17: Comparison of the results of CO_2 calculations of individual Länder with corresponding figures from the federal inventories

State (Land)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					[Gg CO_2]					
Baden-Württemberg	74,374	78,590	78,036	78,673	74,535	78,074	81,759	78,570	80,080	77,379
Bavaria	84,544	88,972	87,041	90,335	87,871	88,307	92,265	89,837	92,708	90,590
Berlin	26,941	27,957	25,234	26,643	25,531	24,445	24,726	23,560	22,876	23,693
Brandenburg	81,894	66,751	58,894	57,104	54,011	50,791	50,312	50,762	59,255	57,784
Bremen	13,433	13,586	12,903	12,517	13,341	13,239	14,256	14,170	13,857	12,793
Hamburg	12,743	14,226	13,116	13,813	13,361	13,467	14,572	13,940	*13,651*	*13,362*
Hesse	50,338	53,945	53,267	56,060	56,201	56,126	59,935	57,264	57,156	54,688
Mecklenburg – West Pomerania	15,539	10,757	9,360	9,473	9,510	10,233	11,636	10,654	10,413	10,627
Lower Saxony	77,138	82,276	*80,915*	*79,553*	78,192	*78,334*	78,475	*79,440*	80,405	*77,316*
North Rhine – Westphalia	299,028	309,888	306,287	300,041	295,874	303,349	312,345	307,064	304,784	294,014
Rhineland-Palatinate	27,394	29,448	28,914	30,248	30,274	31,490	31,463	31,646	31,167	30,311
Saarland	23,708	25,767	24,398	23,214	24,313	23,133	23,852	21,825	23,795	22,833
Saxony	91,465	77,105	64,059	66,046	62,988	61,349	56,223	51,036	37,167	35,116
Saxony-Anhalt	50,863	38,085	31,892	27,887	26,307	25,200	25,652	25,294	25,261	26,900
Schleswig-Holstein	24,200	23,826	24,082	24,590	24,191	22,940	23,517	22,654	22,426	21,868
Thuringia	28,098	22,071	18,687	16,334	13,992	13,240	13,641	12,806	12,713	12,438
Result for all German Länder	**981,699**	**963,249**	**917,084**	**912,531**	**890,493**	**893,716**	**914,629**	**890,521**	**887,713**	**861,712**
Sectoral approach UBA (CRF 1.A)	977,713	944,417	898,318	889,779	871,089	869,889	892,374	861,302	854,542	828,541
International air transports (CRF 1.C.1.a)	12,023	11,937	13,095	14,068	14,688	15,256	15,993	16,530	17,069	18,406
National result (CRF 1.A + CRF 1.C.1.a)	**989,736**	**956,354**	**911,413**	**903,846**	**885,777**	**885,146**	**908,367**	**877,832**	**871,610**	**846,948**
How the Länder results differ from the national results (Gg)	**-8,037**	**6,895**	**5,671**	**8,684**	**4,716**	**8,571**	**6,262**	**12,689**	**16,103**	**14,765**
How the Länder results differ from the national results (%)	**-0.8**	**0.7**	**0.6**	**1.0**	**0.5**	**1.0**	**0.7**	**1.4**	**1.8**	**1.7**

State (Land)	2000	2001	2002	2003	2004 [Gg CO_2]	2005	2006	2007	2008	2009
Baden-Württemberg	74,940	80,108	76,549	75,598	74,768	77,222	78,283	70,952	72,556	66,153
Bavaria	88,705	90,377	84,578	83,783	83,190	80,541	81,879	74,972	80,430	77,930
Berlin	23,661	24,068	21,281	21,249	20,184	19,998	19,915	17,466	18,604	18,027
Brandenburg	60,564	60,928	61,537	57,910	58,882	59,910	58,273	58,173	56,587	52,968
Bremen	14,079	14,137	14,031	14,667	13,057	12,222	12,704	13,645	13,056	12,529
Hamburg	*13,073*	*12,784*	*12,495*	12,328	11,589	11,343	11,451	10,940	10,891	10,982
Hesse	56,011	57,817	54,897	55,528	54,787	54,441	53,170	50,916	52,159	49,128
Mecklenburg – West Pomerania	10,256	10,718	10,908	10,451	10,961	10,511	11,080	10,081	10,867	9,505
Lower Saxony	74,228	*73,145*	72,061	*71,040*	70,019	*70,158*	70,298	*69,898*	*69,402*	65,810
North Rhine – Westphalia	293,987	299,969	295,293	295,885	291,555	282,533	287,140	289,557	286,158	260,666
Rhineland-Palatinate	28,853	29,574	27,793	26,787	26,432	26,399	27,110	25,596	27,453	26,181
Saarland	23,459	23,260	22,964	23,278	23,917	24,799	23,577	25,714	22,961	18,377
Saxony	41,552	48,842	49,038	49,625	48,476	47,019	48,295	46,854	46,927	47,980
Saxony-Anhalt	26,301	26,840	27,518	28,171	27,145	27,846	27,821	26,477	26,973	26,772
Schleswig-Holstein	21,378	22,737	21,455	21,401	20,592	19,356	19,339	17,032	18,688	18,430
Thuringia	12,059	12,339	12,066	11,924	11,812	11,450	11,283	10,422	10,911	10,526
Result for all German Länder	**863,106**	**887,643**	**864,465**	**859,625**	**847,366**	**835,749**	**841,617**	**818,694**	**824,623**	**771,964**
Sectoral approach UBA (CRF 1.A)	827,825	849,669	835,355	832,122	817,510	803,248	808,296	785,639	785,832	733,401
International air transports (CRF 1.C.1.a)	19,529	19,101	19,001	19,357	21,170	23,088	24,236	25,135	25,422	24,726
National result (CRF 1.A + CRF 1.C.1.a)*	**847,354**	**868,771**	**854,356**	**851,479**	**838,680**	**826,336**	**832,531**	**810,774**	**811,254**	**758,127**
How the Länder results differ from the national results (Gg)	**15,752**	**18,872**	**10,109**	**8,146**	**8,686**	**9,412**	**9,086**	**7,919**	**13,369**	**13,837**
How the Länder results differ from the national results (%)	**1.9**	**2.2**	**1.2**	**1.0**	**1.0**	**1.1**	**1.1**	**1.0**	**1.6**	**1.8**

*) A correction is required, since at the Länder level energy consumption is not corrected to taken account of international air transports!

Remark: The italicised figures, in grey table cells, are not part of consistent time series and were generated via gap-closure procedures (see text).

In terms of trend, the comparison found excellent agreement between the combined Länder results and the Federal inventory. On an average for the 20 years in question, the total CO_2 emissions for the Länder were 1.0 % higher than the Federal result. The extremes of the deviations ranged from -0.8 % in 1990 to 2.2 % in 2001.

3.2.1.2.3 Planned improvements

Following the reporting process, the results of the comparison are regularly discussed, and reviewed with regard to potential for improvement, with the representatives of the Länder Working Group on Energy Balances (Länderarbeitskreis Energiebilanzen). At present, no concrete plans for further improvements are in place.

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

3.2.2 International bunker fuels

3.2.2.1 Emissions from international transports (1.C.1.a/1.C.1.b)

The area of international transports is divided into international civil air transports (1.C.1.a) and international sea transports (1.C.1.b), the latter of which also includes blue-water fisheries and maritime navigation.

3.2.2.2 Emissions from international air transports (1.C.1.a)

3.2.2.2.1 Source category description (1.C.1.a)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	NS/IS	CS D (lubricants)
CH_4	Tier 3	NS/IS	CS
N_2O	Tier 3	NS/IS	CS
NO_X, CO, NMVOC, SO_2	Tier 3	NS/IS	CS

Source category 1.C.1.a "International civil aviation", which is part of the relevant reported source category, is not included in key-category analysis.

Emissions from fuel consumption for international air transports are included in inventory calculation; however, in agreement with the IPCC Good Practice Guidance (IPCC, 2000: p. 2.57) they are not reported as part of national total inventories.

International air traffic from German airports has been growing continually, in both relative and absolute terms. This trend seems to have been interrupted, however, as a result of the 2009 economic crisis and the impacts of the Eyjafjallajökull eruption in 2010, and thanks to fleet modernisations, efficiency improvements and improved capacity use. The development of the resulting greenhouse-gas emissions is shown in the following figure.

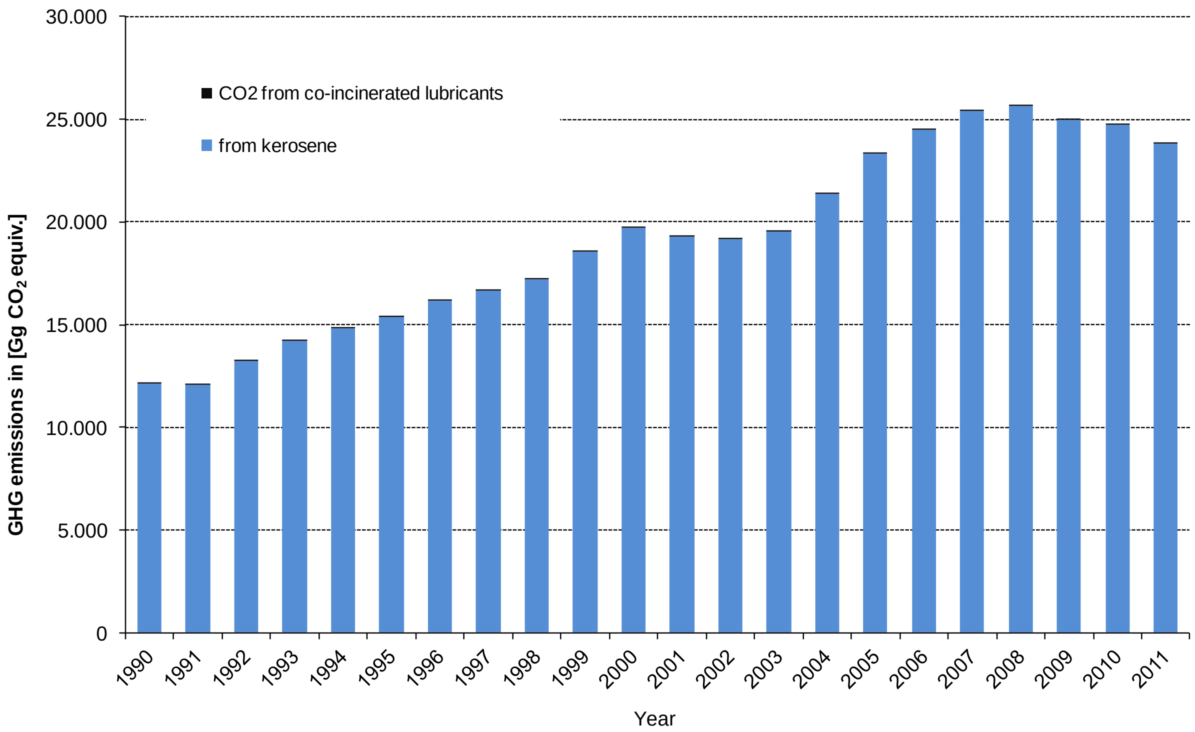


Figure 24: Development of greenhouse-gas emissions of international air traffic departing from Germany, 1990 - 2011

3.2.2.2.2 Methodological issues (1.C.1.a)

German energy statistics do not yet provide an official breakdown of fuel consumption relative to international air-transport emissions. To permit differentiation by national and international consumption nevertheless, these fuel-consumption figures are broken down by domestic and international air transports.

This breakdown is made in accordance with an annual split factor that refers to domestic air transports' share of total kerosene consumption. For 1990, a figure of about 15 %, based on individual movements of aircraft, was obtained via a research project. For years as of 2003, the relevant figure is provided directly by Eurocontrol (which calculates in accordance with Tier 3). For the years 1991 through 2002, interpolation is carried out via a continuous change function that is based on aircraft-movement data.

International air transports' so-determined shares of the kerosene consumption figures listed in the Energy Balance (AGEB) and in the official mineral-oil data (Amtliche Mineralöldaten) of the Federal Office of Economics and Export Control (BAFA) (AGEB, 2012; BAFA, 2012), are as follows:

Table 18: Development of international air transports' share of total kerosene consumption

Year	**1990**	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**
Share in [%]	84.9	89.2	89.7	90.0	90.2	90.5	91.4	91.7
Year	**2010**	**2011**						
Share in [%]	92.4	92.9						

Avgas consumption is reported separately, and solely for domestic air transports. It does not enter into calculation of the split factor.

International civil aviation is separately listed as such in the CSE.

Additional information relative to the activity data and emission factors used is presented in Chapter 3.2.10.1 on national civil air transports.

3.2.2.2.3 Uncertainties and time-series consistency (1.C.1.a)

Cf. National air transport, Chapter 3.2.10.1.3.

3.2.2.2.4 Source-specific quality assurance / control (1.C.1.a)

For details, cf. National air transport, Chapter 3.2.10.3.4.

3.2.2.2.5 Source-specific recalculations (1.C.1.a)

Recalculations with respect to the 2012 report were carried out to take account of a correction of the ratio, as calculated by Eurocontrol for the years as of 2007, between kerosene consumption for national flights and kerosene consumption for international flights.

Table 19: Revision of international air transports' share of total kerosene consumption in Germany, 2007-2010

	Units	2007	2008	2009	2010
Submission 2013		91.63	91.72	91.91	92.38
Submission 2012	[%]	91.90	92.01	92.29	92.64
Absolute difference		-0.26	-0.29	-0.38	-0.26
Relative difference	[%]	-0.29	-0.31	-0.42	-0.28

Table 20: Resulting revision of kerosene consumption for international air transports leaving from Germany, 2007-2010

	Units	2007	2008	2009	2010
Submission 2013		343,101	347,026	337,524	334,201
Submission 2012	[TJ]	344,088	348,121	338,933	335,129
Absolute difference		-987.5	-1,095	-1,409	-928
Relative difference	[%]	-0.29	-0.31	-0.42	-0.28

Table 21: Resulting revision of quantities of co-combusted lubricants, 2007-2009

	Units	2007	2008	2009	2010
Submission 2013		10.34	7.98	6.71	1.44
Submission 2012	[TJ]	10.37	8.00	6.74	1.45
Absolute difference		-0.03	-0.02	-0.03	-0.01
Relative difference	[%]	-0.29	-0.25	-0.45	-0.69

The changes in input data as described lead to the following recalculations, with regard to the Submission 2012, in reported greenhouse-gas emissions:

Table 22: Resulting recalculation of GHG emissions of international air transports for the years 2007 to 2010

	Units	2007	2008	2009	2010
Submission 2013	[Gg	25,382	25,672	24,969	24,723
Submission 2012	CO_2	25,455	25,753	25,073	24,792
Absolute difference	equiv.]	-73	-81	-104	-69
Relative difference	[%]	-0.29	-0.31	-0.42	-0.28

The further impacts on the overall inventory are described in detail in Chapter 3.2.10.1.5.

3.2.2.2.6 Planned improvements (1.C.1. a)

Cf. National air transport, Chapter 3.2.10.1.

3.2.2.3 Emissions from international maritime transport / maritime navigation (1.C.1.b)

3.2.2.3.1 Source category description (1.C.1.b)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	T1	NS	CS D (lubricants)
CH_4	T1	NS	D
N_2O	T1	NS	D
NO_X, CO, NMVOC, SO_2	T1	NS	D

Source category 1.C.1.b "International maritime transport / maritime navigation", which is part of the relevant reported (as a memo item) source category, is not included in key-category analysis.

International maritime transports includes both maritime shipping and blue-water fisheries. Fuel consumption and emissions of German blue-water fisheries are deducted from international maritime transports; in accordance with the IPCC's requirements, those fisheries data are reported as part of the national overall inventory under *1.A.4.c iii – Other sectors: Fisheries* (see the source-category-specific recalculations below and Chapter 3.2.11).

Emissions from consumption of diesel fuel and heavy fuel oil for international transports of ocean-going ships are included in the inventory calculation although, in keeping with the UNFCCC guidelines, they are not reported as part of total national inventories.

Since 1984, consumption of heavy fuel oil has been increasing, as high oil prices have pushed up prices for diesel fuels, the maritime-transport sector has grown worldwide and use of diesel engines that can run on heavy fuel oil has increased.

Temporary emissions reductions, especially those that occurred in 1992 and 2009, have been / were caused by trade and oil crises.

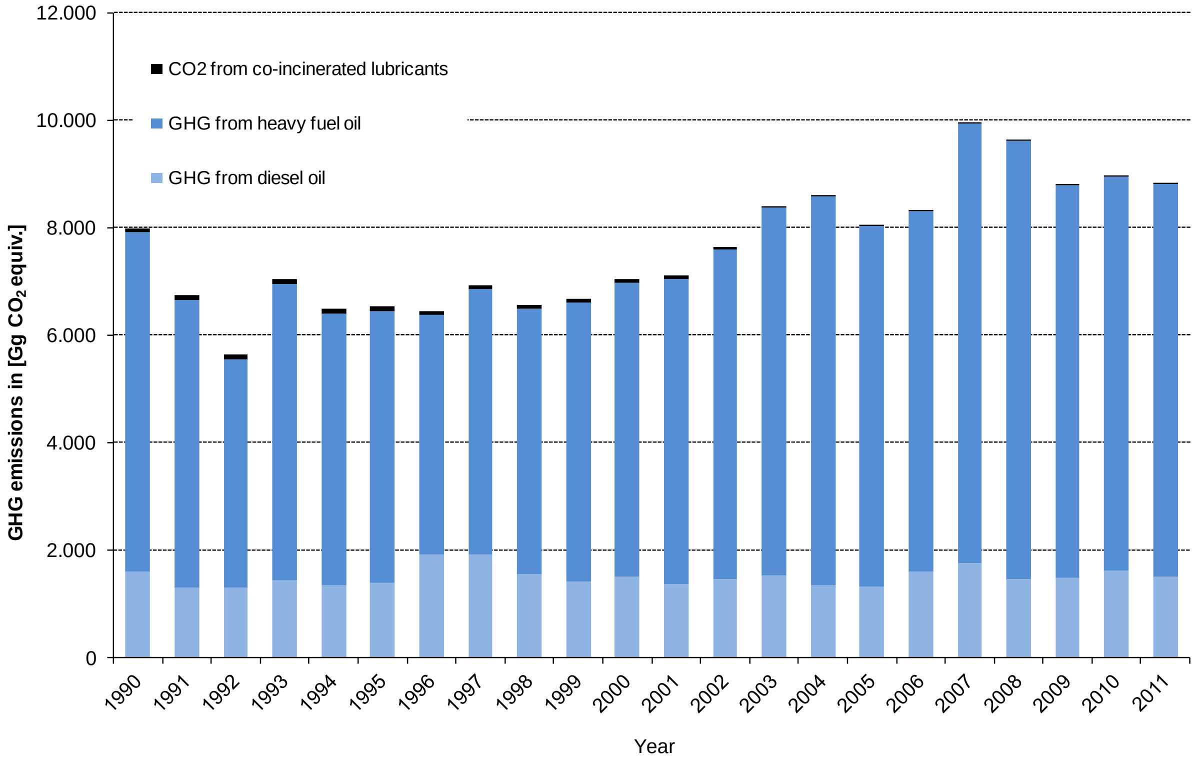


Figure 25: Development of greenhouse-gas emissions in international maritime transports, 1990 – 2011

3.2.2.3.2 Methodological issues (1.C.1.b)

Germany reports in keeping with Tier 1. This means that emissions are calculated as the product of fuel sales in Germany, country-specific emission factors for CO_2 and default emission factors for CH_4 and N_2O.

As a rule, the **activity data** for bunkering of ocean-going ships are taken from the Energy Balances of the Federal Republic of Germany (AGEB, 2012), in which the data are listed separately to take account of differences in taxation of fuels sold in ports.

Table 23 Activity data used in National Energy Balances

Fuel	Energy Balance line (EBZ)	Relevant years
Diesel fuel Heating oil, heavy / heavy fuel oil	6 – High-seas bunkering	since 1990

For years for which an Energy Balance does not become available on time, data are obtained from the "Amtliche Mineralöldaten für die Bundesrepublik Deutschland" ("Official mineral-oil data for the Federal Republic of Germany"), which are published by the Federal Office of Economics and Export Control (BAFA) (BAFA, 2012; for the present context: Table 6j, column: "Bunker int. Schifffahrt" ("bunkering, international shipping") and enter into the National Energy Balances.

A conservatively calculated share of these statistically recorded quantities is allotted to German blue-water fisheries and, thus, reported under *1.A.4.c iii – Other sectors: Fisheries* as part of the national inventory (cf. Chapter 3.2.11).

Table 24: Annual bunkered quantities (in TJ) in international sea transports leaving from Germany

	1990	1995	2000	2005	2006	2007	2008	2009
Heavy fuel oil[1,2]	80,230	64,382	69,578	85,370	85,277	104,066	103,830	92,614
Diesel fuel [1,3]	23,336	20,426	21,542	18,636	22,376	24,441	20,300	20,748
of 1.A.4.c iii [4]	*1,928*	*1,928*	*1,509*	*1,098*	*988*	*988*	*988*	*878*
of 1.C.1.b [5]	*21,408*	*18,498*	*20,033*	*17,538*	*21,388*	*23,453*	*19,312*	*19,870*
	2010	**2011**						
Heavy fuel oil[1,2]	93,063	92,663						
Diesel fuel [1,3]	22,483	21,046						
of 1.A.4.c iii [4]	*878*	*878*						
of 1.C.1.b [5]	*21,605*	*20,168*						

1) Annual bunkered quantities pursuant to National Energy Balance, line 6: Bunker fuels
2) Heavy fuel oil: allocated to a degree of 100% to international sea transports
3) Diesel fuel: divided between international sea transports and German high-seas fisheries
4) Share for German high-seas fisheries: conservatively calculated on the basis of fleet sizes (cf. Chapter 3.2.11)
5) Share for international sea transports: Bunkered quantities pursuant to Energy Balance, less the share for 1.A.4.c iii

In addition, pertinent quantities of co-combusted lubricants, along with the resulting CO_2 emissions, are recorded and reported. Figures for annual inputs of lubricants are also obtained from the aforementioned "Amtliche Mineralöldaten für die Bundesrepublik Deutschland" and converted to TJ, via a net calorific value of 40 GJ/t. Domestic deliveries have varied widely over the years, independently of fuel inputs (cf. Table 25).

To date, a conservative estimate has been applied whereby 50 % of the input quantities are co-combusted and thus produce CO_2 emissions.

Table 25: Annual quantities of lubricants co-combusted in international sea transports leaving from Germany (in TJ)

	1990	1995	2000	2005	2006	2007	2008	2009
Domestic deliveries [1]	1,832	2,082	1,627	283	238	47	362	712
of this, co-combusted[2]	*916*	*1,041*	*814*	*141*	*119*	*24*	*181*	*356*
	2010	**2011**						
Domestic deliveries [1]	621	216						
of this, co-combusted[2]	*310*	*108*						

1) Annual domestic deliveries pursuant to BAFA
2) Conservative assumption: 50% co-combusted

With regard to the CO_2 **emission factor** for diesel fuel, 74,000 kg/TJ, and to that for heavy heating oil, 78,000 kg/TJ, the reader's attention is called to the documentation in Annex 2, Chapter *CO_2 emission factors*. For co-combustion of lubricants, an IPCC default figure of 80,000 kg CO_2/TJ is currently being used.

For calculation of N_2O, CH_4, CO, NO_X and NMVOC emissions, IPCC default emission factors from the Revised 1996 IPCC Guidelines (Reference Manual, 1996b: p.1.90 Table 1-48) are used.

On the other hand, it is assumed that emissions from co-combustion of lubricants are covered by the emission factors for the fuels used and thus are included in the emissions calculated for the various fuels. Therefore, all emission factors for co-combusted lubricants, with the exception of that for CO_2, are reported as IE (included elsewhere).

3.2.2.3.3 Uncertainties and time-series consistency (1.C.1.b)

Since the emission factor for carbon dioxide is a calculatable value that depends solely on fuel composition, the uncertainty for that emission factor is considered to be very low. It is set here at ±5 %. On the other hand, default uncertainties of the IPCC are used for the emission factors for methane and nitrous oxide.

3.2.2.3.4 Source-specific quality assurance / control and verification (1.C.1.b)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Source-specific verification of the emission factors for CO_2, methane and nitrous oxide was carried out via comparison with the pertinent factors used by other nations.

Due to a lack of relevant additional national and international sources (such as EU-ETS), it was not possible to compare activity data and emissions for this area.

3.2.2.3.5 Source-specific recalculations (1.C.1.b)

With respect to the data provided in the Submission 2012, only marginal recalculations, to take account of corrected activity data for 2010, were carried out.

Table 26: Correction of quantities of heavy fuel oil used, following the revision of the 2010 Energy Balance

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Submission 2012	[TJ]	80,230	64,382	69,578	85,370	85,277	104,066	103,830	92,614	93,063
Submission 2013		80,230	64,382	69,578	85,370	85,277	104,066	103,830	92,614	93,058
Δ absolute		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**
Δ relative	**[%]**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**

Table 27: Resulting recalculations of greenhouse-gas emissions for 2010

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Submission 2012	[Gg CO_2 eq.]	7,993	6,538	7,043	8,047	8,326	9,952	9,637	8,809	8,970
Submission 2013		7,993	6,538	7,043	8,047	8,326	9,952	9,637	8,809	8,970
Δ absolute		**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.4**
Δ relative	**[%]**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.004**

3.2.2.3.6 Planned improvements (1.C.1.b)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

In 2013 or later, use will begin of LNG bunkered in Germany. Such use will duly be taken into account in future reports.

3.2.3 Storage

In a research project carried out in co-operation with the University of Utrecht (UU STS, 2007), emissions from non-energy-related use of industrially used fuels were calculated for the first time for the years between 1990 and 2004 and then compared with the figures used for the CO_2 Reference Approach. The pertinent results are summarised in Annex 2, Chapter 13.9 of the NIR 2007.

3.2.4 CO_2 capture and storage (CCS)

At present, CO_2 capture and storage (CCS) technology is still in the research phase in Deutschland; some pilot systems are in place. Currently, storage via CCS is not included in the German inventory.

3.2.5 Special country-specific aspects

There are no special aspects that would influence reporting.

3.2.6 Public electricity and heat production (1.A.1.a)

3.2.6.1 Source-category description (1.A.1.a)

CRF 1.A.1a	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**339,017.9**	**(27.83%)**	**314,159.6**	**(33.93%)**	**-7.33%**
All fuels	**N_2O**	**L**	**-/T2**	**3,568.9**	**(0.29%)**	**2,631.9**	**(0.28%)**	**-26.25%**
All fuels	**CH_4**	**-**	**T/T2**	**185.8**	**(0.02%)**	**1,684.2**	**(0.20%)**	**903.49%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category *Public electricity and heat production* is a key category for CO_2 emissions in terms of level and trend. For N_2O emissions, it is a key category only in terms of level, and for CH_4 emissions, it is a key category only in terms of trend.

Under source category 1.A.1.a, "Public electricity and heat production", the CSE includes district heating stations and electricity and heat production of public power stations. Plants that feed electricity produced from biomass into the public grid are also assigned to source category 1.A.1.a.

Some 105 GW of net bottleneck capacity were in place in the public electricity generating sector in 2011. Of this amount, about 73 GW were operated with fossil fuels or with transformation products of fossil fuels. As a group, all fossil-driven plants generated some 318 TWh of electrical work. This corresponds to about 69 % of all public electricity generation (about 431 TWh). About 231 TWh of electricity were generated solely with lignite and hard coal.

In 2011, combined heat and power (CHP) stations contributed net electricity production of about 51 TWh, and net heat production of 107 TWh, to the public energy supply. The district-heat supply is supplemented with heat, amounting to 14 TWh, from heat-only boiler stations that are normally run in peak-load operation. (*FEDERAL STATISTICAL OFFICE,* 2012a).

The following figure presents an overview of development of CO_2 emissions in source category 1.A.1.a:

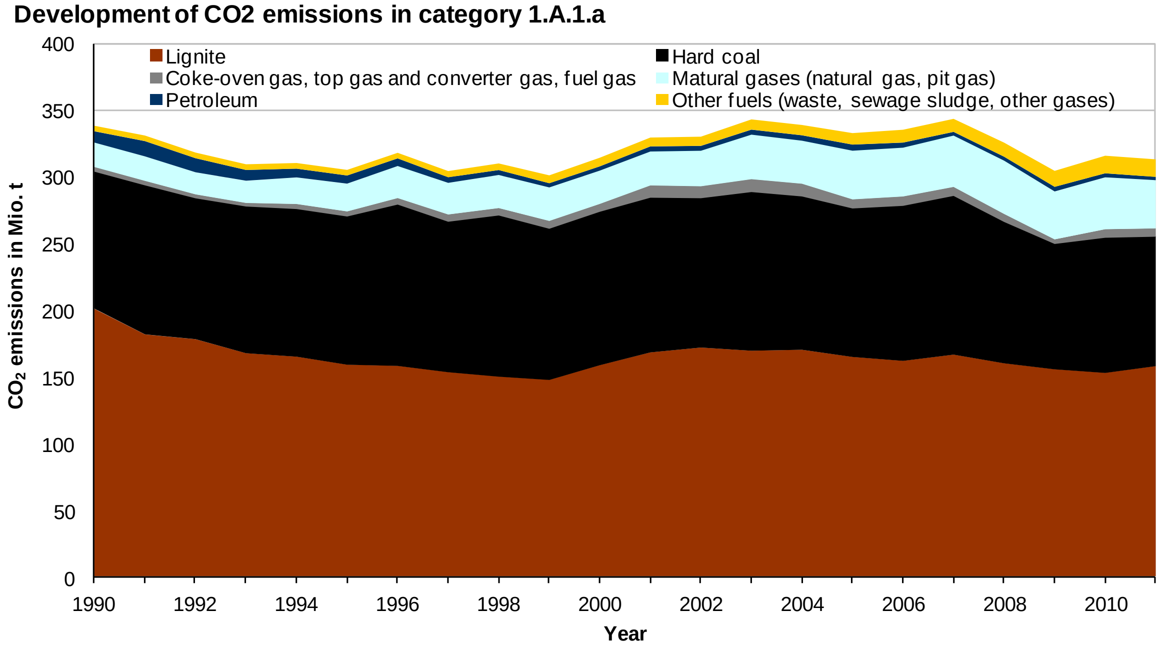


Figure 26: Development of CO_2 emissions in source category 1.A.1.a

Overall, emissions until 1999 show a falling trend, due primarily to closure of four lignite-fired installations in the new German Länder. Thereafter, a number of installations were replaced. As of 2000, then, the newly installed capacities, in the category of lignite-fired power stations, exceeded those of the decommissioned power stations, and thus emissions began increasing again. Nonetheless, overall emissions from lignite-based electricity generation are considerably below the corresponding emissions level in 1990.

In the main, the emissions trend is shaped by the development and structures of the electricity generation installations involved, since those installations account for the majority of the pertinent emissions. From 1990 through 1993, electricity consumption decreased, as a result of the collapse of industry in the new German Länder. From 1994 until 2007, a marked increase in electricity consumption occurred in all sectors, sparking increases in electricity production. As a result, emissions from electricity production also increased. In addition, electricity exports increased. Those exports begin showing up in the overall balance as of 2003. The increasing trend has been tempered by increased use of natural gas, by improvements in power stations' efficiency and by increasing electricity generation via renewable energies.

In 2007, particularly large quantities of coal were used for electricity generation, in keeping with low prices for emissions certificates. Thereafter, beginning as early as 2008, a marked emissions decrease occurred, as a result of increase use of nuclear power, natural gas and renewable energies. In 2009, the financial and economic crisis occurred, also affecting the public energy supply. In particular, hard-coal-fired power stations, which are used in the medium-load range, produced considerably less electricity, thereby also producing considerably lower emissions. With that trend, emissions from hard-coal-fired electricity generation dropped below the 1990 level, for the first time since that year. As seen via the relevant time series, hard-coal-fired power stations show higher fluctuations in fuel inputs than lignite-fired power stations do. The reason is that they, in contrast to lignite-fired power stations, are operated primarily in the medium-load range, where they respond more markedly to fluctuations in demand. What is more, they are dependent on import prices. Furthermore, as of the mid-1990s sectoral shifting occurred, from industry (1.A.1.c and 1.A.2.f) to the public electricity supply (1.A.1.a), as more and more operators reported their data in the public electricity supply category.

Petroleum plays only a minor role in Germany's electricity supply. It is used primarily for auxiliary and supplementary firing in coal-fired and waste-to-energy CHP power stations, as well as for peak-load generation. Use of petroleum in these roles has dropped by more than half since 1990. In the crisis year 2009, when petroleum became considerably cheaper than natural gas, use of petroleum for peak-load generation increased again somewhat.

Use of natural gas for electricity generation has increased markedly since 1990. That trend has not led to an equivalent emissions increase, however, since the specific CO_2 emissions of natural gas are considerably lower than those of coal. The significant increase in natural gas use seen since 2005 is due especially to the commissioning of a considerable number of major gas and steam turbine power stations and medium-sized gas-turbine power stations. What is more, natural gas is increasingly being used as balancing energy for electricity generation with fluctuating renewable energies. Since 1990, waste inputs in waste-incineration plants and for co-incineration have also been increasing, as a result of changes in relevant laws. While increased use of waste in this area produces additional emissions, it helps prevent methane emissions from landfills. Use of industrial gases for electricity generation depends on production, as the crisis year 2009 showed. In addition, the relevant figures depend on whether operators, in the context of statistical surveys, report their use in the "industry" category or "public electricity supply" category. Overall, changes in sectoral classification repeatedly occur in connection with all fuels.

In 2010, electricity generation with nearly all fossil fuels increased – sharply, in some cases – as a result of economic recovery, and this led to increased CO_2 emissions. Nonetheless, emissions from electricity generation remained below their 2008 level. A cold winter was another reason why CO_2 emissions increased in 2010. The resulting increased demand for heat led to higher fuel inputs in district heating stations.

In 2011, CO_2 emissions from public electricity generation showed almost no change in comparison to the previous year, even though electricity generation from nuclear power stations decreased significantly. This development can be explained as the result a) of a considerable increase in electricity generation from renewable energy sources and b) of a reduction in electricity exports. Overall, the public energy generation sector's CO_2 emissions decreased slightly from their level in 2010, as a mild winter reduced demand for district heat.

3.2.6.2 Methodological issues (1.A.1.a)

Activity rates

The calculation method has been selected on the basis of current key-source analysis, and it conforms to the decision tree in the IPCC Good Practice Guidance.

The fuel input for public electricity production is given in line 11 ("Public thermal power stations") of the Energy Balance. The fuel inputs for public heat production are given in lines 15 ("thermal power stations") and 16 ("district heating stations").

In the "Balance of Emissions Causes" model, the energy inputs listed in the Energy Balance are divided among several time series, with the help of statistical data. The aim of the calculations is to produce a database that is adjusted to the special technical characteristics of electricity and heat production. As a result, fuel-specific and technology-specific emission factors can be applied to the relevant activity data.

For the 2006 report, the activity data for the new German Länder for the year 1990 were revised and substantiated in the framework of a research project (FKZ 205 41 115 / sub-project A, "Revision and Documentation of Fuel Inputs for Stationary Combustion System in the new German Länder for the year 1990").

In the case of electricity and heat generation in waste incineration plants of public power stations, and of heat generation in waste incineration plants of public district heating stations, the pertinent activity data for household and municipal waste, and for industrial waste, are taken both from the Energy Balance and from the waste statistics of the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, FS 19 Reihe 1).

To date, the waste quantities listed in both energy statistics and the Energy Balance have been considerably lower than those given by the waste statistics of the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, FS 19 Reihe 1). The quality of the data provided by energy statistics has increased considerably in recent years. Such statistics now differentiate fuel data in a way that makes it possible, via calculation, to separate out figures for solid biomass (especially waste and scrap wood), biogenic gases, sewage sludge and waste heat. Industrial waste appeared as a fuel category in energy statistics for the first time in 2008. To ensure that all waste-related fuel inputs are taken into account as completely as possible, i.e. to close the gap that emerges with respect to energy statistics, it is necessary to make use of additional data from waste statistics.

As of the NIR 2006, the fossil and biogenic fractions of household / municipal waste are listed separately, in a ratio of 1/1. The fossil/biogenic composition of industrial waste varies in keeping with the type of facility involved. As a result, the biogenic fractions for co-combustion in lignite-fired and hard-coal-fired power stations, and for electricity and heat generation in public utilities' power stations fired with substitute fuels, are listed separately.

The existing assumptions relative to the biogenic fraction of sewage sludge have been retained.

The activity data for other fuels are taken directly from the Energy Balance. Where pertinent statistical indications or experts' assessments are available, fuel inputs are additionally divided into two size classes (combustion systems smaller and larger than 50 MW). The dividing line between these two categories is based on legal regulations pertaining to licensing of combustion systems in the Federal Republic of Germany.

As of the NIR 2011, CO_2 emissions from top-gas combustion in public power stations are reported in source category 1.A.1.a. The following table provides an overview of relevant emissions from top-gas use, for the entire time series since 1990.

Table 28: CO_2 emissions from top-gas combustion in public power stations

[Millions of t of CO_2)									
1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
3.236	3.283	3.008	2.719	3.744	3.745	4.796	5.282	5.440	5.782
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
5.930	9.243	8.990	9.723	9.597	6.866	7.112	6.578	5.858	3.317
2010	**2011**								
6.228	6.085								

Emission factors (except for that for CO_2)

The underlying data for the emission factors used are provided by the report on the research project "Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010" ("Determination and evaluation of emission factors for combustion plants in Germany for the years 1995, 2000 and 2010"; RENTZ et al, 2002). The values for the intermediate years 1996 - 1999 and 2001 - 2009 are obtained via linear interpolation. That project, along with the linear interpolation for the intermediate years, has also provided the underlying data for the emission factors presented in Chapters 3.2.7, 3.2.8, 3.2.9.6 and 3.2.10.5, where the factors include power stations, gas turbines and boilers for generation of steam and hot/warm water. The research project was carried out by the Franco-German Institute for Environmental Research (Deutsch-Französisches Institut für Umweltforschung – DFIU) at the University of Karlsruhe, and it was completed at the end of 2002. The project aim was to determine and evaluate representative emission factors for the main air pollutants produced by combustion systems in Germany that are subject to licensing requirements, and to do so for the years 1995, 2000 and 2010. The procedure for achieving that aim consists primarily of analysing and characterising the relevant emitter structures, and the pertinent emission factors, for the year 1995, and then of adequately carrying that data forward for the years 2000 and 2010. The procedure systematically determines emission factors for the substances SO_2, NO_X, CO, NMVOC, particulates and N_2O. Furthermore, it differentiates between 12 coal fuels, 4 liquid fuels, 7 gaseous fuels and firewood. In addition, the available data relative to emission factors of other substances are also compiled; these other substances include PAH, PCDD/F, As and Cd for combustion systems subject to licensing requirements, and CH_4 for gas turbines and combustion systems subject to licensing requirements that fall under the TA Luft. Annex 3 (Chapter 19.1.2) discusses the procedure used in the research project.

In connection with a major research project that began at the end of 2008 and was completed in 2011 (FICHTNER et al. 2011), we have begun updating the described database for emission factors (except for that for CO_2). The reference year for the proposed values is 2004. On that basis, emission factors are being predicted for the years 2010, 2015 and 2020. In 2011, on the basis of the relevant research results, we updated a considerable number of time series – primarily with regard to coal-fired plants – for the emission factors for SO_2 (except for lignite), NO_x and mercury. We continued that work in 2012, with a special focus on N_2O emission factors. In addition, we updated the SO_2 emission factors for lignite. We plan to update additional emission-factor time series, and report the results, in the context of future inventory reports.

In Germany, N_2O is monitored only in exceptional cases; for this reason, no relevant data from regular measurements are available. On the other hand, relevant emissions behaviour in combustion of hard coal and lignite, especially in fluidised-bed combustion, has been specifically studied, especially in the 1990s. The FICHTNER et al 2011 project has reviewed and updated the values used to date. Table 36 shows the results for large installations of public power stations (with thermal outputs from combustion of 50 megawatts or more), while Table 37 shows the results for smaller installations of the energy sector and of industry. These factors have been used as a basis for calculating the source-category-specific emission factors for the CSE.

Table 29: Technological emission factors for nitrous oxide from large combustion systems

Fuel / combustion technology	N_2O emission factor [kg/TJ]
Public power stations:	
Hard coal / dry firing	1.0
Hard coal / slag tap firing	1.9
Lignite / dry firing	3.5
Liquid fuel / boiler firing	1.0
Natural gas / boiler firing	0.5
Industrial power stations, industrial boilers and district heating stations:	
Hard coal / dry firing	1.0
Hard coal / slag tap firing	2.0
Hard coal / fluidised bed combustion	20
Hard coal / grate firing	4.0
Lignite / dry firing	3.4
Lignite / fluidised bed combustion	8.0
Lignite / grate firing	3.5
Liquid fuel / boiler firing	1.0
Natural gas / boiler firing	0.5
Gas turbines and gas and steam turbine plants:	
Natural gas	1.7
Light heating oil	2.0

The data presented in Table 30, taken from from the research project RENTZ et al (2002), served as the basis for systems < 50 MW furnace thermal output. The relevant median figures are shown in brackets.

Table 30: Technological emission factors for nitrous oxide from systems < 50 MW furnace thermal output

Fuel / combustion technology	N_2O emission factor [kg/TJ]
Boiler firing with:	
Hard coal	10.0
Lignite	10.7
Biomass	3.0
Light heating oil	1.1
Heavy heating oil	3.0
Natural gas	0.6
Gas turbines and gas and steam turbine plants:	
Natural gas	1.7
Light heating oil	2.0

Information on process-related CO_2 emissions from flue-gas scrubbing (flue-gas desulphurisation) in large combustion systems is provided by Annex 3 in Chapter 19.1.2.3.

For the 2011 reporting round, for the first time ever and in the framework of a research project carried out by the Institute for Future Studies and Technology Assessment (IZT), "Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV" ("Processing of data in emissions declarations pursuant to the 11th Ordinance on the Execution of the Federal Immission Control Act"), special CH_4 emission factors for gas engines were determined. The average value for natural gas as a fuel, 309 kg/TJ, is markedly higher than the previously used value, 0.3 kg/TJ, which is approximately the same as the value for steam-turbine power stations. With emissions-monitoring data, it was possible to confirm that significant methane leakage occurs via leakage of unburned natural gas. The pertinent measurements can vary considerably, in keeping with the type of engine and engine-maintenance standards involved. For biogas, sewage gas, landfill gas and mine gas, an average CH_4 emission factor of 185 kg/TJ was determined. For biogas, at least, it was possible to confirm that figure with data from emissions monitoring. In light of the lower methane concentrations of biogenic gases, the corresponding factor must be set lower for them than for natural gas.

3.2.6.3 Uncertainties and time-series consistency (1.A.1.a)

Uncertainties for activity data were determined, for the first time ever, for the 2004 report year (research project FKZ 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, Chapter 13.6 of the NIR 2007.

Other aspects relative to time-series consistency of activity data are explained in Chapter 18.4 and Chapter 18.6.

The figures for the uncertainty of the CO_2 emission factor, and for the statistical distribution function for that uncertainty, have been estimated by the Federal Environment Agency. The figures are based on the range covered by the carbon contents of the various individual fuels.

The uncertainty of the determined emission factors was evaluated in the framework of the project (mentioned in Chapter 3.2.6.2) of RENTZ et al (2002) and FICHTNER et al (2011).

3.2.6.3.1 Methods for determining uncertainties of emission factors

The uncertainties in emissions data result from several different factors. These include *precision*, which is influenced by chance and systematic errors in the framework of emission measurement, as well as by the completeness of the database with regard to available measurements. Another factor consists of *variability* of emissions. In this area, a distinction must be made between variability in emissions of a single plant, within the period in question (*intra-plant variability*) and differences between the emissions behaviours of the various sources considered (*inter-plant variability*).

Other sources of possible uncertainties can affect calculation of emissions with the help of emission factors. In the framework of IPCC-GPG (2000: Chapter 6), methods – adapted, in each case, to data availability – are proposed:

Where *continuous* measurements have been carried out, uncertainties should be characterised via direct determination of statistical indexes such as standard deviation and the 95%-confidence interval.

In determination of *plant-specific emission factors*, any available local measurements should be used. In addition, any special operational states (start-up and shut-down processes) and load changes should be taken account of, and available measurements should be reviewed for representativeness in light of the relevant plant's emissions behaviour.

In use of *emission factors from the literature*, all of the data-quality information provided by the sources in question should also be used. Furthermore, transferability should be reviewed

– to what extent is the emission factor in question representative of the situation in the relevant area being studied? If the factor is not representative, an experts' assessment should be carried out.

In general, use of *experts' assessments* is recommended in cases in which available empirical data do not suffice for quantification. A sample explanation is provided in Annex 3, Chapter 14.1.2.2, of the NIR 2007.

3.2.6.3.2 Result for N_2O

The individual evaluations of the uncertainties for the N_2O emission factors are described in the final report of the research project (FICHTNER et al, 2011). A Monte Carlo simulation carried out by the research contractor yielded percentage uncertainties of up to +/- 50 % for CRF category 1.A.1.a (as well as for categories 1.A.1.b, 1.A.1.c and 1.A.2.f / all other) (remark: values for +/- ranges must be divided by 2; cf. IPCC-GPG (2000: Chapter 6, p. 6.14). In the process, we continue to assume a uniform distribution of uncertainties.

3.2.6.3.3 Result for CH_4

Combustion systems in Germany are not subject to monitoring of CH_4 emissions; for this reason, no systematic-measurement data are available in this area. Consequently, relevant individual data items available in Germany and Switzerland have been relied on. As a result of this database limitation, the research project did not attempt any systematic correlation with source categories treated by the project (cf. Chapter 3.2.6.2). The individual CH_4 emission factors, as determined in the research project RENTZ et al (2002), are summarised in Annex Chapter 19.1.2.2. Previously, the factors listed there, for hard coal fired in combustion systems < 50 MW (mean value for D: 3.35 kg/TJ), and for light heating oil and natural gas fired in gas turbines, were used in the CSE for the years as of 1995. Review and adoption of the project's remaining proposals are still pending. For these fuels, the existing emission factors in the CSE are used without change (solid fuels: 1.5 kg/TJ; liquid fuels: 3.5 kg/TJ; and gaseous fuels: 0.3 kg/TJ).

As part of an experts' assessment carried out by the research contractor, pursuant to Tier 1 of the IPCC-GPG (2000: Chapter 6), an upper limit of +/- 50 % was estimated for the percentage uncertainty in source category 1.A.1a (as well as in source categories 1.A.1b, 1.A.1c and 1.A.2f / all other); in the process, we assume a uniform distribution of uncertainties – as was the case for N_2O.

3.2.6.3.4 Time-series consistency of emission factors

The emission factors for N_2O were determined in the framework of a research project (FICHTNER et al 2011), for the year 2004 (reference year). The research project saw no indications of changes over time in the individual emission factor. Earlier assumptions to the effect that at least the values for gas turbines might vary over time were not confirmed. For this reason, we have used constant values in each time series, for the period 1995 to 2011, and assumed that the values are valid predictive values for the period through 2020.

In this light, the time series for N_2O between 1995 and 2011 must be assessed as consistent overall. The time series of CH_4 emission factors for 1995 to 2011 were also reviewed and assessed as internally consistent.

In the NIR 2009, we reported on the period from 1990 to 1994.

To ensure time-series consistency, the CH_4 emission factors determined for combustion-engine systems were retroactively applied for the period back to 1990. Methane leakage is likely to have been higher in the early 1990s than it is with modern engine systems. Too little relevant measurement data is available for that period, however.

For most biogenic fuels, statistical fuel-input data are available only for the period since 2003. As a result, it is not possible to provide a consistent time series, for the period since 1990, for such fuels. That limitation affects only the trend for CH_4 emissions, which increases sharply as of the year 2003.

3.2.6.4 Source-specific quality assurance / control and verification (1.A.1.a)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the EF and ED of methane and nitrous oxide and for the pertinent AD.

For carbon dioxide, quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

To document its quality-assurance measures in preparation of Energy Balances, the Working Group on Energy Balances (AGEB) submits pertinent quality reports to the Federal Environment Agency (UBA) (cf. Chapter 18.4.2). In 2012, the AGEB began carrying out systematic comparisons between the 2011 Estimated Balance (provisional) and the 2010 Energy Balance (final) (cf. Chapter 18.4.2). In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[20].

Quality assurance for official statistics is carried out via an internal quality system. That system's quality reports are available for inspection within the Internet publications of the *Federal Statistical Office*.

In addition to these measures, the AGEB plays a role in the annual review process, and regular exchanges take place with the AGEB in the framework of that body's regular meetings, which are regularly attended by UBA representatives. At such meetings, methodological issues are discussed, and general exchanges take place for the purposes of clarifying data-collection issues and verifying data.

General measures for assuring the quality of emission factors for combustion plants, as applied in the framework of the research projects RENTZ et al (2002) and FICHTNER et al (2011), are outlined in the methods description in Annex 3, Chapter 19.1.2.1 (after Figure 81). Their results were reported in the NIR 2005.

3.2.6.5 Source-specific recalculations (1.A.1.a)

For source category 1.A.1.a, recalculations were required for the period as of 2004, as a result of revision of the applicable waste model.

In addition, the provisional figures for the year 2010 have now been replaced with now-available final statistics, leading to the following changes.

[20] AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 (last checked on 30 October 2009)

Table 31: Source-specific recalculations, CRF 1.A.1.a

Units [Gg]	NIR 2012	NIR 2013	Difference, absolute					Difference, relative
Year	Total	Total	gas	liquid	other	solid	Total	Total
2004	340,557	340,147	0	0	-410	0	**-410**	-0.12%
2005	334,035	333,999	0	0	-36	0	**-36**	-0.01%
2006	335,958	336,475	0	0	517	0	**517**	0.15%
2007	344,300	344,622	0	0	322	0	**322**	0.09%
2008	326,016	326,673	0	0	657	0	**657**	0.20%
2009	304,603	305,426	0	0	824	0	**824**	0.27%
2010	315,558	316,843	-53	-34	2,021	-648	**1,286**	0.41%

3.2.6.6 Planned improvements (source-specific) (1.A.1.a)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

3.2.7 Petroleum refining (1.A.1.b)

3.2.7.1 Source-category description (1.A.1b)

CRF 1.A.1.b	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**20,005.9**	**(1.64%)**	**18,380.0**	**(1.99%)**	**-8.13%**
All fuels	N_2O	-	-	121.7	(0.01%)	59.4	(0.01%)	-51.15%
All fuels	CH_4	-	-	13.3	(0.00%)	6.5	(0.00%)	-50.69%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category *Petroleum refining* is a key category for CO_2 emissions in terms of emissions level and trend.

The figures given above apply for refinery power stations (part of source category 1.A.1.b).

The crude oil distillation capacity of German petroleum refineries totalled around 117.6 Mt in 2011. In that period, 93 Mt of crude oil, along with 12 Mt of intermediate products, were input for processing. Production of petroleum products totalled 129.4 Mt, of which about 62.0 Mt consisted of fuels, about 23.9 Mt consisted of heating oils, about 14.2 Mt consisted of naphtha and about 29.3 Mt consisted of other products. (MWV, 2012, Tab PRE1.1, Tab 4, Tab 5j).

Petroleum processing plants operate power stations with electrical output of about 1.4 GW. In 2010, those power stations generated 6.5 TWh of electricity. (*STATISTISCHES BUNDESAMT (Federal Statistical Office),* 2010c).

Under source category 1.A.1.b, Petroleum refining, the CSE lists the sub-categories "refinery bottom-heating systems" and "electricity and heat production of refinery power stations".

The following figures provides an overview of emissions trends in source category 1.A.1.b:

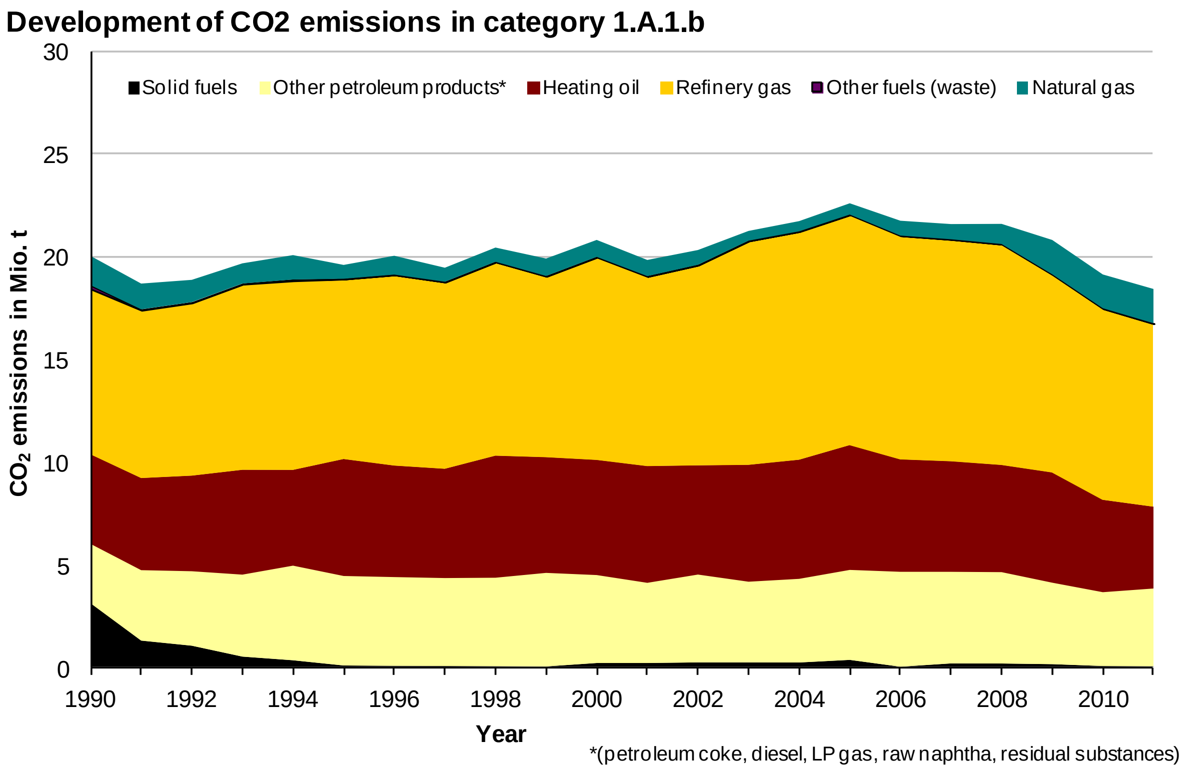


Figure 27: Development of CO_2 emissions in source category 1.A.1.b

Since 1990, emissions have shown a slightly increasing trend overall. While some relevant installations have been decommissioned since 1990 – although such decommissioning has taken place on a smaller scale than that seen in the hard-coal and lignite mining sectors – production increased nevertheless. And while installation efficiencies were improved, increased production of lighter petroleum products, and intensified ultra-hydrodesulphurisation, led to increases in specific fuel consumptions. The emissions fluctuations that have occurred over the years can be explained as the result of differences in production quantities. The maximum production of petroleum products to date, totalling 123.6 million t, occurred in 2005. The pertinent emissions were correspondingly high. Thereafter, production decreased, to a level of 103.3 million t of petroleum products in 2011, and emissions decreased as a result. Petroleum processing is one of the few sectors in Germany that have not profited from economic recovery. This is due to a still-difficult global market situation resulting from overcapacities, especially in Europe. In 2010, one German refinery stopped operating. As a result, German refineries' capacity utilisation increased somewhat in 2011. All in all, production was down, however, as a result of decreased demand for petroleum products. Processing plants' resulting lower own consumption led to a further decrease of emissions.

3.2.7.2 Methodological issues (1.A.1.b)

Activity data

Fuel inputs for electricity production in refinery power stations are included in Energy Balance line 12 ("Industrial thermal power stations"). Energy Balance lines 38 and 39 show energy consumption (for heat production) of refineries and used-oil-processing facilities. Fuel inputs for heat production in refinery power stations, and for bottom heating in refinery processes, are derived from these figures.

The time-series structure that results from the breakdown of energy inputs from the Energy Balance, in the BEU model, is shown in the Figure "Structural allocation, 1.A.1.b Refineries" .

Activity data for refineries are determined with the help of figures of the Federal Statistical Office, and of the Federal Office of Economics and Export Control (BAFA), for fuel inputs for electricity and heat production in petroleum refining.

The BAFA statistics include figures for total fuel inputs of refineries (refineries and processing of used oil). For calculation of activity data for electricity production, energy inputs for heat production (EB line 38) are subtracted from those figures. That procedure shows what amount of the energy input in Energy Balance line 12 must be allocated to refinery power stations.

The data of the *Federal Statistical Office* relative to electricity and heat production in refinery power stations cannot be adopted directly, since the data-collection methods of BAFA and the Federal Statistical Office differ. While BAFA's data show only refineries' own consumption, the "Statistik" 067 and 060 published by the *Federal Statistical Office* cover all of the fuels used by refinery power stations. Since refinery power stations also feed electricity into the public grid, the Federal Statistical Office's figures are higher than the corresponding figures of BAFA. Other relevant differences occur in the definitions used for the fuels "heating oil, heavy" and "other petroleum products". In comparison to the BAFA data, the data of the Federal Statistical Office show a larger quantity of other petroleum products overall and a smaller quantity of heavy heating oil. The Energy Balance uses BAFA's mineral-oil statistics for orientation. In the interest of maintaining consistency with the Energy Balance, the ratio between a) the fuel inputs for heat production in refinery power stations and b) the fuel inputs for electricity production in refinery power stations is calculated, on a fuel-specific basis, from the Federal Statistical Office's statistics. That factor, in conjunction with fuel inputs for electricity production in refinery power stations, can then be applied to the fuel consumption given by BAFA in order to calculate fuel inputs in refinery power stations for heat production.

The activity data for refinery-process bottom heating are obtained by subtracting fuel inputs in refinery power stations for heat production from refineries' final energy consumption (EB line 38 Refineries).

Energy inputs in facilities for used-oil processing (EB line 39) are reported under 1.A.1.c "Other transformation sector".

Emission factors (except for that for CO_2)

The emission factors for refinery power stations have been taken from the research projects RENTZ et al (2002) and FICHTNER et al (2011). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. The cited project does not provide any emission factors for the bottom-heating systems that supply process heat. To compensate for this gap, for bottom-heating systems the same values for N_2O and CH_4 were chosen that are used for refinery power stations.

3.2.7.3 Uncertainties and time-series consistency (1.A.1.b)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, in the Chapter "Uncertainties in the activity data of stationary combustion systems" (Chapter 13.6 of the NIR 2007).

3.2.7.3.1 Result for N_2O

The results of Chapter 3.2.6.3.2 apply mutatis mutandis.

3.2.7.3.2 Result for CH_4

The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

3.2.7.3.3 Time-series consistency of emission factors

The results of Chapter 3.2.6.3.4 apply mutatis mutandis.

3.2.7.4 Source-specific quality assurance / control and verification (1.A.1.a)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the EF and ED of methane and nitrous oxide and for the pertinent AD.

For carbon dioxide, quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

With regard to emission factors, the results of Chapter 3.2.6.3 apply mutatis mutandis.

3.2.7.5 Source-specific recalculations (1.A.1.b)

For reported year 2010, replacement of provisional values with values from original statistics leads to the recalculations shown below. :

Table 32: Recalculations in CRF 1.A.1.b

Units [Gg]	NIR 2012	NIR 2013	Difference, absolute				Difference, relative
Year	Total	Total	gas	liquid	solid	Total	Total
2010	**19,857**	**19,084**	-95	-563	-105	**-763**	**-3.48%**

3.2.7.6 Planned improvements (source-specific) (1.A.1.b)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

3.2.8 Manufacture of solid fuels and other energy industries (1.A.1.c)

3.2.8.1 Source-category description (1.A.1.c)

CRF 1.A.1.c	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**64,393.8**	**(5.29%)**	**17,006.6**	**(1.84%)**	**-73.59%**
All fuels	N_2O	-	-	680.5	(0.06%)	187.1	(0.02%)	-72.50%
All fuels	CH_4	-	-	85.3	(0.01%)	13.4	(0.00%)	-84.25%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category *Manufacture of solid fuels and other energy industries* is a key category, in terms of both emissions level and trend, of CO_2 emissions.

The above figures refer to power stations, and to other boiler furnaces for production of steam and hot/warm water, in source category 1.A.1.c.

Source category 1.A.1.c includes hard-coal and lignite mining, coking and briquetting plants and extraction of crude oil and natural gas. In 2010, the German hard-coal mining sector extracted 12.1 Mt of usable hard coal (12.9 Mt in 2010) (STATISTIK DER KOHLEWIRTSCHAFT 2012: for 2011, Übersicht (overview) 1 and www.kohlenstatistik.de) Coke production in 2010 amounted to Mt (AGEB 2011). Production of hard-coal briquettes was discontinued in 2008.

In 2010, 176.5 Mt of crude lignite was produced in Germany (ibid.). Production of lignite briquettes and other lignite products amounted to about 7 Mt (ibid.). Steam for drying of raw lignite, for production of refined lignite products, is obtained from lignite-fired power stations with process-steam extraction (CHP plants). From these plants, steam is drawn off for drying crude lignite for production of lignite products.

In 2011, German production of petroleum totalled 2.68 Mt (MWV, 2012), while production of natural gas totalled about 11.9 Nm³ (AGEB, 2011). The fuel inputs required for installations' own operations are reported in source category 1.A.1.c.

In the CSE, source category 1.A.1.c Manufacture of solid fuels and other energy industries includes electricity and heat production in steam-turbine power stations, broken down by hard-coal mining and lignite mining (mine power stations); electricity and heat production in gas turbines, gas engines and diesel engines of all colliery and mine power stations; other heat production in industrial boilers within the transformation sector (not including refineries); and manufacture of hard-coal coke and operation of diesel engines for propulsion purposes in colliery and mine power stations. In reporting, they are broken down into the categories "large combustion systems" and "plants falling under the Technical Instructions on Air Quality Control" (TA Luft).

The following figure provides an overview of emissions trends in source category 1.A.1.c:

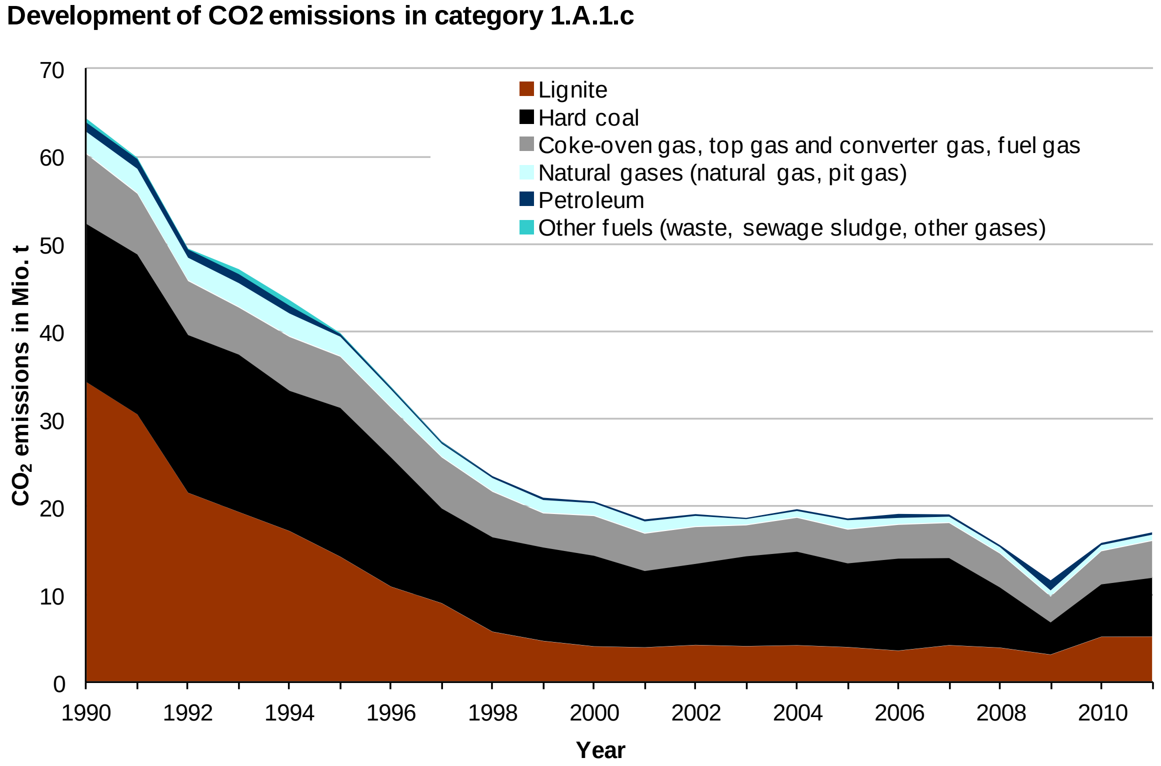


Figure 28: Development of CO_2 emissions in source category 1.A.1.c

The figure clearly shows how sharply emissions in this source category have decreased since 1990. The largest emissions decrease occurred in the area of lignite, use of which decreased strongly in the new German Länder from usage levels of the industry of the former GDR. From raw lignite, a range of refined products used to be produced for industry, households and small commercial operations. A comprehensive transition from lignite to other fuels then took place until the end of the 1990s. In a – then considerably reduced – number of industrial plants and commercial operations, use of hard coal, petroleum and natural gas intensified, while coal-burning stoves in homes were replaced with more modern heating systems fired with heating oil and natural gas. As a result, coal briquette and dust production in the new German Länder decreased from nearly 39 million t in 1990 to about 2.6 million t in 1997. Most lignite-processing plants were closed in that period, and thus emissions decreased sharply. As of 1998, energy for drying lignite products in the new German Länder was provided solely via process steam from public power stations. In the old German Länder, improvements in plants' efficiencies, along with reduced production in that area as well, until 2003, reduced emissions. Thereafter, emissions increased again slightly, as a result of production increases.

Emissions from use of hard coal in sector 1.A.1.c have been decreasing markedly since 1990. That decrease is due, firstly, to a sharp reduction in hard coal mining; while hard coal production still exceeded 70 million t in 1990, by 2011 it amounted to just less than 12 million t. Secondly, the decrease is due to the fact that some installations have shifted, for reporting purposes, from the hard coal mining category to the public electricity supply category, thereby shifting their emissions as well. The power stations remaining in source category 1.A.1.c also feed electricity into the public grid.

In 2010, fuel inputs in the lignite-fired and hard-coal-fired power stations allocated to source category 1.A.1.c. increased, as a result of economic recovery and related increased electricity demand. Another explanation for the increased fuel consumption is that some power stations have been taken from the public electricity generation sector and placed in the lignite mining sector. This has led to higher emissions overall.

Use of industrial gases (coke-oven gas, top gas and converter gas) also decreased until the end of the 1990s. The primary reason for this is that city-gas production was phased out through 1996, in a process involving decommissioning of local gas works. Coke production also decreased markedly. Production of hard coal coke decreased from 19 million t in 1990 to less than half of that figure in 2008. Production in 2009 amounted to only 6.7 million t, as a result of low steel production. In 2010, then, as the economic situation improved, hard-coal-coke production increased to 8.1 million t. Consequently, emissions from combustion of top gas and coke-oven gas rose considerably. While 8 mine coking plants were still in operation in 1990, only one such plant is in operation today, along with a total of four metallurgical coking plants. Overall, plant closures and efficiency increases have decreased emissions markedly in this sector.

3.2.8.2 Methodological issues (1.A.1c)

The calculation method has been selected on the basis of the latest key-category analysis.

Fuel inputs for electricity production in power stations of the hard-coal and lignite mining sector are listed in Energy Balance line 12, "Industrial thermal power stations". Fuel inputs for heat production in the transformation sector are listed in Energy Balance lines 33-39 and in sum line 40 ("Total energy consumption in the transformation sector").

Fuel inputs for electricity production in power stations of the hard-coal mining sector are determined with the help of figures of the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, 2011c). The activity data for heat production in power stations of the hard-coal mining sector correspond to Energy Balance line 34 "Energy input in collieries and briquette plants of the hard-coal mining sector".

The listed fuel input for electricity production in mine power stations is based on association information (personal communication from DEBRIV, the federal German association of all lignite producing companies and their affiliated organisations). Inputs for heat production, especially for lignite drying for production of lignite products, are not shown in the Energy Balance. Those are calculated from figures for production of lignite products (STATISTIK DER KOHLENWIRTSCHAFT n.y.) and from the specific fuel inputs required for drying (personal communication from DEBRIV, February 2007), listed as "non- Energy-Balance inputs" in the CSE, and reported as such.

The quantities of fuel used for production of hard-coal coke are taken directly from the Energy Balance, line 33 (coking plants).

The fuel input for heat production in the other transformation sector is obtained by combining the energy consumption figures in Energy Balance lines 33 to 39 (total energy consumption in the transformation sector). Those figures include mines' own consumption; facilities for petroleum and natural gas production and for processing of waste oil; plants that produce coal products; plants for production and processing of fissile and fertile materials; and wastewater-treatment facilities' own consumption.

As of the 2011 report, CO_2 emissions from top-gas combustion in coking plants are reported in source category 1.A.1.c. The following table provides an overview of CO_2 emissions from top-gas use in coking plants, for the entire time series since 1990.

Table 33: CO_2 emissions from top-gas combustion in coking plants

[Millions of t of CO_2)									
1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
5.328	5.234	4.579	4.220	5.201	4.899	4.686	4.947	4.342	3.131
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
3.636	3.725	3.668	3.015	3.341	3.308	3.293	3.332	3.230	2.421
2010	**2011**								
3.220	3.795								

Revision of the data for 1990, and for the years 1991-1994, for the new German Länder is described in Annex Chapter 19.1.1.

Emission factors (except for that for CO_2)

The emission factors for power stations and other boiler combustion for production of steam and hot/warm water, in source category 1.A.1.c, have been taken from RENTZ et al (2002) and FICHTNER et al (2011). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. Within the sector, the research projects differentiate between STEAG power stations, other power stations in the hard-coal mining sector, power stations in the lignite mining sector and other boiler combustion for production of steam and hot/warm water.

The majority of emission factors for coking plants have been obtained from BFI (2012). That data source's emission factors for contained sources have been allocated to source category 1.A.1.c, since those emissions result primarily from bottom-heating of coke ovens. By contrast, the emission factors determined for fugitive sources have been allocated, by definition, to source category 1.B.1.b. In both source categories, calculations cover CO emissions from coking plants, along with other pollutants.

3.2.8.3 Uncertainties and time-series consistency (1.A.1.c)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project FKZ 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, Chapter 13.6 of the NIR 2007.

The procedure for determining uncertainties for the emission factors is described in Chapter 3.2.6.3.1.

3.2.8.3.1 Result for N_2O

Relatively large numbers of fluidised-bed combustion systems are used in plants within the lignite-mining sector – which plants are part of sector 1.A.1.c. Such systems are known to have relatively higher N_2O emissions than systems using other types of coal-combustion technologies. On the other hand, relevant emissions behaviour in combustion of hard coal and lignite, particularly in fluidised-bed combustion, has been specifically studied, especially in the 1990s. For this reason, enough measurement data were available to permit systematic survey of N_2O emission factors in the research project. The remarks made in Chapter 3.2.6.3.2 apply mutatis mutandis.

3.2.8.3.2 *Result for CH_4*

The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

3.2.8.3.3 *Time-series consistency of emission factors*

The results of Chapter 3.2.6.3.4 apply mutatis mutandis.

3.2.8.4 Source-specific quality assurance / control and verification (1.A.1c)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the EF and ED of methane and nitrous oxide and for the pertinent AD.

For carbon dioxide, quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

The results of Chapter 3.2.6.4 apply mutatis mutandis.

3.2.8.5 Source-specific recalculations (1.A.1.c)

In the main, recalculations had to be carried out for 2010 to take account of updating of provisional Energy Balance data. For 2009, recalculations were also carried out – with regard to lignite, for which CO_2 emission factors had been changed.

The resulting changes are as follows:

Table 34: Recalculations in CRF 1.A.1.c

Units [Gg]	NIR 2012	NIR 2013	Difference, absolute					Difference, relative
Year	Total	Total	gas	liquid	other	solid	Total	Total
2009	11,514	12,279	0	0	0	-1	**765**	**6.65%**
2010	13,646	16,637	-85	-781	0	3,020	**2,992**	**21.92%**

3.2.8.6 Planned improvements (source-specific) (1.A.1.c)

Upon completion of the emissions calculation, the AGEB made a number of corrections in the Energy Balance; those corrections will be integrated within the inventory for the next submission.

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

3.2.9 Manufacturing industries and construction (1.A.2)

This source category consists of several sub- source categories defined in close harmony with the IPCC categorisations (CRF). It is described in detail via the relevant sub-chapters.

The calculation algorithms for BEU structural elements in source category 1.A.2 were revised, within the research project "Substantiation of the data quality of activity data" (FKZ 204 41 132), and they are now governed by a consistent system. For the most part, they are based on reliable data of the Federal Statistical Office.

Sectoral differentiation of activity data was carried out solely for process combustion.

As of 2008, classification of economic sectors (Wirtschaftszweige = WZ), in energy statistics, is being changed from the "WZ 2003" standard to the "WZ 2008" standard. As a result, activity data relative to process combustion are now being taken from individual statistics in keeping with the relevant key for the change (STATISTISCHES BUNDESAMT 2008: "Umsteigeschlüssel WZ 2003 auf WZ 2008" (FEDERAL STATISTICAL OFFICE 2008: key for the change from WZ 2003 to WZ 2008))

With respect to power and heat production, industrial power stations and boiler systems are aggregated by technologies (gas engines, gas turbines, gas and steam plants and steam turbines), as well as by permit-law provisions (TA-Luft and 13th BImSchV).

The various individual calculation algorithms were substantiated in detail in the aforementioned research project.

Following emissions calculation at the structural-element level, sum values for the sub-source categories in 1.A.2 are formed, via maximally IPCC-conformal aggregation of results. Since the NIR 2006, most process combustion has been reported on a sector-specific basis. The available data do not permit fully IPCC-conformal disaggregation. For example, heat and power production of industrial power stations and thermal power stations cannot be oriented to specific sectors; for this reason, it is reported in combined form, under 1.A.2.f Other.

Differentiation of energy-related process combustion for heat and power production in industrial power stations and in boiler systems was carried out via Statistik 067 (Statistics 067; electricity-production systems of the manufacturing sector, and of the mining and quarrying sectors (Stromerzeugungsanlagen des Verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden); *STATISTISCHES BUNDESAMT*, 2010c).

A change in Statistics 067 (op. cit.) of the Federal Statistical Office has led to a jump in the activity data for heat and electricity production. Until 2001, only the fuel inputs for electricity production in electricity production systems were listed. As of 2002, fuel inputs for heat and electricity production are listed. No data are available for inputs for heat production for years prior to 2002.

The ratio between the fossil and biogenic fractions in industrial waste is obtained from the Energy Balance, from waste statistics (STATISTISCHES BUNDESAMT, FS 19 Reihe 1) and from the relevant industry association figures for substitute fuels.

All of the listed amounts of standard fuels used in all sub- source categories have been taken from the Energy Balance of the Federal Republic of Germany and disaggregated in the Balance of Emission Causes (BEU). In addition to the figures provided from the Energy Balance, in various sub- source categories substitute fuels have now been listed. The relevant amounts were determined in a research project (UBA 2005b, FKZ 204 42 203/02) and are now updated annually with the help of association data (see below). As these figures show, use of substitute fuels has been increasing. This has led to reductions in use of conventional fuels, via de facto fuel substitutions.

In the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; (UBA 2005b, FKZ 204 42 203/02)), the required improvements relative to the topic of "waste fuels" in the energy sector were found to be tied to substitute fuels in four industrial sectors, and the pertinent data were obtained from the relevant industrial associations. As a result, considerably improved, sector-specific data are now available relative to use of substitute fuels in process combustion, and in industrial power stations, in the industrial sectors pig-iron production, pulp and paper production and lime and cement production.

Special aspects of the various sub- source categories are described in the relevant sub-chapters. Special note should be taken of the collective group 1.A.2.f Other.

The uncertainties for the new structural elements created in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; (FKZ 204 41 132) were determined in keeping with the method described in the research project 204 42 203/02. That determination is described in the final report for the research project (FKZ 204 41 132) and in Annex 13.6 of the NIR 2007.

Carbon dioxide emissions predominate in CRF category 1.A.2. Other greenhouse gases account for only very small shares of total emissions.

A sharp reduction in greenhouse-gas emissions occurred in the period 1990 through 1994. It was caused by decommissioning of inefficient manufacturing plants in the new German Länder following the 1990 political transition in Germany.

The emissions fluctuations that occurred in subsequent years reflect production trends in Germany's manufacturing sector, which were tied to overall economic trends.

3.2.9.1 Manufacturing industries and construction – iron and steel (1.A.2.a)

CRF 1.A.2.a	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**34,742.0**	**(2.85%)**	**34,323.0**	**(3.71%)**	**-1.21%**
All fuels	N_2O	-	-	161.4	(0.01%)	132.7	(0.01%)	-17.74%
All fuels	CH_4	-	-	52.5	(0.00%)	61.7	(0.01%)	17.65%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category *Manufacturing industries and construction – iron and steel* is a key category, in terms of emissions level and trend, for CO_2 emissions.

The iron and steel industry (sub- source category 1.A.2.a) is the second important CO_2-emissions source, along with the cement industry, in the area of process combustion.

3.2.9.1.1 Source-category description (1.A.2a)

The source category comprises the production areas of pig iron (blast furnaces), sinter, rolled steel, iron and steel casting, Siemens-Martin steel, electric steel and the power stations and boilers of the entire steel industry.

Production of Siemens-Martin steel generated emissions only in the new German Länder, and only until shortly after 1990. Thereafter, production was completely discontinued. In the old German Länder, production of Siemens-Martin steel was discontinued before 1990.

In production of pig iron, large amounts of the fuels used in blast furnaces are needed for the reduction processes that take place in the furnaces, while most of the fuel used in other production areas of the iron and steel industry is used for heat production.

The following figure provides an overview of CO_2 emissions in the various sub- source categories in 1.A.2.a.

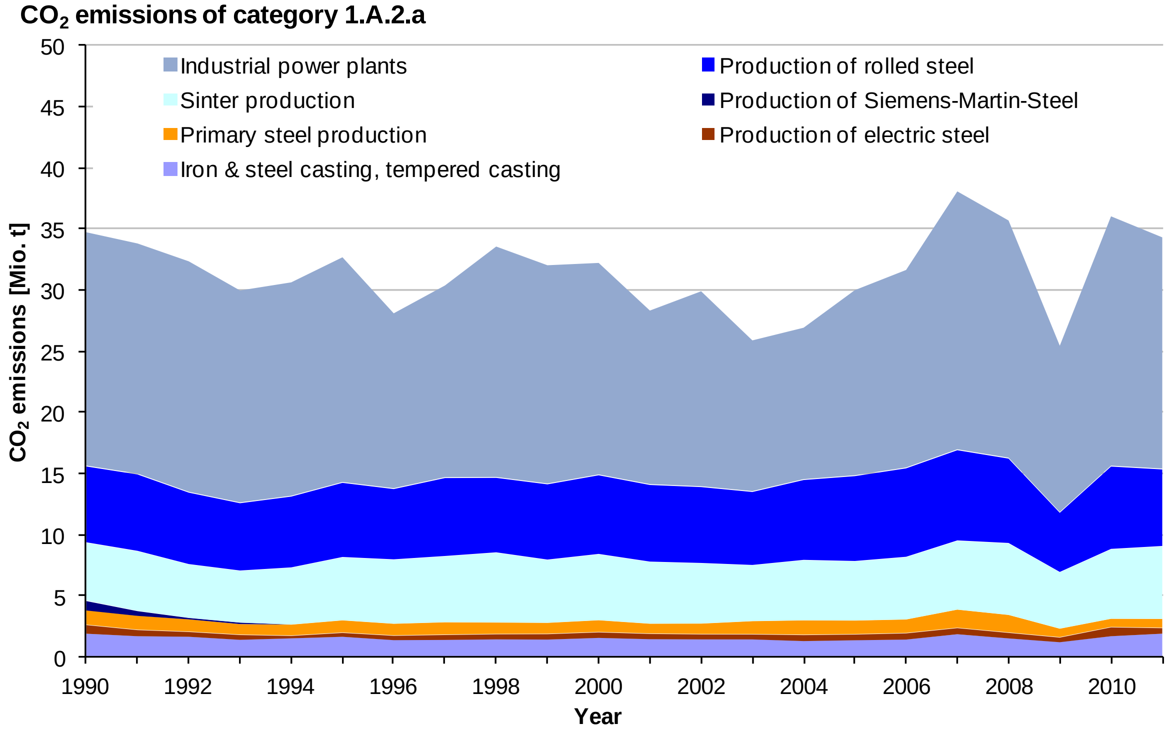


Figure 29: Development of CO_2 emissions in source category 1.A.2.a

As the overview reveals, major fluctuations have occurred over the years. In most cases, those swings were tied to fluctuations in production. In the period 1990 through 1994, emissions reductions occurred primarily as a result of restructuring of the iron and steel sector in the new German Länder following the political transition of 1990.

The drop in CO_2 emissions is particularly pronounced in the crisis year 2009, in which the steel industry registered a sharp production decrease. In 2010, emissions increased again as a result of economic recovery, which had an especially strong impact on the steel industry. In 2011, steel production decreased very slightly, leading to a very slight decrease in CO_2 emissions.

The largest emissions share comes from the areas of rolled-steel and sinter production. In the blast furnace category, only the natural-gas and coking-gas inputs required for furnace operation are reported in source category 1.A.2.a. Process-related emissions are listed in source category 2.C.1.

3.2.9.1.2 Methodological issues (1.A.2a)

This sub- source category comprises process combustion in the various production areas of the iron and steel industry. The relevant fuel-use amounts, including those for secondary fuels, are contained in the Balance of Emission Causes (BEU).

In work to obtain activity data for conventional fuels in this source category, a new data source was developed in the 2011 report year: the so-called "BGS" group (fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) locally connected to such operations). This improved relevant disaggregation. While the legal basis for surveys relative to the BGS group is no longer available as of the 2012 report year, the pertinent data are currently being provided, in the same structure, on the basis of an agreement with the Wirtschaftsvereinigung Stahl German steel industry association. This change has no impact on relevant calculations.

In addition to providing activity data for sintering plants, blast furnaces, basic oxygen furnaces (converters) and rolling mills, BGS-group data support additional disaggregation of the electric steel sector.

The BGS-group data also permit data-based differentiation of the solid-fuel categories "hard coal and hard coal briquettes"; "coke" and "coke breeze with particle size less than 10 mm". Fuel inputs for coke and coke breeze are summed, and listed under "coke". The "liquid fuels" listed for the BGS group are classified under "heating oil, heavy".

The BGS-group data list fuel inputs in natural units. For the present purpose, those units are converted into energy units, using the relevant net calorific values listed by the Working Group on Energy Balances (AGEB). For gases, the BGS-group data use a norm of 35.16912 MJ/m^3. That figure has been adopted in the methods for calculating activity data for blast-furnace gas, coke-oven gas, natural gas and converter gas.

The method for calculating emissions from secondary fuels has been retained, in keeping with the results of the research project "Einsatz von Sekundärbrennstoffen" ("Inputs of secondary fuels"; UBA 2005b, FKZ 204 42 203/02).

In the area of emissions from the iron and steel industry, a distinction is made, for the entire time series as of 1990, between process-related emissions and energy-related emissions. The method for calculation of process-related emissions is described in Chapter 4.4.1.2 of source category 2.C.1.

3.2.9.1.3 Uncertainties and time-series consistency (1.A.2.a)

Uncertainties were determined for all fuels in 2004 (except for substitute fuels), and for substitute reducing agents, with regard to the entire time series. The relevant method is described in a research report (UBA 2005b, FKZ 204 42 203/02). The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) included in the relevant final report.

The statistical data used for calculation until the 2011 report, from the Federal Statistical Office's Fachserie 4 Reihe 8.1, were aggregated in keeping with the BGS-group framework in those statistics. When production of those statistics has been discontinued, the basic BGS-group data will be used directly for calculation.

Direct use of the BGS-group data does not increase the uncertainties. The uncertainties as determined on the basis of the research report were retained, in keeping with the conservative approach applied.

The BGS-group data are available for all reporting years; consequently, the time series is consistent. Legislation is currently being prepared that would ensure the continued availability of the data in the current form. Data provision until a relevant legal provision is in place has been contractually assured via an agreement with the steel-industry assocation.

3.2.9.1.4 Source-specific quality assurance / control and verification (1.A.2.a)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Source category 1.A.2.a, in conjunction with source category 2.C.1, presents extremely complex issues, since there are discrepancies between pertinent methods used in connection with the Energy Balance, with emissions reporting, with emissions trading and with relevant association statistics. In the interest of data quality assurance, regular experts' discussions have to be carried out for the purpose of comparing and evaluating data.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

The aforementioned agreement with the steel-industry association calls for the association to carry out quality assurance for the BGS-group data in keeping with the QSE manual.

3.2.9.1.5 Source-specific recalculations (1.A.2.a)

For this source category, this year recalculations were carried out for the year 2010, because the pertinent final Energy Balance (updated) became available; the last report made use of the provisional Energy Balance. The recalculations have led to the following changes in CO_2 emissions for 2010:

Table 35: Recalculations in CRF 1.A.2.a

Units [Gg]	NIR 2012	NIR 2013	Difference, absolute				Difference, relative
Year	Total	Total	gas	liquid	solid	Total	Total
2010	34,269	36,050	255	35	1,491	1,780	5.20%

3.2.9.1.6 Planned improvements (source-specific) (1.A.2.a)

No improvements are planned at present.

3.2.9.2 Manufacturing industries and construction – non-ferrous metals (1.A.2.b)

CRF 1.A.2.b	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	CO_2	-	-	1,601.2	(0.13%)	1,608.0	(0.17%)	0.42%
All fuels	N_2O	-	-	17.8	(0.00%)	8.6	(0.00%)	-51.66%
All fuels	CH_4	-	-	1.2	(0.00%)	1.5	(0.00%)	28.69%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category *Non-ferrous metals* is not a key category.

3.2.9.2.1 Source category description (1.A.2.b)

This source category aggregates process combustion of various areas of non-ferrous-metal production. The available data do not support more detailed description.

3.2.9.2.2 Methodological issues (1.A.2.b)

The pertinent fuel inputs are contained in the Balance of Emission Causes (BEU). The source for fuel inputs consists of statistics for the manufacturing sector (Statistik 060 – Energieverwendung des produzierenden Gewerbes (energy use in the manufacturing sector; *STATISTISCHES BUNDESAMT* (Federal Statistical Office) 2011b) (Melde-Nr. (reporting number) 27.43 (WZ 2003 old; WZ = classification system for economic data) → 24.43 (WZ 2008 new); Erzeugung und erste Bearbeitung von Blei, Zink und Zinn (production and initial processing of lead, zinc and tin) 27.44 (WZ 2003 old) → 24.44 (WZ 2008 new); Erzeugung und erste Bearbeitung von Kupfer (production and initial processing of copper)) and, for differentiations relative to heat and electricity production, Statistik 067 (*STATISTISCHES BUNDESAMT*, 2011c).

Descriptions of calculation algorithms for activity data in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

As a result of such revision, production and initial processing of precious metals, aluminium and other non-ferrous metals are now taken into account in determination of activity data.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The 1990 activity data for the new German Länder were revised and substantiated, with the help of new data, in the project "Base year and updating" ("Basisjahr und Aktualisierung" (UBA 2005c: FKZ 205 41 115); see Annex Chapter 19.1.1).

3.2.9.2.3 Uncertainties and time-series consistency (1.A.2.b)

Uncertainties for all activity data were determined in 2004. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.2.4 Source-specific quality assurance / control and verification (1.A.2.b)

For the EF and ED, quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the AD (activity data). .

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.2.5 Source-specific recalculations (1.A.2.b)

For this source category, this year recalculations were carried out for the year 2010, because the pertinent final Energy Balance (updated) became available; the last report made use of the provisional Energy Balance. The recalculations have led to the following changes in CO_2 emissions for 2010:

Table 36: Recalculations in CRF 1.A.2.b

Units [Gg]	NIR 2012	NIR 2013	Difference, absolute				Difference, relative
Year	**Total**	**Total**	gas	liquid	solid	**Total**	**Total**
2010	1,463	1,572	110	14	-15	**109**	**7.48%**

3.2.9.2.6 Planned improvements (source-specific) (1.A.2.b)

No improvements are planned at present.

3.2.9.3 Manufacturing industries and construction – Chemicals (1.A.2.c)

CRF 1.A.2.c	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**IE**	**IE**	**IE**	**IE**	**IE**	**IE**	**IE**	**IE**

The chemical industry's process combustion and own power production are not listed separately; instead, they are summarised in 1.A.2.f Other.

Fuel inputs in calcium-carbide production are process-related and are reported under CRF 2.B.4 (cf. Chapter 4.3.4).

This approach has been confirmed by the research project "Base year and updating" (UBA 2005c, FKZ 205 41 115), for 1990 in the new German Länder (the most important production location): the relevant coke was used as a production material and not as a fuel for energy. Calcium-carbide production is thus not a source of energy-related CO_2 emissions.

The emissions for the entire sub- source category 1.A.2.c are thus included elsewhere (IE). 1.A.2.c has not been listed separately in the key-category analysis.

The data currently available do not permit identification of the relevant steamcrackers.

3.2.9.4 Manufacturing industries and construction – Pulp, paper and print (1.A.2.d)

CRF 1.A.2.d	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	CO_2	-	-	3.6	(0.00%)	14.6	(0.00%)	301.68%
All fuels	N_2O	-	-	2.9	(0.00%)	13.3	(0.00%)	354.24%
All fuels	CH_4	-	-	0.5	(0.00%)	2.5	(0.00%)	354.24%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2		IE	

The source category *Pulp, paper and print* is not a key category.

3.2.9.4.1 Source category description (1.A.2.d)

The energy consumption for production of pulp, paper and printed products – otherwise referred to as the "pulp and paper industry" for short – can be described only for substitute fuels, of which this industry uses large amounts.

Emissions from use of regular fuels in process combustion, and emissions generated by plants in own-power production, have not been listed separately. They are summarised under 1.A.2.f Other.

3.2.9.4.2 Methodological issues (1.A.2.d)

Only some of the substitute fuels used by the paper industry are listed in the Energy Balance. The fuels in question consist of waste from the relevant sectors' own production areas. The data on the types and amounts of substances used were provided by the German Pulp and Paper Association (VDP). The great majority of the substitute fuels used in the sector consist of wood and pulp fibres – and, thus, of biomass. The biogenic and fossil fractions of pertinent fuels were derived in the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen") (UBA 2005b, FKZ 204 42 203/02). In addition, CO_2 emission factors were derived on the basis of data on carbon content, water content and net calorific values.

3.2.9.4.3 Uncertainties and time-series consistency (1.A.2.d)

In the framework of a research project, the uncertainties of the CO_2 emission factors derived for substitute fuels were determined using the Monte Carlo method (UBA 2005b, FKZ 204 42 203/02). In the procedure, figures for C content, water content and net calorific value were taken into account. Such figures are based on varying estimates, as well as on small numbers of measurements and analysis results, and thus show wide spreads. The CO_2 emission factors for secondary fuels, along with the relevant uncertainties, apply throughout the entire relevant time series, because no findings on trends are available. The time series are thus consistent.

3.2.9.4.4 Source-specific quality assurance / control and verification (1.A.2.d)

For the EF and ED, quality control (pursuant to Tier 1), in conformance with the requirements of the QSE manual and its associated applicable documents, has been carried out. The responsible experts have been unable to carry out quality assurance. The Single National Entity has carried out additional quality assurance.

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the AD (activity data). .

The paper industry has long kept records of inputs of secondary fuels (VDP, various years). In spite of small structural breaks in the time series in such records, the records clearly show the paper industry's increasing use of substitute fuels in place of regular fuels.

3.2.9.4.5 Source-specific recalculations (1.A.2.d)

Updating of the relevant fuel data led to the following recalculations:

Units [Gg] Year	NIR 2012 Total	NIR 2013 Total	Difference, absolute Total	Difference, relative Total
2009	12	8	-4	-32.04%
2010	9	9	0	5.42%

3.2.9.4.6 Planned improvements (source-specific) (1.A.2.d)

No improvements are planned at present.

3.2.9.5 Manufacturing industries and construction – Sugar production (1.A.2.e)

CRF 1.A.2.e	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**-**	**T/-**	**1,989.2**	**(0.16%)**	**190.7**	**(0.02%)**	**-90.41%**
All fuels	N_2O	-	-	25.6	(0.00%)	2.1	(0.00%)	-91.73%
All fuels	CH_4	-	-	3.8	(0.00%)	0.1	(0.00%)	-96.86%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The *Sugar production* source category is a key category for CO_2 emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-90.41 %), and thus an extremely low emissions level has been attained, the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

3.2.9.5.1 Source-category description (1.A.2.e)

This source category includes only the sugar industry's process combustion. Plants generating their own power are not listed separately; they are reported under 1.A.2.f Other.

3.2.9.5.2 Methodological issues (1.A.2.e)

Descriptions of calculation algorithms for activity data in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

As a result of this revision, it was determined that the statistics publications Statistik 060 (*STATISTISCHES BUNDESAMT*, 2010b) and Statistik 067 (*STATISTISCHES BUNDESAMT*, 2010c) list all of the fuels required for calculation of the pertinent activity data and should be used as data sources.

The relevant calculation algorithms, and special analyses relative to fuel inputs, are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.5.3 Uncertainties and time-series consistency (1.A.2.e)

For 2004, the uncertainties for all activity data were determined for the first time. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.5.4 Source-specific quality assurance / control and verification (1.A.2.e)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance for the EF and ED carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the AD.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.5.5 Source-specific recalculations (1.A.2.e)

For this source category, this year recalculations were carried out for the years 2009 and 2010, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance. For 2009, the recalculations corrected an error in the area of gaseous fuels.

The recalculations have led to the following changes in CO_2 emissions:

Units [Gg]	NIR 2011	NIR 2012	Difference, absolute				Difference, relative
Year	Total	Total	gas	liquid	solid	Total	Total
2009	**450**	**238**	**-212**	**0**	**0**	**-212**	**47.08%**
2010	**459**	**178**	**-218**	**-59**	**-3**	**-281**	**-61.19%**

3.2.9.5.6 Planned improvements (source-specific) (1.A.2.e)

No improvements are planned at present.

3.2.9.6 Manufacturing industries and construction – Other (1.A.2.f, sum)

CRF 1.A.2.f	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	137,298.8	(11.27%)	78,190.5	(8.45%)	-43.05%
All fuels	N_2O	-	-	1,180.2	(0.10%)	647.6	(0.07%)	-45.13%
All fuels	CH_4	-	-	178.7	(0.01%)	94.4	(0.01%)	-47.20%

The source category *Manufacturing industries and construction – Other*, the sum of all other sub- source categories, is a key category, in terms of emissions level and trend, for CO_2 emissions. Key-category analysis was carried out only for the sum of sub- source categories in 1.A.2.f.

The NIR inventory structure includes the sub- source categories 1.A.2.f Cement (structural element "Production of cement clinkers (process combustion)"), 1.A.2.f Ceramics (structural element "Production of ceramics products (process combustion)"), 1.A.2.f Glass (structural element "Production of glass (process combustion)"), 1.A.2.f Lime (structural element "Production of lime (process combustion)") and 1.A.2.f Other ("other manufacturing" in the CSE, with various structural elements).

Binding key-category analysis has been carried out. In addition, the predominant (in terms of emissions) sub- source categories have been identified. 1.A2.f Cement and 1.A.2.f Other are worthy of special note: 1.A2.f Cement as a significant source of process combustion, and 1.A.2.f Other as a collective group that includes emissions from heat and power production of industrial power stations and industrial boiler systems, as well as (inter alia) energy-related emissions from the chemical industry.

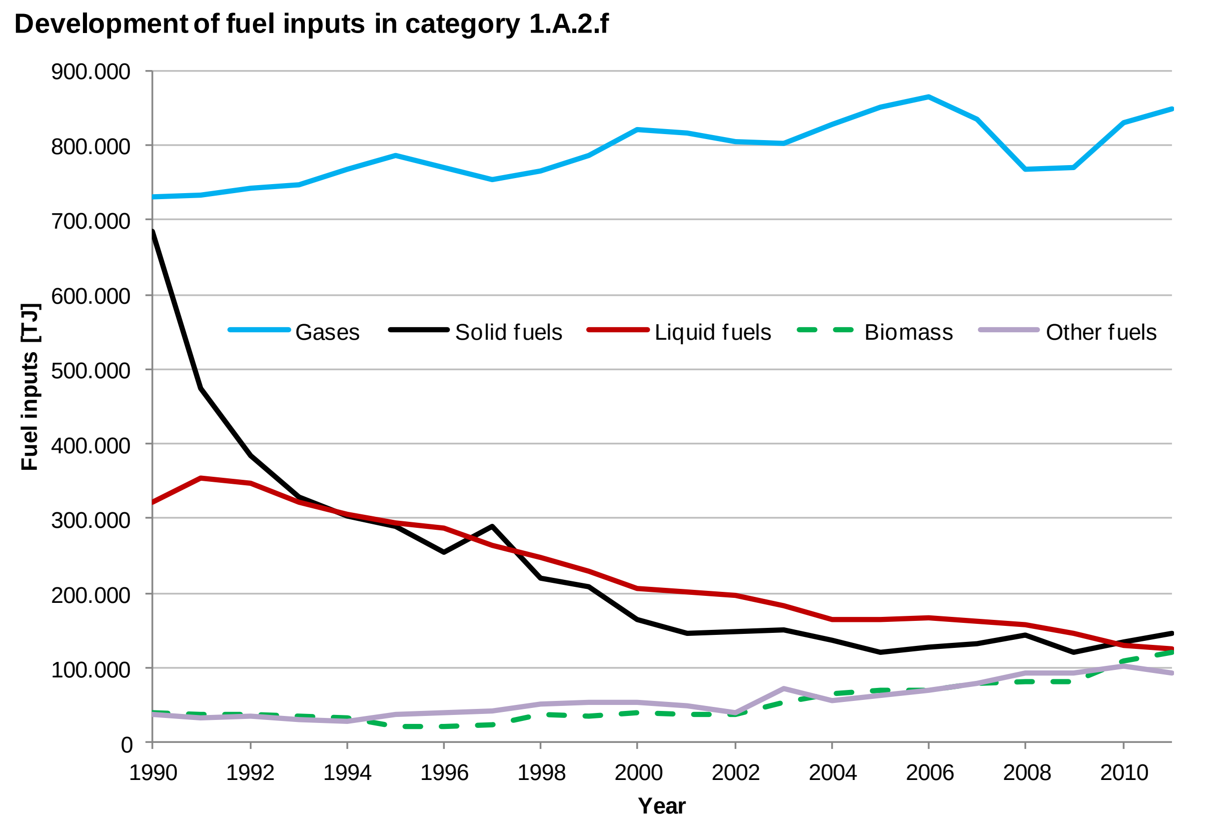


Figure 30: Development of fuel inputs in source category 1.A.2.f

This source category exhibits a marked change in fuel inputs.

A particularly noticeable decrease in use of solid fuels has occurred, primarily via reduced use of lignite and intensified use of gas, biomass and substitute fuels (waste).

A statistical discontinuity is seen in the area of biomass. Prior to the entry into force of the Act on Energy Statistics (Energiestatistikgesetz), biomass inputs for energy generation either were not recorded statistically or were recorded only in part. Biomass's share of energy generation has been increasing.

In 2009, inputs of nearly all fossil fuels decreased markedly, as a result of the economic slowdown. In 2010, those inputs then increased considerably, as a result of economic recovery. In 2011, the inputs have remained unchanged from their 2010 level.

3.2.9.7 Manufacturing industries and construction – Cement production (1.A.2.f, Cement)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS/IE	NS/IE	CS/IE

Outside of the framework of binding key-category analysis, this sub- source category must be considered particularly important.

3.2.9.7.1 Source-category description (1.A.2.f, Cement)

In this source category, only process combustion from burning of clinkers can be listed. The final step in cement production, i.e. grinding and mixing, is not included. As a power-intensive process, it is included in power production (1.A.1). Some plants within this category also generate power for their own use; such generation is not listed separately, but is included under 1.A.2.f Other.

In addition to substitutions of raw materials (smelter slag instead of cement clinkers, a subject not treated here in its own right), cement production involves considerable fuel substitutions in burning of clinkers. In the process, both conventional fuels, such as lignite, hard coal, oil and gas, and "secondary fuels" (waste from other economic sectors) are used. This reduces consumption of regular fuels.

3.2.9.7.2 Methodological issues (1.A.2.f, Cement)

The pertinent inputs of conventional fuels are contained in the Balance of Emission Sources (BEU). The source for fuel inputs for energy-related process combustion is Statistik des produzierenden Gewerbes (manufacturing-sector statistics; Melde-Nr. (reporting number) 26.51 (WZ 2003 old; WZ = classification system for economic data) → 23.51 (WZ 2008 new), Cement production). The source for pertinent differentiation from heat and electricity production is Statistik 067 (*STATISTISCHES BUNDESAMT* (Federal Statistical Office), 2011c).

As of 2002, the data for Statistik 067 (op. cit.) are found only among three-digit reporting numbers. This means that only data for reporting number 26.5 (WZ 2003 old) → 23.5 (WZ 2008 new) (production of cement, lime and burnt plaster) can be used as a basis.

To permit relevant separation, the individual data available for the period through 2001 for production of cement (reporting number 26.51 (WZ 2003 old) → 23.51 (WZ 2008 new)), production of lime (reporting number 26.52 (WZ 2003 old) → 23.52 (WZ 2008 new)) and production of plaster (reporting number 26.53 (WZ 2003 old) → 23.53 (WZ 2008 new)) were analysed. The various types of production involved (cement, lime, plaster) were differentiated via allocation of individual fuels.

In the process, it was seen that relevant fuel inputs in electricity-generating plants were listed only for production of cement and plaster. In addition, in all years only light heating oil was listed for the cement industry, while for the plaster industry coal dust and dry coal, and natural gas and heavy heating oil, were also listed. For this reason, fuel inputs for light heating oil (Meldenummer (reporting number) → 26.5 (WZ 2003 old) 26.5 (WZ 2008 new)) have been allocated to the cement industry, in the relevant proportions.

It is assumed that the fuel “Other petroleum products”, which was reported for the first time in Statistik 067 (*STATISTISCHES BUNDESAMT* (Federal Statistical Office), 2011c) as of 2003, must also be allocated to the plaster industry, since technologies used to date in the cement industry (for use of light heating oil) are not suited for use of other petroleum products.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The fuel inputs for the new German Länder in 1990 were calculated on the basis of specific fuel consumption in 1989 and production in 1990.

The cement industry uses significant amounts of substitute fuels that do not appear in national statistics and in the Energy Balance. Relevant production figures and fuel-use amounts have been taken from statistics of the VDZ cement-industry association. The procedure used to compile activity data oriented to the old and new German Länder as of 1990, and to all of Germany as of 1995, is described in the final report of the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; UBA 2005b, FKZ 204 42 203/02). Data on the relevant types, amounts and energy contributions of the substitute fuels used were provided by the VDZ.

In a first step, fuel inputs were allocated to the groups "Biomass" or "Other fuels (waste)", in keeping with IPCC procedures. In the research project "Inputs of secondary fuels", the biogenic fractions of relevant fuels were derived and then entered into the calculations, with the help of split factors. In the same project, CO_2 emission factors were derived for substitute fuels, on the basis of data on carbon content, water content and net calorific value (UBA 2005b, FKZ 204 42 203/02).

3.2.9.7.3 Uncertainties and time-series consistency (1.A.2.f, Cement)

In the framework of the research project "Inputs of secondary fuels", the uncertainties of the CO_2 emission factors derived for substitute fuels were determined using the Monte Carlo method (UBA 2005b, FKZ 204 42 203/02). In the procedure, figures for C content, water content and net calorific value were taken into account. Such figures are based on varying estimates, as well as on small numbers of measurements and analysis results, and thus show wide spreads. The CO_2 emission factors for secondary fuels, along with the relevant uncertainties, apply throughout the entire relevant time series, because no findings on trends are available. The time series are thus consistent.

Uncertainties were determined for all fuels in 2004 and for the aforementioned substitute fuels with regard to the entire time series. The relevant methods are explained in Annex Chapter 13.6 of the NIR 2007 and in the final report of the research project (UBA 2005b, FKZ 204 42 203/02).

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) included in the relevant final report.

The activity data for the new German Länder, for base year 1990 and the following years, 1991-1994, were adjusted in keeping with findings from the pertinent research project (FKZ 205 41 115 / Sub-project A "Revison and substantiation of fuel inputs for stationary combustion plants in the new German Länder for the year 1990"). The relevant recalculation method is described in the Annex, 19.1.2.1.

3.2.9.7.4 Source-specific quality assurance / control and verification (1.A.2.f, Cement)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

In the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"), the data series for inputs of substitute fuels in the cement industry were subjected to intensive quality checks (UBA 2005b, FKZ 204 42 203/02). In addition, figures of the Verein der Zementindustrie (VDZ) cement-industry association were checked for validity and integrated within their proper sectoral context.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.7.5 Source-specific recalculations (1.A.2.f, Cement)

Recalculations had to be carried out for 2010, since the relevant final Energy Balance became available (the last report used the relevant provisional Energy Balance) and showed that all values for the year 2010 had to be corrected. The resulting changes are as follows:

Table 37: Recalculations in CRF 1.A.2.f Cement

Units [Gg]	NIR 2012	NIR 2013	Difference, absolute					Difference, relative
Year	Total	Total	gas	liquid	other	solid	Total	Total
2010	6,730	6,132	-5	-259	0	-334	**-597**	**8.88%**

3.2.9.7.6 Planned improvements (source-specific) (1.A.2.f, Cement)

Fuel allocations to the areas cement, lime and plaster is to be reviewed.

3.2.9.8 Manufacturing industries and construction – Ceramics (1.A.2.f, Ceramics)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS/IE	NS/IE	CS/IE

3.2.9.8.1 Source-category description (1.A.2.f, Ceramics)

Source category Ceramics, 1.A.2.f, includes process combustion in the brick industry, including other construction ceramics. Some plants within this category also generate power for their own use; such generation is not listed separately, but is included under 1.A.2.f Other.

3.2.9.8.2 Methodological issues (1.A.2.f, Ceramics)

The fuel inputs for process combustion are calculated in the Balance of Emission Sources (BEU). The fuel-input data have been taken from manufacturing industry statistics (Statistik des produzierenden Gewerbes; Melde-Nr. (reporting no.) 26.40 (WZ 2003 old) → 23.32 (WZ 2008 new), Ziegelei (brickworks), production of other construction ceramics), and, for differentiation from heat and electricity production, Statistik 067 (*STATISTISCHES BUNDESAMT* (Federal Statistical Office), 2011c).

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.8.3 Uncertainties and time-series consistency (1.A.2.f, Ceramics)

Uncertainties for all fuels were determined, for the first time, for 2004 (research project "Substantiation of the data quality of activity data, FKZ 204 41 132)". The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.8.4 Source-specific quality assurance / control and verification (1.A.2.f, Ceramics)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.8.5 Source-specific recalculations (1.A.2.f, Ceramics)

For this source category, this year recalculations were carried out for the year 20010, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance.

3.2.9.8.6 Planned improvements (source-specific) (1.A.2.f, Ceramics)

No improvements are planned at present.

3.2.9.9 Manufacturing industries and construction – Glass (1.A.2.f, Glass production)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS/IE	NS/IE	CS/IE

3.2.9.9.1 Source-category description (1.A.2.f, Glass production)

This sub- source category includes process combustion for the areas of flat-glass production; concave-glass production; production of glass fibre; finishing and processing of flat glass; and production and finishing of other glass and technical glass products.

Some plants within this category also generate power for their own use; such generation is not listed separately, but is included under 1.A.2.f Other.

3.2.9.9.2 Methodological issues (1.A.2.f, Glass production)

The source for fuel inputs for energy-related process combustion is Statistik des produzierenden Gewerbes (manufacturing-sector statistics; Melde-Nr. (reporting number) 26.1 (WZ 2003 old; WZ = classification system for economic data) → 23.1 (WZ 2008 new), Production of glass and glassware). The source for pertinent differentiation from heat and electricity production is Statistik 067 (*STATISTISCHES BUNDESAMT* (Federal Statistical Office), 2011c).

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.9.3 Uncertainties and time-series consistency (1.A.2.f, Glass production)

Since 1995, when official statistics were converted to the economic-sector classification system (Klassifikation der Wirtschaftszweige; *STATISTISCHES BUNDESAMT* (Federal Statistical Office), 2002c), only one set of statistics has been used for Germany as a whole. This has considerably improved time-series consistency in comparison to that for the period 1990 to 1994.

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and included in the relevant final report.

Uncertainties were determined for all activity data, for the first time, for the year 2004. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.9.4 Source-specific quality assurance / control and verification (1.A.2.f, Glass production)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.9.5 Source-specific recalculations (1.A.2.f, Glass production)

For this source category, this year recalculations were carried out for the year 2010, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance.

3.2.9.9.6 Planned improvements (source-specific) (1.A.2.f, Glass production)

No improvements are planned at present.

3.2.9.10 Manufacturing industries and construction – Lime (1.A.2.f, Lime production)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS/IE	NS/IE	CS/IE

3.2.9.10.1 Source-category description (1.A.2.f, Lime production)

With regard to inputs of conventional fuels and to inputs of substitute fuels, the process-combustion figures refer to production of lime.

3.2.9.10.2 Methodological issues (1.A.2.f, Lime production)

The relevant inputs of regular fuels are contained in the Balance of Emission Sources (BEU). The fuel-input data has been taken from manufacturing industry statistics (Statistik des produzierenden Gewerbes; Melde-Nr. (reporting no.) 26.52/lime (WZ 2003 old) → 23.52 (WZ 2008 new)).

Pursuant to Statistik 067 (*STATISTISCHES BUNDESAMT* (Federal Statistical Office), 2011c), in the years 1995 – 2001 the lime industry used no fuels for electricity production. It is assumed that this industry will continue to produce no electricity. For calculations, therefore, only Statistik 060 (*STATISTISCHES BUNDESAMT* (Federal Statistical Office), 2011b) is used.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The fuel inputs for the new German Länder in 1990 were calculated on the basis of specific fuel consumption in 1989 and production in 1990.

Since 2003, the lime industry has used minor amounts of substitute fuels that do not appear in national statistics and in the Energy Balance. The fuel-input data was provided by the Bundesverband der Deutschen Kalkindustrie national lime-industry association. The procedure used to compile activity data oriented to the territory of Germany, for the period as of 2003, is described in the final report of the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; UBA 2005b, FKZ 204 42 203/02). The data on the types and amounts of substitute fuels used were also provided by the Bundesverband der Deutschen Kalkindustrie national lime-industry association. In the research project "Inputs of secondary fuels", the biogenic fractions of relevant fuels were derived and then entered into the calculations, with the help of split factors. In the same project, CO_2 emission factors were derived for substitute fuels, on the basis of data on carbon content, water content and net calorific value (ibid.).

3.2.9.10.3 Uncertainties and time-series consistency (1.A.2.f, Lime)

Since 1995, when official statistics were converted to the economic-sector classification system (Klassifikation der Wirtschaftszweige; *FEDERAL STATISTICAL OFFICE*, 2002c), only one set of conventional-fuel statistics has been used for Germany as a whole. This has considerably improved time-series consistency in comparison to that for the period 1990 to 1994.

Uncertainties were determined for all regular fuels, for the first time, for the year 2004. The relevant method is described in Annex 13.6 of the NIR 2007.

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and included in the relevant final report.

In the framework of the research project "Inputs of secondary fuels" (UBA 2005b, FKZ 204 42 203/02), the uncertainties of the CO_2 emission factors derived for substitute fuels were determined using the Monte Carlo method. Such figures are based on varying estimates, as well as on small numbers of measurements and analysis results, and thus show wide spreads. The CO_2 emission factors for secondary fuels, along with the relevant uncertainties, apply throughout the entire relevant time series, because no findings on trends are available. The time series are thus consistent.

The activity data for the new German Länder, for base year 1990 and the following years, 1991-1994, were adjusted in keeping with findings from the pertinent research project (FKZ

205 41 115 / Sub-project A "Revison and substantiation of fuel inputs for stationary combustion systems in the new German Länder for the year 1990").

3.2.9.10.4 Source-specific quality assurance / control and verification (1.A.2.f, Lime)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

In the research project "Inputs of secondary fuels" (UBA 2005b, FKZ 204 42 203/02), the time series for data on substitute-fuel inputs in the lime industry were also intensively checked for consistency and plausibility. To those ends, the industry's entire energy and emissions situation was considered – i.e. the same procedure was used that has been applied to other economic sectors with substitute-fuel inputs. Such quality assurance is subject to the constraint that the relevant data provided by the Bundesverband Kalk lime-industry association begin with the year 2003, however.

The data obtained fit with the overall picture for the sector, in light of relevant other fuel consumption and the pertinent CO_2 emissions.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.10.5 Source-specific recalculations (1.A.2.f, Lime production)

For this source category, this year recalculations were carried out for the year 2010, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance.

3.2.9.10.6 Planned improvements (source-specific) (1.A.2.f, Lime production)

Fuel allocations to the areas cement, lime and plaster is to be reviewed.

3.2.9.11 Manufacturing industries and construction – Other energy production (1.A.2.f, Other)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

As a result of its function as a collective category for fuel inputs that cannot be disaggregated to the individual-sector level, this sub- source category is particularly significant; it contributes substantially to the entire energy sector's CO_2 emissions.

3.2.9.11.1 Source-category description (1.A.2.f Other)

In this sub- source category, all those emissions are reported for which the relevant energy inputs cannot be disaggregated in keeping with the categories in 1.A.2. This sub- source category is responsible for about ¾ of all CO_2 emissions of source category 1.A.2. When emissions from use of biomass in process combustion are not included, its share becomes even larger.

All heat and power generation in industrial power stations and boiler systems is listed in this sub- source category. All energy-related emissions from the chemical industry are also reported in it. No specific data are assigned to the structural element "Other process combustion". A large part of the energy inputs listed in 1.A.2.f Other should really be allocated to the various corresponding sectors, but the available data do not permit such allocation. Since no delivery data are available for the gases in source category 1.A.2, these gases cannot be assigned to the various individual processes. They are thus reported here in sum form.

3.2.9.11.2 Methodological issues (1.A.2.f Other)

The fuel inputs for electricity generation in industrial power stations are shown in Energy Balance line 12. The difference resulting after deduction of the fuel inputs for refinery power stations, mine power stations, power stations in the hard-coal-mining sector and, for the period until 1999, for the power stations of Deutsche Bahn (German Railways) consists of the activity data for other industrial power stations. These data cannot be further differentiated at present.

Additional data from the Federal Statistical Office are needed for allocation of fuel inputs to heat production in industrial power stations and boiler systems. Fuel inputs for heat production in CHP systems can be determined from relevant statistics. The activity data for boiler systems are calculated as the pertinent difference.

For both electricity production and heat production, gas turbines, gas and steam systems and gas engines are differentiated.

A detailed description of the relevant calculation algorithms, which were extensively revised for the 2008 reporting year, is provided in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; FKZ 204 41 132).

With the new data source "BGS-Bogen" ("BGS form; see above), it has become possible to list, separately, use of top gas for energy production in live-steam boilers in the iron and steel industry.

The total energy quantity listed in Energy Balance line 54 (metal production), for use of top gas, is lower than the total top-gas input as shown by the BGS data (see above). The thusly underestimated input quantity is assigned, by definition, to part of the relevant flaring and line losses.

Emission factors (except for that for CO_2)

The emission factors for power stations and other boiler combustion for production of steam and hot/warm water, in source category 1.A.1.f / all other, have been taken from RENTZ et al (2002) and FICHTNER et al (2011). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. The research projects break down the relevant sector into power stations of Deutsche Bahn AG, other industrial power stations and other boiler combustion systems for production of steam and hot/warm water.

3.2.9.11.3 Uncertainties and time-series consistency (1.A.2.f, Other)

Activity data

The uncertainties were determined, for the first time, for 2004. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) included in the relevant final report.

Emission factors

The procedure for determining uncertainties is described in Chapter 3.2.6.3.1.

Result for N_2O: The results of Chapter 3.2.6.3.2 apply mutatis mutandis.

Result for CH_4: The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

The results obtained in Chapter 3.2.6.3.4 in determination of time-series consistency apply mutatis mutandis.

3.2.9.11.4 Source-specific quality assurance / control and verification (1.A.2.f, Other)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

Activity data

The quality of the data was reviewed in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; FKZ 204 41 132) and improved via use of statistics of the Federal Statistical Office as a database. No other data sources with long-term availability have been identified.

Emission factors

The results obtained in Chapter 3.2.6.4, in the general procedure for source-specific quality assurance / control and verification, apply mutatis mutandis.

3.2.9.11.5 Source-specific recalculations (1.A.2.f, Other)

Activity data

For this source category, this year recalculations were carried out for the year 2010, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance. In addition, recalculations were carried out to take account of the revision of the waste model, in which a number of instances of double-counting were identified and eliminated.

Table 38: Recalculations for CO_2 in CRF 1.A.2.f Other

Units [Gg] Year	NIR 2012 Total	NIR 2013 Total	Difference, absolute gas	liquid	other	solid	Total	Difference, relative Total
2004	63,254	61,776	0	0	-1,477	0	**-1,477**	**-2.34%**
2005	64,743	63,729	0	0	-1,014	0	**-1,014**	**-1.57%**
2006	65,742	65,106	0	0	-636	0	**-636**	**-0.97%**
2007	65,085	63,649	0	0	-1,435	0	**-1,435**	**-2.21%**
2008	62,419	61,574	0	0	-845	0	**-845**	**-1.35%**
2009	61,082	59,979	212	-137	-1,178	1	**-1,103**	**-1.81%**
2010	64,616	63,886	2,045	-412	-1,954	-408	**-731**	**-1.13%**

Emission factors:

The results of Chapter 3.2.6.5 apply mutatis mutandis.

3.2.9.11.6 Planned improvements (source-specific) (1.A.2.f, Other)

Activity rates:

No improvements are planned at present.

Emission factors:

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

3.2.10 Transport (1.A.3)

3.2.10.1 Transport – Civil aviation (1.A.3.a)

3.2.10.1.1 Source category description (1.A.3.a)

CRF 1.A	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Aviation gas	CO_2	-	-	2,309.6	(0.19%)	1,836.9	(0.20%)	-20.47%
Aviation gas	N_2O	-	-	24.0	(0.00%)	19.3	(0.00%)	-19.40%
Aviation gas	CH_4	-	-	2.0	(0.00%)	1.8	(0.00%)	-11.14%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 1, Tier 2	NS/IS	CS D (lubricants)
CH_4	Tier 1, Tier 2	NS/IS	D
N_2O	Tier 1, Tier 2	NS/IS	D
NO_X, CO	Tier 3	NS/IS	CS
NMVOC	Tier 1, Tier 3	NS/IS	CS/D
SO_2	Tier 1	NS/IS	CS

The source category *Civil aviation* is not a key category.

In terms of emissions origins, air transports differ considerably from land and water transports, since aircraft burn most of their fuel under atmospheric conditions that differ from those on the ground and that are not constant. The main factors that influence the combustion process in this sector include atmospheric pressure, environmental temperature and humidity – all of which are factors that vary considerably with flight altitude.

In addition to considering carbon dioxide, the debate on the climate effects and airborne-emissions-related environmental impacts of air transports focuses mainly on water vapour and nitrogen oxides and, secondarily, on hydrocarbons, particulates, carbon monoxide and sulphur dioxide. In the framework of national emissions reporting, figures for other emissions are also required, however. The following remarks thus refer to emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O, laughing gas), nitrogen oxides (NO_X, i.e. NO and NO_2), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), sulphur dioxide (SO_2), particulates (total suspended particulates; TSP) and ammonia (NH_3).

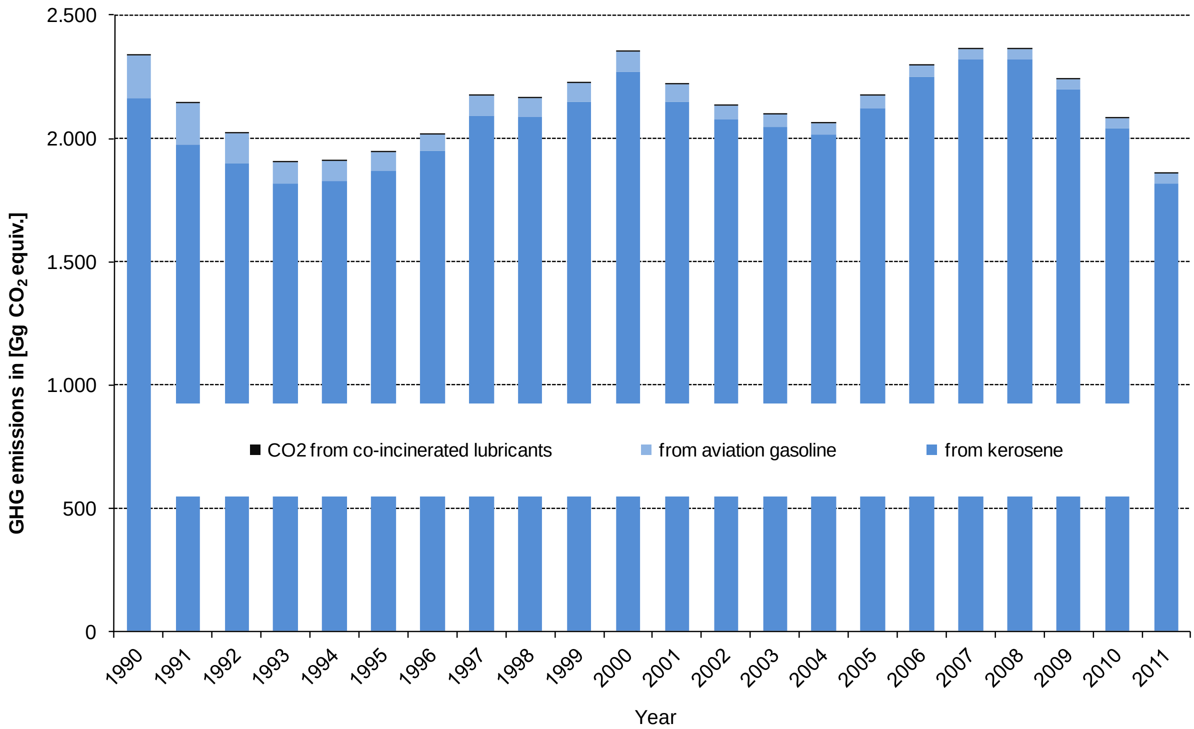


Figure 31: Development of greenhouse-gas emissions in national air transports, 1990 – 2011

3.2.10.1.2 Methodological issues (1.A.3.a)

This year, air-transport emissions are being calculated for the first time in accordance with Tier 3a, i.e. taking account of the annual flight mileages logged by the relevant individual aircraft types, broken down by national and international flights, and taking account of the operational states LTO cycle (landing/take-off cycle, i.e. aircraft movements to an elevation of 3,000 feet / about 915 m) and cruise.

In general, emissions are determined on the basis of the Energy Balance data for consumption of kerosene and aviation gasoline (AGEB, 2012). For years for which no data are yet available, data of the Federal Office of Economics and Export Control (BAFA, 2012) are used. The manner in which national (domestic, i.e. within Germany) and international air transports are differentiated plays a decisive role in reporting. The differentiation is achieved via a "split factor" that describes national kerosene consumption as a share of total kerosene consumption. For all years as of 2003, pertinent figures provided by Eurocontrol, the European Organisation for the Safety of Air Navigation, are used. Using the ANCAT model, Eurocontrol calculates fuel consumption on the basis of individual aircraft movements. It does not cross-check fuel consumption against national Energy Balances, however. The split factor for the years 1990 through 2002 has been determined in a different manner – with the help of a research project's findings relative to the mileage, expressed in terms of great-circle distances, flown by the various different types of aircraft (FKZ 360 16 029 – "Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV)" ("Development of an independent model for calculations oriented to air transports (TREMOD-AV)"; (IFEU & ÖKO-INSTITUT 2010). The relevant data are collected by the Federal Statistical Office. For breakdown of kerosene consumption by the phases LTO (landing/take-off) and cruise, the results of calculations made in TREMOD-AV (TREMOD Aviation), on the basis of data of the Federal Statistical Office, are used.

For reporting purposes, emissions are determined, in each case, by multiplying fuel consumption for the relevant flight phase by the pertinent specific emission factor. CO_2 and SO_2 emissions figures do not depend on what Tier method is used; they depend solely on quantities and characteristics of consumed fuel. Emissions of NMVOC, CH_4, CO, NO_X and N_2O, on the other hand, depend on engines, flight altitudes, flight phases, etc., and thus they are described more precisely by higher-Tier methods. The emission factors for NO_X, CO and HC are thus taken from the results of the TREMOD calculations.

Since 2007, figures for the relevant aviation gasoline consumed are no longer reported together with figures for consumed jet kerosene; they are reported separately. As proposed in IPCC 2006a, emissions from consumption of aviation gasoline are calculated separately, with adapted emission factors and net calorific values, pursuant to the Tier 1 method. In such calculation, there is no need for any breakdown into national and international transports; aviation gasoline is used only in smaller aircraft that fly mostly domestic routes. That understanding functions as a conservative assumption; it leads to slight overestimation of national emissions.

Activity data:

<u>Aviation turbine fuel / jet kerosene</u>

The relevant consumption data accord with the figures for aviation fuel sold in Germany, pursuant to the national Energy Balance (the latest version, covering the period until 2011) and to the official mineral-oil data provided by the Federal Office of Economics and Export Control (AGEB, 2012; BAFA, 2012).

For the present purposes, jet-kerosene-consumption figures from the Energy Balance and from BAFA statistics have to be broken down by national and international flights, in the manner described above. The calculations within TREMOD-AV take account of the numbers of flights, for the various aircraft types and great-circle distances involved, for national and international air transports. In the process, the commercial flights recorded by the Federal Statistical Office, for certain airports, are included. The Federal Statistical Office differentiates the other types of flights concerned (at other airports, and non-commercial flights) only by weight classes or aircraft classes, however; it does not differentiate them by destination. The great majority of the relevant commercial flights at other airports are flights by small aircraft fuelled with aviation gasoline. The relevant share of such aircraft types is higher in the non-commercial category, which also includes balloons and motorised gliders. Rough calculations pursuant to IFEU & ÖKO-INSTITUT (2010) indicate that it is appropriate to allocate all such flights to (solely national) avgas consumption.

For reasons of international comparability, the data available from Eurocontrol, for the period as of the year 2003, are still being used.

Table 39: Kerosene consumed in air transports within Germany, as a percentage of total domestic deliveries of kerosene, as of 1990

Year		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
national share(1	[%]	15.1	10.8	10.3	8.3	8.4	8.4	8.3	8.1	7.6	7.1

Source: Öko-Institut (2012) 1990-2002: calculated within TREMOD-AV on the basis of flight data of the Federal Statistical Office; as of 2003: Eurocontrol (ANCAT)[213]

Jet-kerosene consumption is broken down, in accordance with the two flight phases *LTO* and *cruise*, with the help of the results of TREMOD-AV calculations. Those results make it possible to extract kerosene consumption figures for the LTO flight phase (cf. IFEU & ÖKO-INSTITUT, 2010), for both national and international air traffic. Consumption in the cruise flight phase then results, in each case, as the difference between kerosene consumption pursuant to the Energy Balance and consumption in the LTO phase.

Avgas

The relevant consumption data accord with the figures for aviation fuel sold in Germany, pursuant to the national Energy Balance and to the official mineral-oil data provided by the Federal Office of Economics and Export Control (AGEB, 2012; BAFA, 2012). In a conservative approach, all relevant consumption is assumed to occur in national flight operations. Pursuant to IPCC 2006a, breakdown by LTO and cruising flight phases is not required.

Lubricants

The figures for annual inputs of lubricants in air transports are taken from the official mineral-oil statistics (Amtliche Mineralölstatistik) of BAFA, and the co-combusted fraction is determined via expert assessment.

Emission factors:

Aviation turbine fuel / jet kerosene

The emission factor for *carbon dioxide* was derived from the carbon content of jet kerosene. The so-determined *implied emission factor for carbon dioxide from kerosene*, 3,150 g/kg, has been confirmed in numerous publications (including IPCC, 1999: p. 3.64), and it is used, without any changes, for all flight operations (national/international; LTO/cruise).

Nitrous oxide (laughing gas) is a product of nitrogen oxidation in the combustion chamber, and it can occur in traces. The available data for this substance are poor. Since the emission factors have to be broken down in accordance with the two flight phases, the emission factors for both nitrous oxide and *methane* have been taken from the IPCC emission factor database (cf. Table 355).

Other emissions are calculated separately by flight phases, on the basis of the relevant emission factors. In the process, different sources are used.

The data for emissions of NO_X, CO and NMVOC are based on aircraft-type-specific emission factors listed in TREMOD-AV. Those emission factors are used to generate the average (implied) emission factors that are used for reporting within the Central System of Emissions

[3] Current values for 2007 through 2011 obtained via personal e-mail contact with Rachel Burbidge, EUROCONTROL

(CSE). For reporting purposes, and in the manner described above, annual average (implied) emission factors are also derived for the entire fleet.

The emissions per LTO cycle are recalculated using standard values for jet-kerosene consumption per LTO cycle: for national flight operations, the relevant figure is 850 kg jet kerosene / LTO, while for international flight operations an average value of 1,675 kg kerosene / LTO cycle is assumed (IPCC 2006b). Figures relative to the air pollutants additionally considered are presented in Chapter 19.1.3.1 in the Annex.

For the relevant years until 2003, emission factors were converted from [kg emissions / kg of burned fuel] to [kg emissions / TJ converted energy] via a net calorific value of 43,000 kJ/kg. As of 2004, a net calorific value of 42,800 kJ/kg (AGEB, 2011a) is used for conversion.

Avgas

Pursuant to IPCC 2006a, no differentiation by LTO cycle and cruise phase is required for avgas. For this reason, no corresponding differentiation of emission factors was carried out.

For purposes of calculation of *CO_2 emissions*, the standard value pursuant to the *IPCC Guidelines* (2006a) is used. In those guidelines (page 3-64), the emission factors for *methane* and *nitrous oxide* are explicitly defined as equal to the relevant values given for jet-kerosene use. That assumption has been adopted here.

In a procedure similar to that used for jet kerosene, the emission factors for NO_X and CO were obtained from the results of TREMOD calculations carried out with aircraft-type-specific emission factors from the EMEP/EEA database. Those factors were then divided by the relevant avgas consumption, to obtain annual, average emission factors for reporting purposes. All pertinent emission factors are listed in Table 40.

Table 40: Emission factors for avgas (1990-2011)

Greenhouse gas (GG; Treibhausgas)	Emission factor [g/kg]	Remarks regarding the source or calculation
CO_2	3,018.00	from IPCC Guidelines 2006, Table 3.6.4
CH_4	0.36	same as EF kerosene, LTO/national
N_2O	0.10	same as EF kerosene, cruise/national

Source: Öko-Institut (2012)

The relevant emission factors were converted from [kg emissions / kg of burned avgas] to [kg emissions / TJ converted energy]; the conversion factor used for this was the pertinent net calorific value, 44,300 kJ/kg.

Lubricants

The CO_2 emissions from co-combustion of lubricants were calculated via an IPCC default-EF of 80,000 kg/TJ. The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

3.2.10.1.3 Uncertainties and time-series consistency (1.A.3.a)

For determination of uncertainties, the individual components that enter into emissions calculation are identified, and their uncertainties (U_1 to U_x) are quantified. Pursuant to IPCC

GPG (2000), the total uncertainty U_{total} is obtained via additive linking of squared partial uncertainties, in accordance with the following formula:

$$U_{ges} = \sqrt{U_1^2 + U_2^2 + ... + U_n^2}$$

For all time series and flight phases, uncertainties were estimated as mean values. The total uncertainties were calculated as is shown in Annex Chapter 19.1.3.1.2. The left column contains the components that enter into the uncertainty calculation; the relevant partial uncertainties are listed in the neighbouring columns to the right. The columns that then follow to the right contain the values for the required total uncertainties. Some of these, in turn, are individual components of the uncertainties calculation for other values. For example, the uncertainty for national jet-kerosene consumption in the two relevant flight phases, LTO and cruise, is calculated from the partial uncertainties for total national jet-kerosene consumption and from the partial uncertainty for the LTO/cruise differentiation. The latter of these partial uncertainties is based on the number of relevant flights, pursuant to the *Federal Statistical Office*, as well as on assumptions pertaining to the manner in which the fleet is divided (in national flight operations, an average consumption of 850 kg jet kerosene per LTO cycle is applied, in keeping with the IPCC's assumptions). The total uncertainty for jet-kerosene consumption during the LTO and cruise flight phases, in turn, serves as a partial uncertainty in determination of the uncertainties for emissions data.

Some partial uncertainties are based on assumptions. For example, one uncertainty for the entire time series for the split factor for dividing national and international flights is given as an average throughout the time series. For the years 1990 through 2002, the data are based on TREMOD calculations that, in turn, are based on the relevant data of the Federal Statistical Office, on the emission factors in the EMEP/EEA database and on calculations of our own. For the years 2003 to 2011, the pertinent Eurocontrol data are used, data which were calculated with the ANCAT model. Comparisons of random samples of a) results obtained with the ANCAT model and b) actual consumption data show deviations of ±12 %. Eurocontrol data obtained with the AEM 3 model had an uncertainty of only 3 to 5 % (EUROCONTROL 2006).

3.2.10.1.4 Source-specific quality assurance / control and verification (1.A.3.a)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The current calculation procedures have been verified on the basis of more-current data and findings. This applies to the various emission factors used and the energy-content figures required for conversion into energy-related emission factors.

Basically, calculation of greenhouse-gas emissions is based on data of the Energy Balance and on emission factors pursuant to the IPCC-Guidelines. Air transports are divided into national and international air transports, via the split factor, in keeping with TREMOD-AV (for the years 1990-2002) and with the relevant figures of Eurocontrol (as of 2003). In addition, the breakdown into the two flight phases, and the emission factors for NO_X, HC and CO, also result from the TREMOD calculations. Those calculations are based on data of the Federal Statistical Office, as well as on aircraft-type-specific data taken from the EMEP-EEA database. For a growing share of aircraft types for which no specific data are available, emission factors have to be obtained via regressions carried out on the basis of take-off weight. Use of more current, and more complete, aircraft-type-specific data would further improve the quality of the calculations. Furthermore, expansion of the TREMOD calculations, to include differentiation in accordance with the different engines used, would also improve the quality of the calculations.

Except for the emission factors for sulphur dioxide, international standard values were used, taken from the IPCC emission-factors database, the EMEP-EEA database or the EMEP/EEA Guidebook 2009 (EMEP/EEA 2010). Discussions of the various individual values are presented in the "Methodological Aspects" chapters of the presentations of the various emission factors.

In October 2011, for the first time, Eurocontrol provided country-specific consumption and emissions data from the PAGODA model. For the time being, those data are being used only to verify our own surveys.

3.2.10.1.5 Source-specific recalculations (1.A.3.a)

Recalculations with respect to the 2012 report were carried out largely to take account of revision of domestic (national) and international air transports' respective shares, as calculated and communicated by Eurocontrol, of total domestic kerosene sales.

Table 41: Revision of national (domestic, within Germany) air transports' share of domestic kerosene sales, 2007-2010

	Units	2007	2008	2009	2010
Submission 2013		8.37	8.28	8.09	7.62
Submission 2012	[%]	8.10	7.99	7.71	7.36
Absolute difference		0.26	0.29	0.38	0.26
Relative difference	[%]	3.25	3.62	4.98	3.49

These changes lead to the following changes in the activity data used in the present context:

Table 42: Recalculation of kerosene consumption in national air transports, 2007-2010

	Units	2007	2008	2009	2010
Submission 2013		31,327	31,320	29,710	27,550
Submission 2012	[TJ]	30,340	30,225	28,301	26,622
Absolute difference		988	1,095	1,409	928
Relative difference	[%]	3.25	3.62	4.98	3.49

Table 43: Revision of quantities of co-combusted lubricants, 2007-2010

	Units	2007	2008	2009	2010
Submission 2013		0.94	0.72	0.59	0.12
Submission 2012	[TJ]	0.91	0.70	0.56	0.11
Absolute difference		0.03	0.02	0.03	0.01
Relative difference	[%]	3.30	2.86	5.36	9.09

The changes in input data as described lead to the following recalculations, with regard to the Submission 2012, in greenhouse-gas emissions reported for the years 2007 through 2010:

Table 44: Impacts of the described revisions of the inventory on reported greenhouse-gas emissions, as of 2007

	Units	2007	2008	2009	2010
Submission 2013	[Gg CO_2 equiv.]	2,363	2,365	2,242	2,081
Submission 2012		2,290	2,284	2,138	2,012
Absolute difference		73	81	104	69
Relative difference	[%]	3.19	3.55	4.87	3.41

3.2.10.1.6 *Source-specific planned improvements (1.A.3.a)*

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

3.2.10.2 Transport – Road transport (1.A.3.b)

3.2.10.2.1 *Source category description (1.A.3.b)*

CRF 1.A.3.b	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**150,358.3**	**(12.34%)**	**147,867.4**	**(15.97%)**	**-1.66%**
All fuels	N_2O			1,158.4	(0.10%)	1,338.3	(0.14%)	15.53%
All fuels	CH_4			1,106.1	(0.09%)	148.1	(0.02%)	-86.61%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	NS	CS D (biodiesel, lubricants)
CH_4	Tier 3	NS	CS/M/D
N_2O	Tier 3	NS	CS/M
NO_X, CO, NMVOC, SO_2	Tier 3	NS	CS/M

The source category *Road transport* is a key category for CO_2 emissions in terms of emissions level and trend.

Emissions from motorised road traffic in Germany are reported under this category. It includes traffic on public roads within Germany, except for agricultural and forestry transports and military transports. Calculations are made for the vehicle categories of passenger cars, motorcycles, light duty vehicles, heavy duty vehicles and buses. For calculation purposes, the vehicle categories are broken down into so-called *vehicle layers* with the same emissions behaviour. To that end, vehicle categories are also broken down by type of fuel used, vehicle size (trucks and buses by weight class; automobiles and motorcycles by engine displacement) and pollution control equipment used, as defined by EU directives for emissions control ("EURO norms"), and by regional traffic distribution (outside of cities, in cities and on autobahns).

3.2.10.2.2 *Methodological issues (1.A.3.b)*

Since 1990, emissions of CH_4, NO_X, CO, NMVOC and SO_2 from road transports have decreased sharply, due to catalytic-converter use and engine improvements resulting from continual tightening of emissions laws, and due to improved fuel quality.

Between 1990 and 1993, the methane emission factor for petrol dropped sharply, producing a corresponding sharp reduction in methane emissions. This was due especially to a massive reduction in the numbers of vehicles with two-stroke engines in the new German Länder. Further EF decreases have resulted via the aforementioned tightening of emissions standards.

For buses and heavy duty vehicles (over 3.5 t total permissible vehicle weight), maximum permissible levels of hydrocarbon (HC) emissions were lowered considerably (-40 %) via the introduction of the EURO3 standard in 2000. Since EURO3 vehicles were very quick to reach the market as of 2000, the emission factor for hydrocarbon emissions from diesel fuel – and the relevant emissions themselves – decreased considerably after 2000. A similar trend occurred for methane, emissions of which are calculated as a fixed share of total HC emissions.

N_2O emissions result primarily from incomplete reduction of NO to N_2 in 3-way catalytic converters. They are not limited by law. Initially, growth in numbers of cars with catalytic converters caused increases in N_2O emissions in comparison to the 1990 level. Newer catalytic converters are optimised to produce only small amounts of N_2O, however. As a result, N_2O decreased during the period 2000-2006. Since then, such emissions have been increasing again. Those increases are due to increasing use of selective catalytic reduction (SCR) equipment in heavy utility vehicles; under certain conditions, such equipment can produce N_2O as an undesired by-product.

CO_2 emissions depend directly on fuel consumption. From 1990-1999, these emissions increased, since growth in mileage travelled outweighed improvements in vehicle fuel consumption. In the 2000-2009 period, road-transport emissions from consumption of fossil fuels decreased for the first time. The likely reasons for this trend include reductions in specific fuel consumption, the marked shift toward diesel vehicles in new registrations, continual increases in fuel prices, use of biofuels – and consumers' growing tendency to travel to other countries in order to make their fuel purchases (see the following paragraphs).

In the years 2010 and 2011, CO_2 emissions increased again, as the aforementioned trends lost momentum and total transport mileage increased.

Table 45: Emissions from road transports (all figures in Gg)

	CO_2 fossil[1)]	CO_2 *bio*[2)]	CH_4	N_2O	NO_X	CO	NMVOC[3)]	SO_2
1990	150,358.34	0.00	52.12	3.76	1,350.94	6,624.59	1,165.01	90.20
1995	165,104.05	106.48	33.14	5.41	1,162.92	3,872.21	547.09	69.31
2000	171,229.50	869.14	20.84	5.05	1,053.90	2,417.88	315.83	19.67
2005	151,710.57	5,575.96	12.47	3.25	755.60	1,529.89	194.59	0.81
2006	147,812.44	10,181.74	11.14	3.17	732.13	1,388.94	176.73	0.81
2007	144,710.97	11,009.47	9.92	3.29	665.87	1,263.17	158.53	0.79
2008	144,503.49	8,920.63	8.63	3.50	583.54	1,148.94	140.55	0.78
2009	144,187.60	8,033.49	8.00	3.69	530.12	1,085.51	130.95	0.78
2010	145,460.75	8,494.71	7.34	4.01	507.83	1,018.54	121.59	0.79
2011	147,867.39	8,244.23	7.05	4.32	480.70	990.66	117.21	0.80

[1)] including CO_2 from co-combusted lubricants

[2)] CO_2 emissions from biofuels are listed here solely for informational purposes.

[3)] includes evaporation-related emissions

CO_2 emissions from motorised road transports in Germany are calculated via a "*bottom-up*" approach (Tier 2 approach pursuant to IPCC GPG, 2000: p. 2.46): In the pertinent process, the fuels sold in Germany (petrol, (bio-) ethanol fuel, diesel fuel, biodiesel, LP and natural gas, petroleum (until 2002)) are allocated, within the TREMOD ("Transport Emission Model") model, to the various relevant vehicle layers (cf. Chapter 19.1.3.2). The consumption data that enter into the model, for each type of fuel, are obtained from the *Energy Balances*. CO_2 emissions are calculated – following import of the layer-specific fuel consumption figures – using country-specific emission factors from the CSE.

Non-CO_2 emissions are calculated with the aid of the TREMOD model (IFEU, 2012)[22]. That model incorporates a Tier-3 approach whereby mileage of the individual vehicle layers is multiplied by specific emission factors. For passenger cars and light duty vehicles, a "*cold start surplus*" is also added. The total consumption determined for each fuel type is cross-checked against consumption pursuant to the Energy Balance. Then, the relevant emissions are corrected with the help of factors obtained via such cross-checking. For petrol-powered vehicles, the evaporation emissions of VOC are calculated in keeping with the pollution-control technology used.

From the emissions and fuel-consumption figures for the various vehicle layers, aggregated, fuel-based emission factors (kg of emissions per TJ of fuel consumption) are derived and then forwarded to the CSE database. In keeping with the CORINAIR report structure, these factors are differentiated only by type of fuel, type of road (autobahn, rural road, city road) and, within the vehicle categories, by "without/with emissions-control equipment". The following emissions-control categories are differentiated:

Table 46: Differentiation of emissions-control categories in road transports

Vehicle classes considered	Emissions-control system Without	With
Passenger cars / light commercial vehicles with petrol-burning engines	Without catalytic converter	With catalytic converter
Passenger cars / light duty vehicles with diesel engines, busses, heavy duty vehicles, motorcycles	Prior to the EURO 1 standard	As of the EURO 1 standard

For calculation with TREMOD, extensive basic data from generally accessible statistics and special surveys have been used, co-ordinated, and supplemented. An overview of the principal sources and key assumptions is given below. Detailed descriptions of the databases, including information on the sources used, and the calculation methods used in TREMOD, are provided in the aforementioned IFEU report.

Motor-vehicle-fleet data:

For western Germany from 1990 through 1993, and for Germany as a whole as of 1994, car ownership was calculated on the basis of the officially published ownership and new registration statistics of the Federal Motor Transport Authority (KBA). The car ownership analysis for East Germany in 1990 was based on a detailed analysis of the Adlershof car-emissions-testing agency in 1992 and the time series in the statistical annuals of the GDR.

22 To make it possible to derive and assess reduction measures, energy consumption and CO_2 emissions for the various vehicle categories are also calculated with TREMOD. The resulting values are subsequently checked against total consumption and total CO_2 emissions.

For the period between 1991 and 1993, it was necessary to estimate the figures with the aid of numerous assumptions.

Fleet data for the TREMOD model, as of reference years as of 2001, is the result of cross-checking with the database of the Federal Motor Transport Authority (KBA). The supplied data include vehicle fleets for each reference year, broken down as required for emissions calculation, i.e. in accordance with the following characteristics: type of engine (petrol, diesel, other), size class, vehicle age and emissions standard. For each reference year, the mid-year fleet is assumed to be representative of the fleet's composition for the year.

<u>Emission factors:</u>

All emission factors are listed in the "Emission-factor manual for road transports 3.1" ("Handbuch für Emissionsfaktoren des Straßenverkehrs 3.1" (HBEFA) (INFRAS, 2010), a reference work prepared via co-operation, between Germany, Switzerland, Austria and the Netherlands, in derivation of emission factors for road traffic. The emission factors in the manual originate predominantly from the measurement programmes of TÜV Rheinland (TÜV = Technical Control Association) and RWTÜV. Those programmes include foundational studies relative to the reference years 1989/1990. In those studies, a new method was used, for both passenger cars and heavy duty vehicles, whereby emission factors were derived on the basis of driving habits and traffic situations. Emission factors for automobiles until the 1994 (automobile-)model year were updated with the help of field-monitoring data. Version 3.1 of the "Emission-factor manual for road transports", which is used for the current emissions calculations, draws on findings of the EU working group COST 346 and the ARTEMIS research programme.

The emission factors are derived from the development of the various vehicle layers and from the data provided by the "Emission-factor manual for road transports 3.1". The emissions reduction achieved via the introduction of sulphur-free fuels was estimated by the Federal Environment Agency.

For the country-specific emission factors for CO_2, the reader's attention is called to the documentation in Annex 2, the Chapter "CO_2 emission factors". For bioethanol, the value used for gasoline, 72,000 kg/TJ, is used, while an IPCC default value of 70,800 kg/TJ is used for biodiesel.

Country-specific values are also used for liquefied petroleum gas and natural gas – 65,000 kg/TJ and 56,000 kg/TJ, respectively.

An IPCC default value is also used for CO_2 from co-combusted lubricants: 80,000 kg/TJ. The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

<u>Mileage data:</u>

Mileage data were updated on the basis of the "2002 mileage survey" ("Fahrleistungserhebung 2002"; Institute of Applied Transport and Tourism Research (IVT) 2004), the "2005 road-transport census" ("Straßenverkehrszählungen 2005"; Federal Highway Research Institute (BASt), 2007) and data on growth of transports on federal highways (BASt, 2009).

Shifting of fuel purchases to other countries

Because fuel prices in Germany are higher – significantly, in some cases – than in almost all of Germany's neighbours, for some time the fuels used in Germany have included fuels purchased in other countries and brought into the country as "grey" imports.

At present, no precise data are available on this phenomenon, which is significant for truck and automobile traffic in Germany's border regions and which is referred to as "refueling tourism" ("Tanktourismus"). Although several detailed studies have been carried out, no reliable overall picture of the situation is available (cf. LENK et al., 2005).

The sources that have documented shifting of consumers' fuel purchases to other countries (along with the resulting negative impacts on neighbouring countries' own emissions inventories) have included a study published by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW, 2005). The relevant neighbouring countries profit, to a not-inconsiderable degree, from additional revenue from energy taxation of such fuels. Such revenue is likely to be significantly higher than the certificate costs for the pertinent CO_2 emissions would be.

3.2.10.2.3 Uncertainties and time-series consistency (1.A.3.b)

In the framework of a study (IFEU & INFRAS 2009), uncertainties were calculated for the activity data entered into TREMOD, for the emission factors generated in TREMOD and for the emissions calculated in the Central System of Emissions (CSE).

3.2.10.2.4 Source-specific quality assurance / control and verification (1.A.3.b)

Quality control (pursuant to Tiers 1 + 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. The responsible experts have been unable to carry out quality assurance. The Single National Entity has carried out additional quality assurance.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[23].

The emission factors used were compared with those used by the Netherlands, Denmark, Switzerland, France, the UK, Norway and the EU. In the process, different ranges were seen for different greenhouse gases. Most of the emission factors used in the German inventory are either right in the middle of the ranges for their groups (this is the case for the emission factor for CO_2) or in the lower middle sections of those ranges (this is the case for the emission factors for CH_4 and N_2O). The German inventory's EF(N_2O) for petrol and EF(CH_4) for diesel fuel and biomass are exceptions. They are lower than all other corresponding values in the aforementioned international comparison – although they are still relatively close to the corresponding comparative values.

[23] AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 (last checked on 30 October 2009)

3.2.10.2.5 Source-specific recalculations (1.A.3.b)

The presented emissions data were calculated with TREMOD version 5.30 (IFEU, 2012). With respect to the 2012 reporting year, the model was extensively revised with regard to vehicles powered by natural gas and LP gas.

In addition, the data of the Association of the German Petroleum Industry (MWV) that serve as a basis for the Energy Balances with regard to consumption of diesel fuel and biodiesel for the 2005-2009 period, and the official mineral-oil data (Amtliche Mineralöldaten) of the Federal Office of Economics and Export Control (BAFA) with regard to consumption of bioethanol in the 2007-2010 period, were corrected.

Furthermore, provisional data of the "2010 Energy Balance" relative to consumption of diesel fuel, petrol, natural gas and LP gas in road transports were also updated. And revision of total-mileage data in TREMOD 5.30 for the years 2008 through 2010 has led to slight changes in applicable lubricant quantities.

Table 47: Revision of quantities of diesel fuel consumed in road transports, as of 2005

	Units	2005	2006	2007	2008	2009	2010
Submission 2013	[TJ]	1,078,620	1,082,042	1,073,987	1,102,623	1,114,939	1,168,063
Submission 2012		1,077,173	1,081,161	1,078,362	1,107,062	1,114,253	1,166,224
Absolute difference		1,447	881	-4,375	-4,439	686	1,839
Relative difference	[%]	0.13	0.08	-0.41	-0.40	0.06	0.16

Table 48: Revision of quantities of biodiesel fuel consumed in road transports, as of 2005

	Units	2005	2006	2007	2008	2009	2010
Submission 2013	[TJ]	71,824	130,165	143,235	109,393	89,375	88,886
Submission 2012		71,792	130,139	143,431	109,612	89,327	90,673
Absolute difference		32	26	-195	-219	47	-1,787
Relative difference	[%]	0.04	0.02	-0.14	-0.20	0.05	-1.97

Table 49: Revision of quantities of bioethanol fuel consumed in road transports, as of 2005

	Units	2005	2006	2007	2008	2009	2010
Submission 2013	[TJ]	6,817	13,418	12,061	16,328	23,691	30,577
Submission 2012		6,817	13,418	12,065	16,385	23,697	30,403
Absolute difference		0	0	-4	-57	-6	174
Relative difference	[%]	0.00	0.00	-0.03	-0.35	-0.02	0.57

Table 50: Revision of quantities of petrol, natural gas and LP gas consumed in road transports, 2010

	Units	Petrol	Natural gas	LP gas

Submission 2013		791,416	8,768	21,823
Submission 2012	[TJ]	792,257	9,742	21,836
Absolute difference		-841	-974	-13
Relative difference	[%]	-0.11	-10.00	-0.06

Revision of mileage data in TREMOD 5.30 for the years 2008-2010 has led to slight changes in applicable quantities of lubricants, since such quantities are calculated on the basis of mileage travelled.

Table 51: Revision of quantities of co-combusted lubricants, as of 2008

	Units	2005	2006	2007	2008	2009	2010
Submission 2013	[TJ]	1,614	1,627	1,637	1,631	1,640	1,658
Submission 2012		1,614	1,627	1,637	1,625	1,608	1,624
Absolute difference		0	0	0	6	33	34
Relative difference	[%]	0.00	0.00	0.00	0.35	2.03	2.08

The changes in the consumed quantities of fuel and lubricants have led to the following changes in CO_2 emissions:

Table 52: Resulting recalculations of CO_2 emissions from fossil fuels, as of 2005

	Units	2005	2006	2007	2008	2009	2010
Submission 2013	[Gg]	151,581	147,682	144,580	144,373	144,056	145,328
Submission 2012		151,474	147,617	144,904	144,702	144,006	145,308
Absolute difference		107	65	-324	-328	51	20
Relative difference	[%]	0.07	0.04	-0.22	-0.23	0.04	0.01

Table 53: Resulting recalculations of CO_2 emissions from biofuels, as of 2005

	Units	2005	2006	2007	2008	2009	2010
Submission 2013	[Gg]	5,576	10,182	11,009	8,921	8,033	8,495
Submission 2012		5,574	10,180	11,024	8,940	8,031	8,609
Absolute difference		2	2	-14	-20	3	-114
Relative difference	[%]	0.04	0.02	-0.13	-0.22	0.04	-1.32

Table 54: Resulting recalculations of CO_2 emissions from co-combusted lubricants, as of 2008

	Units	2005	2006	2007	2008	2009	2010
Submission 2013	[Gg]	129.15	130.17	130.98	130.44	131.22	132.63
Submission 2012		129.15	130.17	130.98	129.99	128.60	129.93
Absolute difference		0.00	0.00	0.00	0.45	2.62	2.70
Relative difference	[%]	0.00	0.00	0.00	0.35	2.03	2.08

Recalculations of methane and nitrous oxide emissions as of 1990 were required, primarily as a result of the above-described revision of the TREMOD model with regard to the emission factors for natural gas and LP gas. The results are summarised in the following two tables.

Table 55: Resulting recalculations of methane emissions, as of 1990

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Subm. 2013	[Gg]	52.67	33.14	20.84	12.47	11.14	9.92	8.63	8.00	7.34
Subm. 2012		52.12	32.91	20.60	12.21	11.01	9.78	8.49	7.84	7.41
Absolute difference		0.56	0.23	0.24	0.26	0.12	0.15	0.14	0.16	-0.07
Relative difference	[%]	1.07	0.70	1.16	2.14	1.12	1.52	1.69	1.99	-0.99

Table 51: Resulting recalculations of nitrous oxide emissions, as of 1990

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Subm. 2013	[Gg]	3.74	5.41	5.05	3.25	3.17	3.29	3.50	3.69	4.01
Subm. 2012		3.76	5.43	5.07	3.26	3.18	3.31	3.51	3.70	4.03
Absolute difference		-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02
Relative difference	[%]	-0.53	-0.37	-0.40	-0.17	-0.35	-0.40	-0.36	-0.18	-0.59

Together, all of the mentioned changes within TREMOD lead to only minimal changes in the greenhouse-gas emissions to be reported for road transports:

Table 56: Resulting recalculations of total GHG emissions (not including CO_2 emissions from biomass), as of 1990

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Subm. 2013	[Gg CO_2-equiv.]	152,623	167,477	173,232	152,981	149,030	145,941	145,769	145,499	146,858
Subm. 2012		152,617	167,478	173,233	152,870	148,966	146,266	146,098	145,445	146,844
Absolute difference		6	-1	-1	111	64	-325	-329	55	14
Relative difference	[%]	0.004	-0.001	-0.001	0.072	0.043	-0.222	-0.225	0.038	0.009

3.2.10.2.6 Source-specific planned improvements (1.A.3.b)

No improvements are planned at present.

3.2.10.3 Transport – Railways (1.A.3.c)

3.2.10.3.1 Source-category description (1.A.3.c)

CRF 1.A.3.c	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	CO_2		-	2,880.8	(0.24%)	1064.2	(0.11%)	-63.06%
All fuels	N_2O	-	-	12.6	(0.00%)	4.7	(0.00%)	-62.41%
All fuels	CH_4	-	-	2.3	(0.00%)	0.5	(0.00%)	-80.31%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	NS	CS D (biodiesel, lubricants)
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2	Tier 2	NS	CS

The source category *Railways* is not a key category.

Germany's railway sector is undergoing a long-term modernisation process, aimed at making electricity the main energy source for rail transports. Use of electricity, instead of diesel fuel, to power locomotives has been continually increased, and electricity now provides 80 % of all railway traction power[24]. Railways' power stations for generation of required traction current are allocated to the stationary component of the energy sector (1.A.1.a) and are not included in the following section.

In energy input for trains operating in Germany, diesel fuel is the only energy source that plays a significant role apart from electric power. Since 2004, biodiesel has also been used, as an additive. Reliable figures for that fuel have been available since 2009.

In historic vehicles – primarily, steam-powered locomotives operated for exhibition purposes – small quantities of solid fuels are also used. The official Energy Balances provide pertinent evaluatable consumption data for lignite, for the period until 2002, and for hard coal, for the period until 2000. Since no other evaluatable statistics are available, emissions from consumption of solid fuels cannot be calculated for later years.

Use of other fuels – such as vegetable oils or gas – in private narrow-gauge railway vehicles has not been included to date and may still be considered negligible.

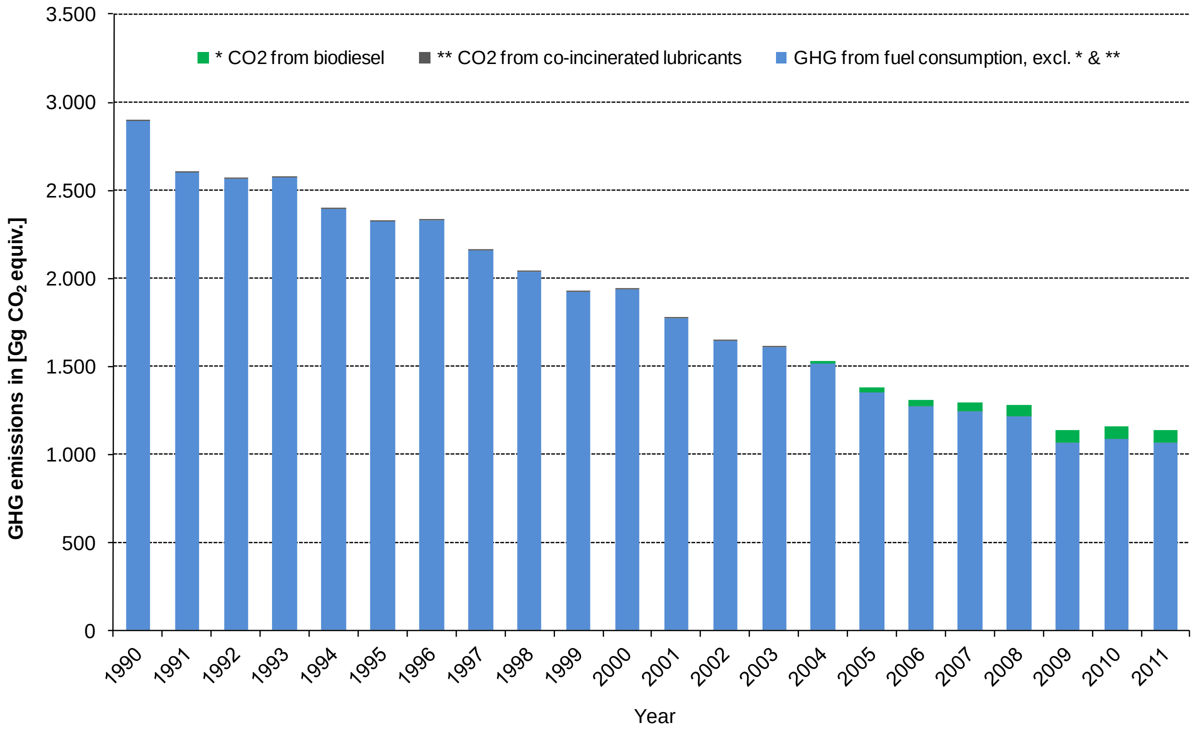


Figure 32: Development of greenhouse-gas emissions from railway transports, 1990-2011 (not including emissions from generation of electric power for railways)

3.2.10.3.2 Methodological issues (1.A.3.c)

No specific information relative to this source category is found in the IPCC Good Practice Guidance (2000: Chapter 2). The relevant emissions are thus calculated as the product of fuel consumption and the relevant country-specific emission factors. This procedure

[24] from Energiewirtschaftliche Tagesfragen, 54th year (Jahrgang; 2004), issue 3, p. 185

conforms to the general Tier 2 method and the basic calculation rule pursuant to equation 2.6 of the IPCC Good Practice Guidance (2000, p. 2.46).

Activity data:

As a rule, energy consumption data (currently: 1990-2004 & 2010-2011) are taken from the official Energy Balances of the Federal Republic of Germany (AGEB, 2012). In particular, the fuel data have been taken from the following Energy Balance lines, for the following periods:

Table 57: Sources for AD in 1.A.3.c

Fuel type	Energy Balance line	Relevant years
Diesel fuel	74 61	through 1994 since 1995
Lignite briquettes	61	since 1996
Raw lignite	61	since 1996
Hard coal	74 61	through 1994 since 1995
Hard-coal coke	61	since 1995

For years for which no Energy Balance is yet available, or only a provisional Energy Balance is available, sales data of the Association of the German Petroleum Industry (MWV) are used. Those data are published in the annual report "Petroleum Data" ("Mineralöl-Zahlen"; in the present instance: page 52, Table "Sectoral consumption of diesel fuel" ("Sektoraler Verbrauch von Dieselkraftstoff") (MWV, 2012)).

Due to inadequacies in the available statistical data, annual figures for biodiesel consumption continue to be calculated on the basis of the official mixture percentages.

Due to a lack of relevant statistical data on annual consumption of lubricants in railway transports, the applicable quantities of co-combusted lubricants, and the resulting CO_2 emissions, are calculated from the quantities of diesel fuel consumed.

A recently completed study for determining annually consumed quantities of other fuels (coal, wood, oil, etc.) in historic railway vehicles unfortunately did not provide data that could be used directly in emissions reporting.

Emission factors:

The emission factors are based, for each specific gas, on the results of various Federal Environment Agency research projects and expert opinions:

- With regard to CO_2, the reader's attention is called to the documentation in Annex 2, the Chapter "CO_2 emission factors". For co-combustion of lubricants, an IPCC default figure of 80,000 kg CO_2/TJ is currently being used.

- The EF (CH_4) for solid fuels are based on the UBA study "Air quality control '88" ("Luftreinhaltung '88") (UBA, 1989b). A comparison of the resulting country-specific emission factors with the corresponding IPCC default values shows that the EF used for coal are higher than the pertinent figures in the IPCC Reference Manual (1996b, Table 1-7). Specific emission factors, for diesel fuel and biodiesel, have been derived for all diesel locomotives in service in Germany. For purposes of emissions calculations, such model-specific emission factors are linked with pertinent operational mileage (kilometers travelled), for each relevant year (TREMOD; IFEU, 2012). The default value in the IPCC Reference Manual (1996b, Table 1-7) is higher than the country-specific EF used by Germany, which reflect trends in engine-based measures to reduce emissions of railway vehicles (1995: 2.45 kg/TJ; 2011: 1.24 kg/TJ).
- As to the solid-fuel emission factor for N_2O, the Federal Environment Agency's experts agree with the Federal Environment Agency study "Luftreinhaltung '88" (UBA, 1989b). The country-specific EF are considerably higher than the corresponding values in the IPCC Reference Manual (1996b, Table 1-8). With regard to diesel fuel and biodiesel, a value is obtained by analogy to heavy duty vehicles without emissions-control equipment. The country-specific emission factor, at 1.0 kg/TJ, is higher than the value of 0.6 kg/TJ given by the Reference Manual (IPCC, 1997, Table 1-8).
- The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

Table 58: Comparison of EF used and default EF

GG	Fuel	Emission factor used [kg/TJ]	Default EF [kg/TJ]	
	Diesel & biodiesel	1.4 - 2.5		
	Hard coal	15.0	**Oil:**	**5.0**
CH_4	Lignite briquettes	15.0	**Coal:**	**10.0**
	Raw lignite	15.0		
	Hard-coal coke	0.5		
	Diesel & biodiesel	1.0		
	Hard coal	4.0	**Oil:**	**0.6**
N_2O	Lignite briquettes	3.5	**Coal:**	**1.4**
	Raw lignite	3.5		
	Hard-coal coke	4.0		

Source: Luftreinhaltung `88 (UBA, 1989b); IFEU (2009)

3.2.10.3.3 Uncertainties and time-series consistency (1.A.3.c)

In the framework of a study (IFEU & INFRAS 2009), uncertainties were calculated for the activity data entered into TREMOD, for the emission factors generated in TREMOD and for the emissions calculated in the Central System of Emissions (CSE).

The activity-rate time series for lignite briquettes, hard coal and hard-coal coke exhibit inconsistencies resulting from statistical conversion as of 1994/1995; these inconsistencies cannot be eliminated at present.

3.2.10.3.4 Source-specific quality assurance / control and verification (1.A.3.c)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[25].

The emission factors used were compared with those used by the Netherlands, Denmark, Switzerland, France, the UK, Norway and the EU. In the process, different ranges were seen for different greenhouse gases. The emission factors used in the German inventory are either in the middle of the ranges for their groups (this is the case for the emission factor for CO_2) or in the lower middle sections of those ranges (this is the case for the emission factors for CH_4 and N_2O).

Since no other sources of data for Germany are known, it is currently not possible to verify the emissions reported here via comparison.

3.2.10.3.5 Source-specific recalculations (1.A.3.c)

With respect to the data provided in the Submission 2012, extensive recalculations were carried out, to take account of revised activity data and emission factors. As described above, these efforts led to adjustment of the activity data for diesel fuel and biodiesel in keeping with the corrected data of the MWV (2005-2009) and of the Energy Balance (2010). The resulting minimal change in biodiesel consumption in 2004 is due solely to rounding.

[25] AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 (last checked on 30 October 2009)

Table 59: Correction of diesel-fuel consumption, as of 2005

	Units	1990	2004	2005	2006	2007	2008	2009	2010
Submission 2013		38,458	20,372	18,142	17,101	16,730	16,389	14,336	14,626
Submission 2012	[TJ]	38,458	20,372	18,877	17,014	16,436	15,932	14,329	12,768
Absolute difference		0	0	-735	87	294	457	7	1,858
Relative difference	[%]	0.00	0.00	-3.89	0.51	1.79	2.87	0.05	14.55

Table 60: Correction of biodiesel consumption, as of 2004

	Units	1990	2004	2005	2006	2007	2008	2009	2010
Submission 2013		0	175	397	498	747	810	987	949
Submission 2012	[TJ]	0	175	413	494	733	784	983	849
Absolute difference		0	0	-16	4	14	26	4	100
Relative difference	[%]	-	0.002	-3.89	0.84	1.94	3.34	0.44	11.74

Table 61: Resulting correction of quantities of co-combusted lubricants, as of 2005

	Units	1990	2004	2005	2006	2007	2008	2009	2010
Submission 2013		19.23	10.27	9.27	8.80	8.74	8.60	7.66	7.79
Submission 2012	[TJ]	19.23	10.27	9.64	8.75	8.58	8.36	7.66	6.81
Absolute difference		0.00	0.00	-0.37	0.05	0.16	0.24	0.00	0.98
Relative difference	[%]	0.00	0.00	-3.84	0.57	1.85	2.87	0.02	14.35

In addition, the CH_4 emission factor for 2010, as provisionally established for the Submission 2012, was modified on the basis of now-available consumption data for various models of diesel locomoties – the value was changed from 1.30 kg/TJ to 1.33 kg/TJ.

Table 62: Correction of the EF(CH_4) for diesel fuel and biodiesel, 2010

	Units	2010
Submission 2013		1.33
Submission 2012	[kg/TJ]	1.30
Absolute difference		0.03
Relative difference	[%]	2.10

The resulting greenhouse-gas emissions were recalculated for the relevant years.

Table 63: Resulting recalculations of GHG emissions (not including CO_2 emissions from biodiesel), as of 2005

	Units	1990	2004	2005	2006	2007	2008	2009	2010
Submission 2013		2,896	1,515	1,350	1,272	1,245	1,219	1,067	1,088
Submission 2012	[Gg CO_2 equiv.]	2,896	1,515	1,404	1,266	1,223	1,185	1,066	950
Absolute difference		0	0	-55	6	22	34	1	138
Relative difference	[%]	0.00	0.00	-3.89	0.51	1.79	2.87	0.05	14.55

Table 64: Resulting recalculations of CO_2 emissions from use of biodiesel, as of 2004

	Units	1990	2004	2005	2006	2007	2008	2009	2010
Submission 2013		0	12	28	35	53	57	70	67
Submission 2012	[Gg]	0	12	29	35	52	56	70	60
Absolute difference		0	0	-1	0	1	2	0	7
Relative difference	[%]	0.00	0.002	-3.89	0.84	1.94	3.34	0.44	11.74

3.2.10.3.6 Source-specific planned improvements (1.A.3.c)

No improvements are planned at present.

3.2.10.4 Transport – Navigation (1.A.3.d)

3.2.10.4.1 Source-category description (1.A.3.d)

CRF 1.A.3.d	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	CO_2	-	-	2,065.7	(0.17%)	768.6	(0.08%)	-62.79%
All fuels	N_2O	-	-	8.6	(0.00%)	3.4	(0.00%)	-60.08%
All fuels	CH_4	-	-	1.7	(0.00%)	0.6	(0.00%)	-67.05%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 1	NS	CS D (biodiesel, lubricants)
CH_4	Tier 1	NS	CS
N_2O	Tier 1	NS	CS
NO_X, CO, NMVOC, SO_2	Tier 1	NS	CS

The source category *Navigation* is not a key category.

Navigation is broken down into the categories "coastal and inland navigation" (domestic) and "international maritime transport". All domestic navigation is diesel-powered (and uses diesel fuel with added biodiesel), while heavy heating oil (heavy fuel oil) is also used in the international shipping sector. Emissions from international navigation are listed in the emissions inventories, as a memo item, but they are not included in total emissions.

Under source category 1.A.3d Navigation, the CSE includes coastal and inland fishing and coastal and inland shipping.

The following figure shows the development of greenhouse-gas emissions in inland shipping since 1990, which development parallels that for fuel inputs in this source category.

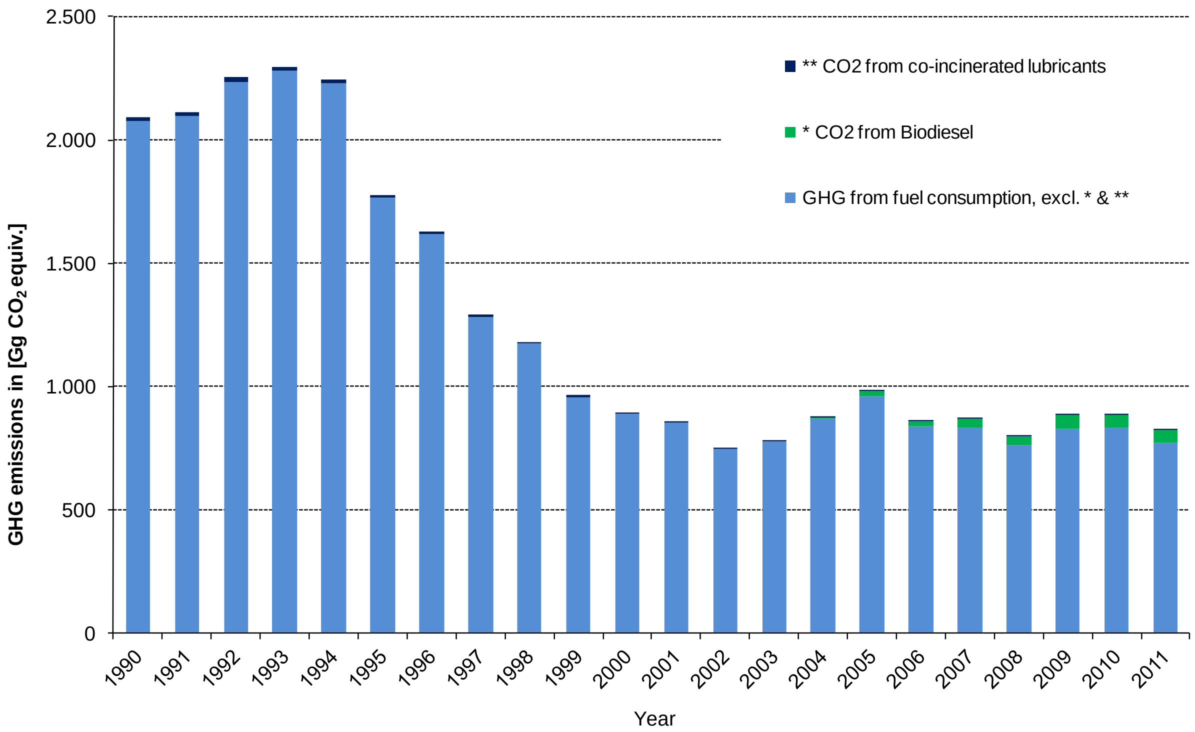


Figure 33: Development of greenhouse-gas emissions in inland shipping, 1990 – 202011

3.2.10.4.2 Methodological issues (1.A.3.d)

For Germany, emissions from this source category are calculated as the product of consumed fuels and country-specific emission factors for CO_2, CH_4 and N_2O. This procedure is in keeping with the general Tier 1 method and the basic calculation rule using the equation "emission factor times fuel consumption" pursuant to the IPCC Good Practice Guidance (2000: Chapter 2.4.1.1, p. 2.51). Refuelling in other countries is also a significant factor in the navigation sector, although no data are available on the relevant quantities involved (cf. Chapter 3.2.10.2.2).

Activity data:

As a rule, energy consumption data (currently: 1990-2004 & 2010) are taken from the official Energy Balances of the Federal Republic of Germany (AGEB, 2012).

For years for which no final Energy Balance is available, data of the Association of the German Petroleum Industry (MWV, 2012) are used. .

On the other hand, data on the annual quantities of lubricants sold to this sector are normally taken from the official mineral-oil data (Amtliche Mineralöldaten) of the Federal Office of Economics and Export Control (BAFA).

Table 65: Sources for the activity data used

Material	Source statistics	location within the source	
Diesel fuel	Energy Balance	line 77 (for period until 1994) line 64 (for period as of 1995)	Coastal and inland navigation
Biodiesel	Energy Balance	line 64 (for period as of 2004)	
Lubricants	Amtliche Mineralöldaten	Table 7j, column [4]	Domestic sales to the inland-navigation sector

Both official balances divide activity data in shipping into the categories *domestic* (AGEB: "Coastal and inland navigation" = BAFA: "an die Binnenschifffahrt" ("for inland shipping")) and *international* (AGEB: "high-seas bunkering" = BAFA: "Bunker int. Schifffahrt" ("bunkering for international shipping"), in accordance with the various differently taxed quantities of ship fuel sold. The manner in which emissions for domestic ship transports and international ship transports are separately calculated and listed (cf. Chapter 3.2.2.3) is in accordance with that breakdown. The criteria for breakdown of domestic and international emissions that are presented in the IPCC-GPG (2000: Table 2.8), on the other hand, cannot be used due to a lack of suitable movement data.

Fuel consumption in coastal and inland-waterway navigation varies in keeping with waterway navigability. Since the mid-1990s, the overall trend for such consumption has been a decreasing one, however, as many ships have been refueling abroad in order to take advantage of lower fuel prices. The abrupt decrease that occurred in 1994/1995 was due solely to a conversion in the Energy Balance, however.

Due to inadequacies in the available statistical data, annual figures for biodiesel consumption continue to be calculated on the basis of the official mixture percentages.

The applicable quantities of co-combusted lubricants, and the relevant resulting CO_2 emissions, are derived from the figures in the official mineral-oil data (Amtliche Mineralöldaten) relative to annual domestic deliveries.

Recently, it was recognized that one – significant – refinery operator had been following a different procedure for notifications to the Association of the German Petroleum Industry (MWV). As a result, the Official Mineral Oil Statistics were then revised accordingly for the period as of 2005. With regard to inland shipping, the national Energy Balance, which is based in part on those statistics, has been revised to date only for the year 2010, however. For the present report, therefore, data from both sources have been used (1990-2004 & 2010-2011: EB, 2005-2009: MWV). The emissions recalculations resulting from these corrections are described in detail below. Data on use of diesel fuel and heavy fuel oil in international maritime transports are provided in the Chapter International maritime transports (1.C.1.b, Chapter 3.2.2.3).

Emission factors:

The diesel emission factors (which currently are adapted for biodiesel) for domestic navigation are based, for each specific gas in question, on the results of various research projects and experts' reviews conducted by the Federal Environment Agency:

- With regard to the CO_2 emission factor, the reader's attention is called to the documentation in Annex 2, Chapter 18.6 – "CO_2 emission factors". For diesel fuel, a country-specific value of 74,000 kg/TJ is used, while for biodiesel an IPCC default value of 70,800 kg/TJ is used. For co-combustion of lubricants, an IPCC default figure of 80,000 kg/TJ is currently being used.
- The CH_4 emission factors used have been derived from the value used for heavy duty vehicles without emissions control systems. A 15% reduction of specific CH_4 emissions in the period 1990 to 2005, resulting from engine improvements, has been assumed, in keeping with experts' estimates. The country-specific EF, at 2.37 to 2.65 kg/TJ, are also lower than the IPCC default value for diesel fuel, 5.0 kg/TJ, as listed in the Reference Manual (IPCC et al, 1996b, p. 1.35, Table 1-7).
- The emission factors for N_2O are in keeping with Federal Environment Agency (UBA) experts' assessments based on the UBA study "Air Quality Control '88" ("Luftreinhaltung '88") and on analogies to heavy duty vehicles without emissions-control equipment. The country-specific EF for diesel fuel and biodiesel, at 1.0 kg/TJ, is higher than the value of 0.6 kg N_2O/TJ given by the Reference Manual (IPCC, 1996b: Table 1-8).

  The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for diesel fuel and biodiesel. The emissions themselves are thus included in quantities calculated for diesel fuel, and they are reported here as "IE" (included elsewhere).

Data on emission factors for use of diesel fuel and heavy fuel oil in international maritime transports are provided in Chapter 3.2.2.3 International maritime transports (1.C.1.b).

3.2.10.4.3 Uncertainties and time-series consistency (1.A.3.d)

In 2009, the uncertainties of the relevant activity data, emission factors and emissions were studied for the first time, in the framework of a research project (IFEU & INFRAS 2009).

The emission factors for CO_2 and N_2O are constant throughout the entire time series and, thus, are consistent.

The activity-data time series for coastal and inland shipping exhibit inconsistencies resulting from the Energy-Balances transition between 1994 and 1995; these inconsistencies cannot be eliminated at present.

3.2.10.4.4 Source-specific quality assurance / control and verification (1.A.3.d)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[26].

The emission factors used were compared with those used by the Netherlands, Denmark, Switzerland, France, the UK, Norway and the EU. In the process, different ranges were seen for different greenhouse gases. The emission factors used in the German inventory are either in the middle of the ranges for their groups (this is the case for the emission factor for CO_2) or in the lower middle sections of those ranges (this is the case for the emission factors for CH_4 and N_2O).

Since no other sources of data for Germany are known, it is currently not possible to verify the emissions reported here via comparison.

3.2.10.4.5 Source-specific recalculations (1.A.3.d)

Only slight recalculations have been carried out with respect to the data provided in the Submission 2012. As described above, the activity data for diesel fuel and biodiesel, which previously had been extrapolated from data for earlier years, were adjusted to the corrected Energy Balance for 2010. (Data for domestic deliveries of lubricants to the inland-shipping sector, pursuant to the official mineral-oil data (Amtliche Mineralöldaten) of the Federal Office of Economics and Export Control (BAFA), were not affected, however.)

[26] AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 (last checked on 30 October 2009)

Table 66: Correction of diesel-fuel consumption, as of 2005

	Units	1990	2004	2005	2006	2007	2008	2009	2010
Submission 2013	[TJ]	27,710	11,625	12,851	11,193	11,167	10,167	11,111	11,182
Submission 2012		27,710	11,625	12,831	11,188	11,317	11,202	9,740	10,107
Absolute difference		0	0	20	5	-150	-1,035	1,371	1,075
Relative difference	[%]	0.00	0.00	0.15	0.04	-1.33	-9.24	14.07	10.63

Table 67: Correction of biodiesel consumption, as of 2005

	Units	1990	2004	2005	2006	2007	2008	2009	2010
Submission 2013	[TJ]	0	100	281	326	499	503	765	725
Submission 2012		0	100	281	325	505	554	488	505
Absolute difference		0	0	0	1	-7	-51	277	220
Relative difference	[%]	0.00	0.00	0.15	0.32	-1.29	-9.21	56.76	43.51

Table 68: Adjustment of quantities of co-combusted lubricants, 2010

	Units	1990	2009	2010
Submission 2013	[TJ]	397	52	62
Submission 2012		397	52	60
Absolute difference		0	0	2
Relative difference	[%]	0.00	0.00	3.07

The emission factors used have remained unchanged, however. The greenhouse-gas emissions were recalculated for the relevant years.

Table 69: Resulting recalculations of GHG emissions (not including CO_2 emissions from biodiesel), as of 2005

	Units	1990	2004	2005	2006	2007	2008	2009	2010
Submission 2013	[Gg CO_2 equiv.]	2,076	868	959	835	833	759	829	834
Submission 2012		2,076	868	957	835	844	836	827	762
Absolute difference		0	0	1	0	-11	-77	1	72
Relative difference	[%]	0.00	0.00	0.15	0.04	-1.32	-9.21	0.18	9.46

Table 70: Resulting recalculations of CO_2 emissions from use of biodiesel, as of 2005

	Units	1990	2004	2005	2006	2007	2008	2009	2010
Submission 2013	[Gg]	0	7	20	23	35	36	54	51
Submission 2012		0	7	20	23	36	39	54	48
Absolute difference		0	0	0	0	0	-4	0	3
Relative difference	[%]	0.00	0.00	0.15	0.32	-1.29	-9.21	0.55	6.80

3.2.10.4.6 Source-specific planned improvements (1.A.3.d)

In another project (FKZ 363 01 403), the basic data used in the TREMOD inland-shipping module for the year 2010 were reviewed and confirmed, to provide an example of such work. Additional such review is planned, along with any resulting necessary adjustments in the time series for the emission factors.

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

3.2.10.5 Transport – Other transport (1.A.3.e)

3.2.10.5.1 Source category description (1.A.3.e)

CRF 1.A.3.e	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**-/T2**	4,751.7	(0.39%)	4,098.1	(0.44%)	-13.76%
All fuels	N_2O	-	-	32.7	(0.00%)	24.4	(0.00%)	-25.41%
All fuels	CH_4	-	-	7.1	(0.00%)	2.8	(0.00%)	-60.91%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 1	NS	CS
CH_4	Tier 1	NS	CS
N_2O	Tier 1	NS	CS

The source category *Other transport* is a key category for CO_2 emissions in terms of level.

Reporting in source category 1.A.3.e – Other transport includes emissions from gas turbines in natural-gas compressor stations and from construction-related transports. Gas turbines in natural-gas compressor stations are a clearly defined plant type. Construction-related transports, on the other hand, are included only as a part of the Energy Balance category "Commercial and institutional [commerce, trade and services] and other consumers".

3.2.10.5.2 Methodological issues (1.A.3.e)

The emissions for the aforementioned areas are calculated as the product of fuel consumption and the relevant country-specific emission factors. The IPCC Good Practice Guidance (2000) does not provide any specific requirements in this area. The procedure chosen is thus in keeping with the general Tier 1 method pursuant to equation 2.3 of the IPCC Good Practice Guidance 2000, page 2.37.

Activity data:

Natural gas compressor stations (CRF 1.A.3.e i) account for the smaller share of energy inputs in this area. Calculation of fuel inputs for natural gas compressors was completely revised for the NIR 2012. As of 2005, the fuel inputs reported for purposes of emissions trading, and aggregated by the emissions-trading authority, are being used directly, as a new data source. In this area, the only data used from that data set is the data for those natural gas compressors that are allocated to the transport network. Natural gas compressors of pumping stations are identified via energy statistics and are thus already included in source category 1.A.1.c. This allocation approach prevents double-counting in the inventory.

In light of the new data situation, it seemed likely that the fuel inputs used were too low, throughout the entire time series. Only the value shown in the 2002 Energy Balance seemed plausible. While fuel inputs for natural gas compressors in the period 1995-2002 were reported in the context of statistics, it may be assumed that the recorded levels were too low. To establish consistency in the relevant time series, therefore, recalculations back to 1990 were carried out. Since the relevant fuel inputs fluctuate annually, in keeping with primary energy consumption, simple interpolation would not have led to the desired consistency. For that reason, a mean for the pertinent relationship (fuel inputs / primary energy consumption) was calculated for the period 2005-2009, and then that mean was used for the calculations back to 1990. This procedure has produced a plausible and consistent time series.

The area of **construction-sector transports** (CRF 1.A.3.e ii) accounts for the majority of energy inputs in this source category. The diesel-fuel and petrol consumption data are taken from Energy Balance lines 79 and 67 (through 1994 and as of 1995) (cf. Chapter 18.2), following deduction of energy inputs for military and agricultural transports. Since construction-sector transports are significant with regard to this category's status as a key category, a highly detailed calculation procedure should be used for this category. At present, due to a lack of detailed data, only the above-described Tier 1 method can be used, however.

Emission factors:

The emission factors for natural-gas use in **natural gas compressor stations** are based, for each specific gas, on the results of various Federal Environment Agency research projects and expert opinions:

- With regard to CO_2, the reader's attention is called to the documentation in Annex 2, the Chapter "CO_2 emission factors".
- The CH_4 EF have been taken from Chapter 4.9.5 and Annex E, Table 5 of the Federal Environment Agency study on stationary combustion systems (RENTZ et al, 2002), while the N_2O EF have been taken from the report FICHTNER et al (2011). The procedure used in the studies is described in Chapter 3.2.6.2.

The emission factors for emissions of **construction-sector transports** are based on the results of various Federal Environment Agency research projects and expert opinions:

- With regard to CO_2, the reader's attention is called to the documentation in Annex 2, the Chapter "CO_2 emission factors". For diesel fuel, a country-specific value of 74,000 kg/TJ is used, while for petrol an IPCC default value of 72,000 kg/TJ is used.
- The country-specific EF (CH_4) are based on a Federal Environment Agency study of the emissions of mobile machinery (IFEU, 2009). These factors reflect the emissions standards that have been phased in gradually, since the mid-1990s, for construction-sector machinery. For 2011, the relevant value for diesel fuel is 1.4 kg/TJ (1995: 4.1 kg/TJ), while for petrol it is 20.6 kg/TJ (1995: 22.8 kg/TJ).
- The country-specific N_2O emission factors for petrol (for the old German Länder for 1990-1994, and for all of Germany as 1995: 3.7 kg/TJ; for the new German Länder for 1990-1994: 2.1 kg/TJ) were also obtained from the Federal Environment Agency study "Air Quality Control '88" ("Luftreinhaltung '88" (UBA, 1989b)). The N_2O emission factor for diesel fuel, 1.0 kg/TJ, was derived, by analogy, from the value for heavy duty vehicles without emissions-control equipment.

3.2.10.5.3 Uncertainties and time-series consistency (1.A.3.e)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, in the Chapter "Uncertainties in the activity data of stationary combustion plants", of the NIR 2007.

The procedure for determining uncertainties for the EF of natural gas compressor stations is described in Chapter 3.2.6.2. Results for N_2O are presented in Chapter 3.2.6.3.2, while those for CH_4 are presented in Chapter 3.2.6.3.3.

The EF time series for N_2O for petrol (construction industry) exhibits inconsistencies resulting from statistical conversion as of 1994/1995; these inconsistencies cannot be eliminated at present. Since 1995, relevant activities in the new German Länder have not been listed separately. As a result, emissions cannot be calculated using new-Länder EF that diverge from those for the old German Länder. Since it cannot be assumed that specific emissions – and, thus, EF – were comparable in the old and new German Länder until 1994, the different EF for those years have been retained. As a result, the time series contains a methodological change, manifested as a jump in the overall EF (IEF).

3.2.10.5.4 Source-specific quality assurance / control and verification (1.A.3.e)

Due to a lack of expert resources, it was not possible to carry out quality control / quality assurance for the activity data, apart from QC/QA for such data for the area of "all-terrain vehicles". Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the EF and ED, and they have also been carried out for the AD relative to "all-terrain transport vehicles".

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance for the area of "pipeline transport" carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[27].

Natural gas compressor stations: The results of Chapter 3.2.6.4 apply mutatis mutandis.

In addition, implied emission factors (IEF) for the area of construction-sector transports were compared with those of other countries. Due to this source category's highly heterogeneous composition, however, such comparisons are extremely difficult to carry out for methane and nitrous oxide.

3.2.10.5.5 Source-specific recalculations (1.A.3.e)

Natural-gas-compressor stations: With respect to the Submission 2012, the nitrous oxide emissions for all years as of 2004 were recalculated, to take account of a correction of the emission factor used for natural gas compressors subject to the 13th Ordinance Implementing the Federal Immission Control Act (13.BImSchV).

Table 71: Revision of the nitrous oxide emission factor for natural gas compressors subject to the 13th Ordinance Implementing the Federal Immission Control Act (13.BImSchV), for the period as of 2004

	Units	2004	2005	2006	2007	2008	2009	2010
Subm. 2013	[kg/TJ]	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Subm. 2012		1.16	1.10	1.02	0.94	0.89	0.85	0.80

[27] AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 (last checked on 30 October 2009)

Absolute difference		0.54	0.60	0.68	0.76	0.81	0.86	0.90
Relative difference	[%]	46.55	54.55	66.67	80.85	91.01	101.18	112.50

Table 72: Recalculation of nitrous oxide emissions of natural gas compressor stations, for the period as of 2004

	Units	1990	1995	2000	2004	2005	2006	2007	2008	2009	2010
Subm. 2013	[Gg]	0.049	0.054	0.059	0.035	0.045	0.045	0.051	0.041	0.043	0.040
Subm. 2012		0.049	0.054	0.059	0.035	0.031	0.029	0.031	0.023	0.023	0.021
Absolute difference		0.000	0.000	0.000	0.000	0.014	0.015	0.019	0.018	0.020	0.019
Relative difference	[%]	0.00	0.00	0.00	0.00	43.61	51.09	62.67	75.78	86.24	91.44

Construction-sector transports:

Changes with respect to the previous report were made to take account of a correction of the procedure for calculating the quantities of petrol consumed by construction-sector transports, in the category "commercial and institutional and other consumers", from the total quantities reported via the Energy Balances. Consumption of avgas in military air transports was taken into account for the first time, and this necessitated minimal corrections for all years considered. In addition, the 2010 Energy Balance was revised.

Table 73: Recalculation of the quantities of petrol consumed by construction-sector transports, for the period as of 1995

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Subm. 2013	[TJ]	2,816	3,132	3,109	3,044	3,052	3,063	3,013	1,809	1,745
Subm. 2012		2,816	3,135	3,110	3,044	3,054	3,069	3,013	1,809	1,750
Absolute difference		0	-3	0	0	-1	-6	0	0	-6
Relative difference	[%]	0.00	-0.09	-0.01	0.00	-0.03	-0.20	0.00	0.00	-0.32

Table 74: Adjustment of the quantities of diesel fuel consumed by construction-sector transports in keeping with the revised 2010 Energy Balance

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Subm. 2013	[TJ]	46,991	41,076	39,926	34,365	34,981	34,656	35,392	37,632	37,151
Subm. 2012		46,991	41,076	39,926	34,365	34,981	34,656	35,392	37,632	38,130
Absolute difference		0	0	0	0	0	0	0	0	-979
Relative difference	[%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.57

The emission factors used have remained unchanged, however.

The following table summarises the adjustments, resulting from the above-described corrections and recalculations, in the greenhouse-gas emissions reported for 1.A.3.e.

Table 75: Resulting recalculations of greenhouse-gas emissions, for the period as of 1995

	Units	1990	1994	1995	2000	2005	2006	2007	2008	2009	2010
Subm. 2013	[Gg CO_2 equiv.]	4,792	4,502	4,635	4,629	4,294	4,548	4,192	4,336	4,315	4,095
Subm. 2012		4,792	4,502	4,636	4,629	4,289	4,542	4,187	4,329	4,309	4,162
Absolute difference		0	0	0	0	5	6	5	6	6	-68
Relative difference	[%]	0.00	0.00	-0.004	-0.001	0.11	0.13	0.12	0.14	0.14	-1.63

3.2.10.5.6 Source-specific planned improvements (1.A.3.e)

Natural-gas-compressor stations: No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

Construction-sector transports: No improvements are planned at present.

3.2.11 Other: Residential, commercial/institutional, agriculture, forestry and fisheries (1.A.4)

3.2.11.1 Source category description (1.A.4)

CRF 1.A.4	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
CRF 1.A.4.a (commerce, trade, services)								
All fuels	**CO_2**	**L**	**T/T2**	**63,949.6**	**(5.25%)**	**33,429.9**	**(3.61%)**	**-47.72%**
All fuels	**CH_4**	**-**	**--**	**1,216.1**	**(0.10%)**	**56.3**	**(0.01%)**	**-95.37%**
All fuels	N_2O	-	-	144.2	(0.01%)	101.5	(0.01%)	-29.61%
CRF 1.A.4.b (Residential)								
All fuels	**CO_2**	**L**	**T/T2**	**129,474.0**	**(10.63%)**	**81,918.8**	**(8.85%)**	**-36.73%**
All fuels	CH_4	-	-	1,200.4	(0.10%)	702.6	(0.08%)	-41.47%
All fuels	N_2O	-	-	801.9	(0.07%)	400.5	(0.04%)	-50.05%
CRF 1.A.4.c (Agriculture, forestry and fisheries)								
All fuels	**CO_2**	**L**	**T/T2**	**11,059.8**	**(0.91%)**	**5,970.9**	**(0.64%)**	**-46.01%**
All fuels	CH_4	-	-	178.5	(0.01%)	103.6	(0.01%)	-41.96%
All fuels	N_2O	-	-	41.7	(0.00%)	41.9	(0.00%)	0.46%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category 1.A.4 *Other* is a key category for CO_2 emissions, in terms of both emissions level and trend, in all of its sub - source categories.

Source category 1.A.4 comprises combustion systems in the areas *Residential*, *Commercial and Institutional* and *Agriculture*, along with various mobile sources.

Heat-generation systems in small combustion systems of small commercial and institutional users are reported in sub- source category 1.A.4.a. Commercial and institutional.

1.A.4.b comprises energy inputs in households (the Residential sector). This refers primarily to combustion systems. In addition, source category 1.A.4.b includes residential mobile sources (not including road transports).

Sub- source category 1.A.4.c comprises the areas of agriculture, forestry and fisheries. Reporting under this category includes emissions from heat generation in small and medium-sized combustion systems and emissions from agricultural transports. Pursuant to the IPCC structure, 1.A.4.c also includes emissions from mobile sources in fisheries and in forestry.

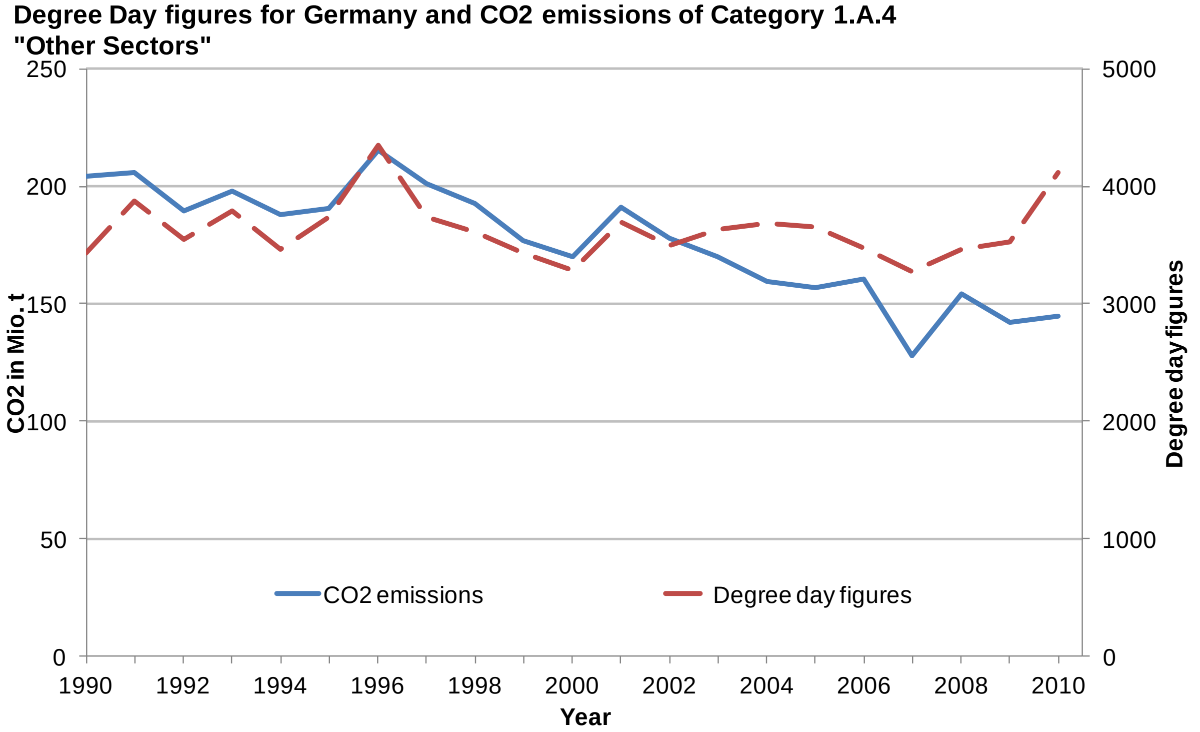


Figure 34: Change in total emissions of 1.A.4, as a function of temperature

The main driver of CO_2 emissions in 1.A.4 is energy consumption for purposes of space heating. Consequently, fluctuations in consumption can plausibly be attributed to differences in periods of winter cold. The trend toward lower CO_2 emissions is a result of higher standards for new buildings and of successful execution of energy-efficiency-oriented modernisations of existing buildings. The trend has also been boosted by shifting to fuels with lower CO_2 emissions. On the other hand, CO_2 emissions from heat pumps, which are being used more and more frequently in new buildings, are not reported here.

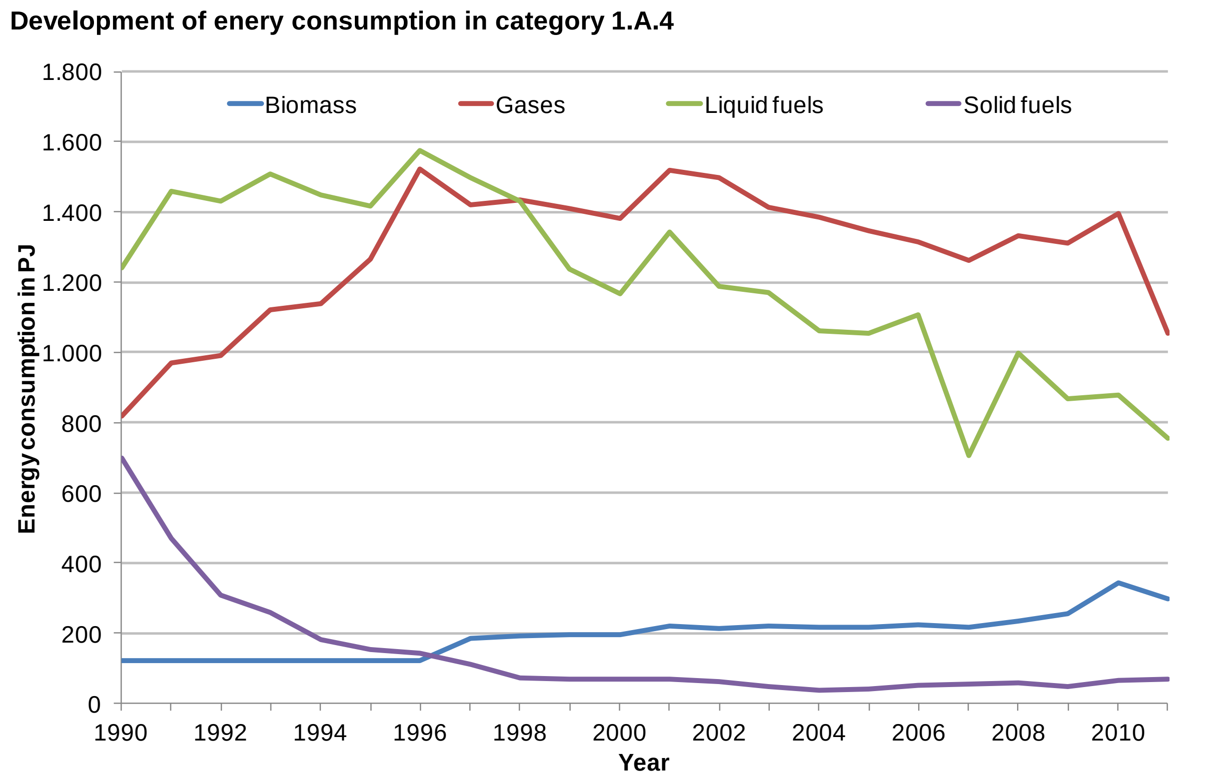


Figure 35: Trends in energy consumption in 1.A.4, for 4 fuel categories

Shifting from liquid fuels (almost exclusively heating oil) and solid fuels (mainly coal) to gaseous fuels (natural gas) and biomass has brought about considerable CO_2-emissions reductions. In 2006 and 2007, a special phenomenon occurred whereby energy consumption was first above-average and then below-average, respectively, as a result of an increase in the value-added-tax (VAT) rate from 16 % to 19 %. Very high heating-oil sales in 2006 brought about increasing CO_2 emissions, since emissions data relative to heating oil are determined on the basis of sales, rather than consumption. "The sharp decrease in energy consumption in 2011, especially in the market for heating energy, is due to the comparatively mild weather experienced in the winter heating period. The decrease is marked, because the winter of the previous year, 2010, was very cold by comparison. The reduction in energy consumption was also the result of reactions to considerably higher energy prices and costs." (Source: Arbeitsgemeinschaft Energiebilanzen (AGEB), Energieverbrauch in Deutschland im Jahr 2011).

The group of combustion systems in the Residential and Commercial/Institutional sectors is very diverse with regard to installation design and size. It covers a spectrum that includes individual room furnaces for solid fuels with a rated thermal output of approximately 4 kW (e.g. fireplaces, ovens), oil and gas furnaces used to generate room heat and hot water (e.g. central heating boilers), hand-fed and automatically fed wood-burning furnaces in the commercial sector and commercial/institutional users' licensable combustion systems with a rated thermal output of several megawatts, to name but a few examples. In total in 2005, more than 36.5 million combustion systems were installed in Germany in the Residential and Commercial and Institutional sectors (STRUSCHKA, 2008: p. 12). Gas-fired combustion systems accounted for a majority of these systems, or some 14.5 million, while combustion systems using solid fuels accounted for some 14.4 million systems and oil-fired furnaces accounted for some 7.9 million systems. The great majority of these systems (about 95 %) are in place in private households (STRUSCHKA, 2008).

Of the wood fuels used in households and in commerce and trade, large quantities are purchased privately or obtained from system owners' own forest parcels. For this reason, in the Energy Balance, the relevant data from the Federal Statistical Office are supplemented with data from a survey of firewood consumption in private households. No official data are available on use of firewood in the source categories commercial and institutional [commerce, trade and services]. As a result, data are taken from a pertinent study from the year 2000 (UBA 2000a). The consumption-level figures determined in that study have been adopted for subsequent years since then. A research project entitled "Development of methods for determination of consumption of biogenic solid fuels in the commercial and institutional sector" ("Methodenentwicklung zur Ermittlung des Verbrauchs biogener Festbrennstoffe im GHD-Sektor") was carried out to determine activity data on use of firewood in the commercial and institutional sector more precisely. Since the project yielded sample results for individual areas, a complete data set on the sector's firewood use – a data set that would support an update – is still lacking. The initial aim of the project was to develop a method that would lead to a general approach. Plans now call for a follow-on project that will build on the experience gained in the first project and complete the results for other sectors. The Energy Balance fuel category "Waste and other biomass" is specified in greater detail in the Satellite Balance. The information in that Balance indicates that only firewood is used in the residential sector, while only gas from wastewater treatment / biogas are used in the sector "Commercial, institutional (commerce/trade/services) and other consumers".

3.2.11.2 Methodological issues (1.A.4)

Activity data

The activity data in source category 1.A.4 are based on the Energy Balances for the Federal Republic of Germany, as prepared by the Working Group on Energy Balances (AGEB). For years prior to 1995 separate Energy Balances are used for the a) old German Länder and b) new German Länder. For years as of 1995, lines 66 (residential) and 67 (commercial and institutional and other consumers) are the standard.

The quantities of gasoline fuels listed in line 66 are all allocated to *Mobile sources in the residential sector* (sub-category *1.A.4.b (ii)*).

Since the data in Energy Balance line 67 – commercial and institutional and other consumers – also include military consumption (offices, and vehicles and aircraft), such military consumption must be deducted from the relevant positions in line 67 (cf. Chapter 3.2.12 with regard to stationary and mobile sources in the military sector).

For energy inputs in *Agricultural combustion systems (1.A.4.c (i)*), which are also included in line 67 of the Energy Balance, relevant data are available, in an existing study (UBA, 2000a), for 1995. That study provides an estimate of agricultural combustion systems' share of total energy inputs in line 67. That share is assumed to have remained constant since then.

Consumed quantities of diesel fuel and gasoline, which are also included in line 67, are allocated completely to mobile consumers (construction-sector, agricultural and military transports). The relevant share for *Agricultural transports (sub-category 1.A.4.c (ii)*) is obtained by deducting pertinent military consumption, as obtained from BAFA data (cf. Chapter 3.2.12), and by deducting construction-sector transports (cf. Chapter 3.2.10.5).

The activity data for high-seas fisheries, which are recorded under *1.A.4.c (iii) – Fisheries*, are conservatively calculated on the basis of the engine types/performance used on active German fishing vessels (EC, 2011) and a fixed consumption level of 200g of diesel fuel per kWh.

Emission factors

The basic data for the emission factors used for N_2O und CH_4, for stationary combustion systems, is provided by the research report "Efficient provision of current emissions data for purposes of air quality control" ("Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung"; STRUSCHKA 2008). Within the context of that project, device-related and source-category-specific emission factors for combustion systems in the residential and commercial/institutional sectors were calculated, with a high level of detail, for all important emissions components for the reference year 2005.

Determination of emission factors is based on a source-category-specific "bottom-up" approach that, in addition, to differentiating (sub-) source categories and fuels, also differentiates system technologies in detail. In the process, several system-specific emission factors are aggregated in order to obtain mean emission factors for all systems within the source categories in question. Use of system-specific / category-specific emission factors ensures that all significant combustion-related characteristics of typical systems for the various categories are taken into account. The procedure is in keeping with the Tier 2/3 method described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006).

The emission factors are structured in accordance with the relevant fuels involved in final energy consumption in Germany:

- Fuel oil EL
- Natural gas,
- Lignite (briquettes from the Rhine (Rheinisch) and Lusatian (Lausitz) coal fields; imported briquettes),
- Hard coal (coke, briquettes, anthracite) and
- Wood (unprocessed wood, wood pellets, residual wood).

In addition, emission factors for combustion systems are determined in accordance with device design, age level, output category and typical mode of operation. The emissions behaviour of the combustion systems in question was determined via a comprehensive review of the literature, in an approach that distinguished between results from test-bench studies and field measurements. Transfer factors were used to take account of the fact that emissions in a test-bench environment tend to be lower than those of corresponding installed systems.

The description of the structure for installed combustion systems was prepared using statistics from the chimney-sweeping trade, as well as with the help of surveys conducted by the researchers themselves in selected chimney-sweep districts of Baden-Wuerttemberg, North-Rhine Westphalia and Saxony. Those data were used to estimate the energy inputs for various system types, to make it possible to determine sectoral emission factors weighted by energy inputs. Table 76 shows the sectoral emission factors determined.

Table 76: Sectoral emission factors for combustion systems in the residential and commercial/institutional sectors for reference year 2005

1.A.4.b (i) - Residential	CH_4 [kg/TJ]	N_2O
Hard coal	129	11
Briquettes	368	9.7
Hard-coal coke	13	0.82
Lignite briquettes	55	5.2
Unprocessed wood	100	1.5
Heating oil EL	0.046	0.55
Natural gas	2.3	0.25
1.A.4.a (i) & c(i) - Commercial and Institutional		
Hard coal	100	10
Briquettes	-	-
Hard-coal coke	-	-
Lignite briquettes	-	-
Wood fuels	56	1.1
Heating oil EL	0.026	0.56
Natural gas	0.16	0.33

The emission factors for 2005 were used, without change, for subsequent years.

Table 77: Sectoral emission factors for mobile sources of the residential, agricultural-transports and fisheries sectors

1.A.4.b (ii) - Mobile sources of the residential sector	CH_4 [kg/TJ]	N_2O
Petrol	37.0	3.7
1.A.4.c (ii) – Agricultural transports		
Diesel fuel	1990: 7.61 1995: 7.17 2011: 4.24	1.0
Petrol	37.0	3.7
1.A.4.c (iii) – Fisheries (here: high-seas fisheries)		
Diesel fuel	7.0	2.0

At present, constant emission factors are being used for mobile sources, for nearly all years under consideration. Country-specific EF that reflect gradually introduced emissions standards are being used solely for methane from consumption of diesel fuel in agricultural machinery and vehicles.

3.2.11.3 Uncertainties and time-series consistency (1.A.4)

Annex 2, Chapter 13.6 in the NIR 2007 describes the method used to determine the uncertainties for the **activity data**.

To date, default uncertainties pursuant to IPCC have been used for *mobile residential sources* and *agricultural transports*.

A complex procedure is required to calculate reliable emission factors in this installation sector. Apart from emission figures, it is also necessary to obtain other information; for example, one must make allowance for the relevant mode of operation (loads), installation structure and device-specific final energy consumption. In data surveys during the aforementioned research and development project, this approach was for the most part followed; nevertheless, given the sheer number of facilities concerned and the wide range of combustion systems and fuels used, the data must be assumed to have a fairly large "basic uncertainty".

For some installation types, moreover, only inadequate data or no data at all were available on emissions behaviour in connection with certain fuels. It is important to remember that the law does not require the greenhouse-gas emissions of combustion systems of residential and commercial/institutional users to be measured. When calculating the emission factors, therefore, in most cases (with the exception of CO_2, which is largely independent from furnace design) the researchers only had recourse to a few results from individual measurements on selected installations. Gaps in the data were closed via adoption of emission factors of comparable combustion systems.

The uncertainties listed for the emission factors for CH_4 and N_2O, for stationary combustion systems, were determined via expert estimation pursuant to IPCC-GPG (2000: Chapter 6). That assessment, which is based on the emissions data obtained for the aforementioned research project, was carried out in the framework of that project by experts of the University of Stuttgart's Institute of Process Engineering and Power Facility Technology (Institut für Verfahrenstechnik und Dampfkesselwesen). Uncertainties were estimated separately for all combustion technologies and fuels. The following sources of error entered into the estimates for N_2O and CH_4:

- Measuring errors in determination of pollutant concentrations;
- Uncertainties in estimating transfer factors (systematic differences between test-bench and field measurements);
- Uncertainties resulting from having too little emissions data;
- Uncertainties resulting from use of different measuring procedures;
- Uncertainties in the installation data used (overall group structure in terms of type, age and performance and fuel consumption)

In gas-fired systems, another error occurs in determination of start-up/shutdown emissions. During start-up/shutdown procedures, some partly unburned CH_4 is emitted from natural gas. Those emissions, which occur upstream and downstream from the actual combustion process, cf. Chapter 3.3.2.4 (natural gas), are a significant reason why CH_4 emission factors for gas-combustion systems are subject to high levels of uncertainties.

As to the distribution of uncertainties, a log-normal distribution is assumed for N_2O emission factors. In all likelihood, the deviations are considerably more pronounced in the vicinity of larger values than they are in the vicinity of smaller values. The emission factors for CH_4 and N_2O were determined for the year 2005, in the framework of the aforementioned research project, and are assumed to have remained constant since then.

3.2.11.4 Source-specific QA/QC and verification (1.A.4)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Information on quality assurance for **activity data** is provided in Chapter 3.2.6.4. For further information on quality assurance, cf. Chapter 18.4.2.

For the purposes of quality assurance for data relative to *stationary combustion systems*, in the context of the aforementioned research and development project, all the input data used from literature and from the research contractor's own investigations were reviewed for validity. As a general principle, in description of the emissions behaviour of combustion systems, emissions data were included in subsequent calculations only if the relevant literature sources contained complete, undisputed data on the fuel used, the design of the furnace, and the furnace's operating mode during measurements. All resources of significance for inventory preparation were substantiated by the research contractor.

In the framework of a quality review carried out by Federal Environment Agency experts, the country-specific emission factors for CH_4 and N_2O, determined in accordance with the Tier 2 standard, were compared with the IPCC Tier 2 default factors in the IPCC Guidelines for emissions inventories (IPCC 2006). For most fuels, the values agreed well (discrepancies within one order of magnitude), although the default values for CH_4 tended to be higher than the country-specific values.

In the framework of quality assurance, calculation with the Tier 1 default values was carried out, in addition to emissions determination pursuant to Tier 2/3, for the residential and commercial/institutional sectors for the year 2005. The results are shown in Table 78.

Table 78: Emissions calculation with country-specific Tier 2/3 emission factors and with the Tier 1 default emission factors pursuant to (IPCC 2006)

	CH_4 [t]				N_2O [t]			
	Residential		Commercial and institutional		Residential		Commercial and institutional	
Emission factors	**Tier 1 default**	**Struschka 2008**	**Tier 1 default**	**Struschka 2008**	**Tier 1 default**	**Struschka 2008**	**Tier 1 default**	**Struschka 2008**
Heating oil EL	6,590	30	2,489	6.5	395	357	149	139
Fuel gases	5,290	2,459	2,496	77	106	266	50	163
Coal fuels	13,452	4,568	6	58	67	340	1	5.6
Wood	60,194	20,001	5,749	1,081	803	284	77	6.2
Total	**85,526**	**27,058**	**10,740**	**1,223**	**1,371**	**1,247**	**279**	**313.8**

The emissions for the commercial/institutional ("small consumers") sector include the emissions of the areas of agriculture, forestry and fisheries.

For N_2O, the emissions-calculation results obtained with both methods showed good agreement. Larger discrepancies were seen in determination of CH_4 emissions. Presumably, this is due to the fact that methane emissions of combustion systems depend strongly on the combustion technology used. Differences in installation structures (i.e. in sector composition), from country to country, thus manifest themselves much more strongly in total emissions (as determined) than in nitrous-oxide emissions. The default emission factor for heating oil, in particular, is very high. The technology-specific emission factor given in IPCC 2006 for boilers shows considerably better agreement with the pertinent country-specific factor for Germany.

No data sources are known that would support a comparison with the data reported here for mobile sources in the residential, agricultural and fisheries sectors. In addition, the country-specific IEF were compared with those of other countries. Due to the heterogeneous composition of the sub- source categories involved, however, that comparison is largely inconclusive – especially with regard to methane and nitrous oxide.

3.2.11.5 Source-specific recalculations (1.A.4)

The availability of the final Energy Balance made it necessary to carry out recalculations, for all fuels, for the year 2010. A significant change resulted with regard to natural gas. In that area, quality-assurance measures identified a number of discrepancies. Those discrepancies were then successfully addressed via corrections of official statistics. That work, in turn, led to considerable upward corrections in the final 2010 Energy Balance that is now available.

Table 79: Recalculations in CRF 1.A.4 (stationary & mobile)

Units [Gg]	NIR 2012	NIR 2013	Difference, absolute				Difference, relative
Year	Total	Total	gas	liquid	solid	Total	Total
1995	190,555	190,555	0	-0.27	0.00	**-0.27**	**0.00%**
1996	215,505	215,505	0	-0.12	0.00	**-0.12**	**0.00%**
1997	201,100	201,100	0	-0.12	0.00	**-0.12**	**0.00%**
1998	192,748	192,748	0	-0.10	0.00	**-0.10**	**0.00%**
1999	176,838	176,838	0	-0.08	0.00	**-0.08**	**0.00%**
2000	170,074	170,074	0	-0.05	0.00	**-0.05**	**0.00%**
2001	190,953	190,953	0	-0.03	0.00	**-0.03**	**0.00%**
2002	177,672	177,672	0	-0.01	0.00	**-0.01**	**0.00%**
2003	170,056	170,056	0	-0.02	0.00	**-0.02**	**0.00%**
2004	159,584	159,584	0	-0.01	0.00	**-0.01**	**0.00%**
2005	157,036	157,035	0	-0.01	0.00	**-0.01**	**0.00%**
2006	160,254	160,254	0	-0.10	0.00	**-0.10**	**0.00%**
2007	127,820	127,820	0	-0.62	0.00	**-0.62**	**0.00%**
2008	154,015	154,015	0	0.00	0.00	**0.00**	**0.00%**
2009	141,800	141,800	0	-0.04	0.04	**0.00**	**0.00%**
2010	144,557	149,174	4,012	-115.04	720	**4,617**	**3.19%**

The figures for high-seas fisheries (1.A.4.c iii) were not affected by these changes, however, since they are based on unchanged data for fleet size and installed engine power.

Table 80: Adjustment of the quantities of diesel fuel consumed in Sector 1.A.4, and of the quantities of petrol consumed by mobile sources in the residential sector, in keeping with the revised 2010 Energy Balance

	Units	Diesel fuel	Petrol
Submission 2013	[TJ]	52,181	3,379
Submission 2012		53,534	3,394
Absolute difference		-1,353	-15
Relative difference	[%]	-2.53	-0.44

For the area of agricultural transports (1.A.4.c ii), changes were made, with respect to the previous report, for all years as of 1995. This resulted from a correction of the procedure for calculating pertinent consumed quantities of petrol from the total quantities reported in Energy Balances for the category "commercial and institutional and other consumers". Consumption of avgas in military air transports was taken into account for the first time, and this necessitated minimal corrections for all years considered.

Table 81: Recalculation of the quantities of petrol consumed by agricultural transports, for the period as of 1995

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Submission 2013	[TJ]	3,889	4,325	4,294	4,203	4,215	4,230	4,161	2,498	2,410
Submission 2012		3,889	4,329	4,294	4,203	4,217	4,238	4,161	2,498	2,417
Absolute difference		0	-4	-1	0	-1	-9	0	0	-8
Relative difference	[%]	0.00	-0.09	-0.01	0.00	-0.03	-0.20	0.00	0.00	-0.32

Table 82: Resulting adjustment of the quantities of petrol consumed in sector 1.A.4 (including adjustment for mobile sources in the residential sector for 2010)

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Submission 2013	[TJ]	6,066	6,720	6,689	6,598	6,392	6,407	6,338	5,943	5,789
Submission 2012		6,066	6,724	6,689	6,598	6,394	6,415	6,338	5,943	5,811
Absolute difference		0	-4	-1	0	-1	-9	0	0	-23
Relative difference	[%]	0.00	-0.05	-0.01	0.00	-0.02	-0.13	0.00	0.00	-0.39

The described corrections had the following impacts on GHG emissions reported for sector 1.A.4 as a whole:

Table 83: Resulting recalculation of greenhouse-gas emissions for the entire sector 1.A.4, for the period as of 1990

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Submission 2013	[Gg CO_2 equiv.]	208,066	191,979	171,295	158,095	161,398	128,898	155,221	142,964	150,744
Submission 2012		208,066	191,979	171,295	158,095	161,399	128,898	155,221	142,964	145,928
Absolute difference		0.00	-0.27	-0.05	-0.01	-0.11	-0.64	0.00	0.01	4,815
Relative difference	[%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.30

3.2.11.6 Source-specific planned improvements (1.A.4)

At present, no improvements are planned with respect to reporting on *stationary combustion systems*.

Upon completion of the emissions calculation, the AGEB made a number of corrections in the Energy Balance; those corrections will be integrated within the inventory for the next submission.

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

3.2.12 Other (1.A.5)

Source category 1.A.5 comprises the combustion-related emissions of the military sector. It is divided into the source categories 1.A.5.a *"Stationary"* and 1.A.5.b *"Mobile"*.

3.2.12.1 Source category description (1.A.5)

CRF 1.A.5	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T**	**11,811.1**	**(0.97%)**	**1,202.1**	**(0.13%)**	**-89.92%**
All fuels	CH_4	-	-	235.6	(0.02%)	4.3	(0.00%)	-98.19%
All fuels	N_2O	-	-	70.4	(0.01%)	9.3	(0.00%)	-86.75%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS/D
CH_4	CS	NS	CS/D
N_2O	CS	NS	CS/D

The source category *Other* is a key category for CO_2 emissions in terms of both emissions level and trend.

The following figure shows the emissions trend as of 1990.

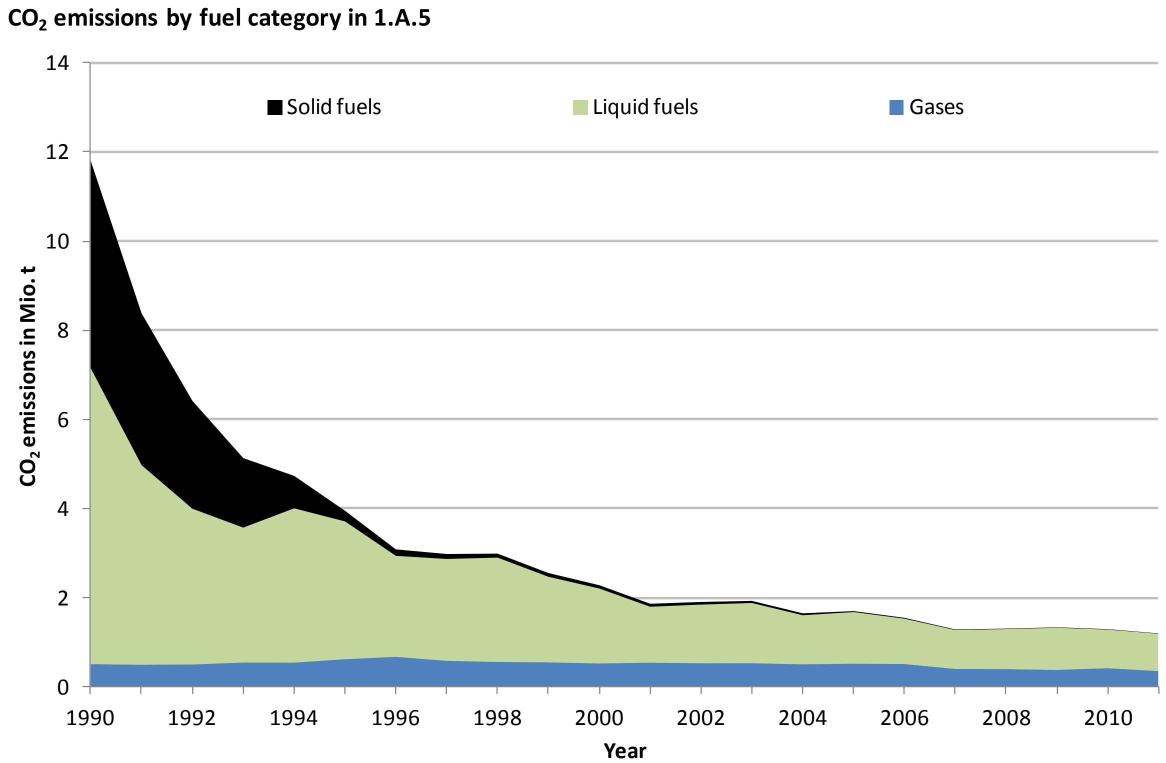


Figure 36: Development of CO_2 emissions in source category 1.A.5

A particularly large emissions reduction has occurred in source category 1.A.5. It is due a) to the closure of many military facilities and b) to marked changes in fuel inputs in stationary combustion systems. A trend is occurring in which gaseous and liquid fuels are supplanting solid fuels.

3.2.12.2 Methodological issues (1.A.5)

Activity data

The Energy Balance of the Federal Republic of Germany (AGEB) provides the basis for the activity data used. Since the Energy Balance does not provide separate listings of military agencies' final energy consumption as of 1995 – and includes that consumption only in line

67, under "commercial, institutional and other consumers" – additional sources of energy statistics had to be found for source category 1.A.5.

For source category **1.A.5.a**, use is made of data of the Federal Office of Defence Administration (BAWV, 2012), which has reported the "Energy input for heat production in the German Federal Armed Forces", by fuels and for 2000-2011, to the Federal Environment Agency. Those figures are deducted from the figures in Energy Balance line 67 (commercial, institutional) and are reported in 1.A.5, rather than in 1.A.4. Since the 2008 report year, use of wood in source category 1.A.5.a is also reported.

Until 1994, military fuel-consumption (diesel fuel and petrol) and aircraft-fuel-consumption (jet kerosine) data for source category **1.A.5.b** were taken from the Energy Balances. Since the Energy Balances lack separate data for the military sector for subsequent years, the official mineral-oil data for the Federal Republic of Germany, published by the Federal Office of Economics and Export Control (BAFA) (BAFA, 2012), are used for the period as of 1994. The consumption figures in that source, which are given in units of 1000 t, are converted into TJ on the basis of the pertinent listed net calorific values.

In addition, use of lubricants and the CO_2 emissions resulting from their co-combustion are recorded. For all years as of 1993, the underlying data on domestic deliveries to military agencies have been taken from the official mineral-oil data of the Federal Office of Economics and Export Control (BAFA). They are converted to TJ via a net calorific value of 40 GJ/t. For the years 1990 through 1992, extrapolation has been carried out on the basis of trends in fuel inputs. To date, a conservative estimate has been applied whereby 50 % of the input quantities are co-combusted and thus produce CO_2 emissions.

As of the 2012 report, consumption of lubricants, and the CO_2 emissions resulting from co-combustion of lubricants, are included. For all years as of 1993, the underlying data on domestic deliveries to military agencies have been taken from the official mineral-oil data of the Federal Office of Economics and Export Control (BAFA). For the years 1990 through 1992, extrapolation has been carried out on the basis of trends in fuel inputs.

Emission factors

The database for the emission factors used for source category **1.A.5.a** consists of the results of a research project carried out by the University of Stuttgart, under commission to the Federal Environment Agency (STRUSCHKA, 2008). Within that project, device-related and source-category-specific emission factors for combustion systems in military agencies were calculated, with a high level of detail, for all important emissions components for the reference year 2005. The method used to determine the factors conforms to the procedure described for source category 1.A.4. Table 84 shows the sectoral emission factors used.

With regard to the CO_2 emission factors used for the military transports considered under **1.A.5.b**, the reader's attention is called to the documentation in Annex Chapter 18.7 on "*CO_2 emission factors*". In general, the same country-specific values are used in this context that are used for the road-transport sector (diesel fuel, gasoline) and for the civil aviation sector (jet kerosene, avgas). For methane and nitrous oxide, country-specific values are also used for ground transports and for use of avgas. For jet kerosene, IPCC default figures are used, in light of the fact that the aircraft used by the sector differ strongly from those used in civil aviation. The same applies to calculation of CO_2 emissions from co-combustion of lubricants. The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

Table 84: Sectoral emission factors for the military sector

Military	CH_4	N_2O
	[kg/TJ]	
- Stationary combustion in offices		
Hard coal	2.0	4.8
Lignite briquettes	242	0.37
Heating oil EL	0.017	0.56
Natural gas	0.042	0.29
- Military transports		
Diesel fuel	6.0	1.0
Petrol	37.0	3.7
Kerosene	0.5	2.0
Avgas	8.2	2.3
Lubricants	IE	IE

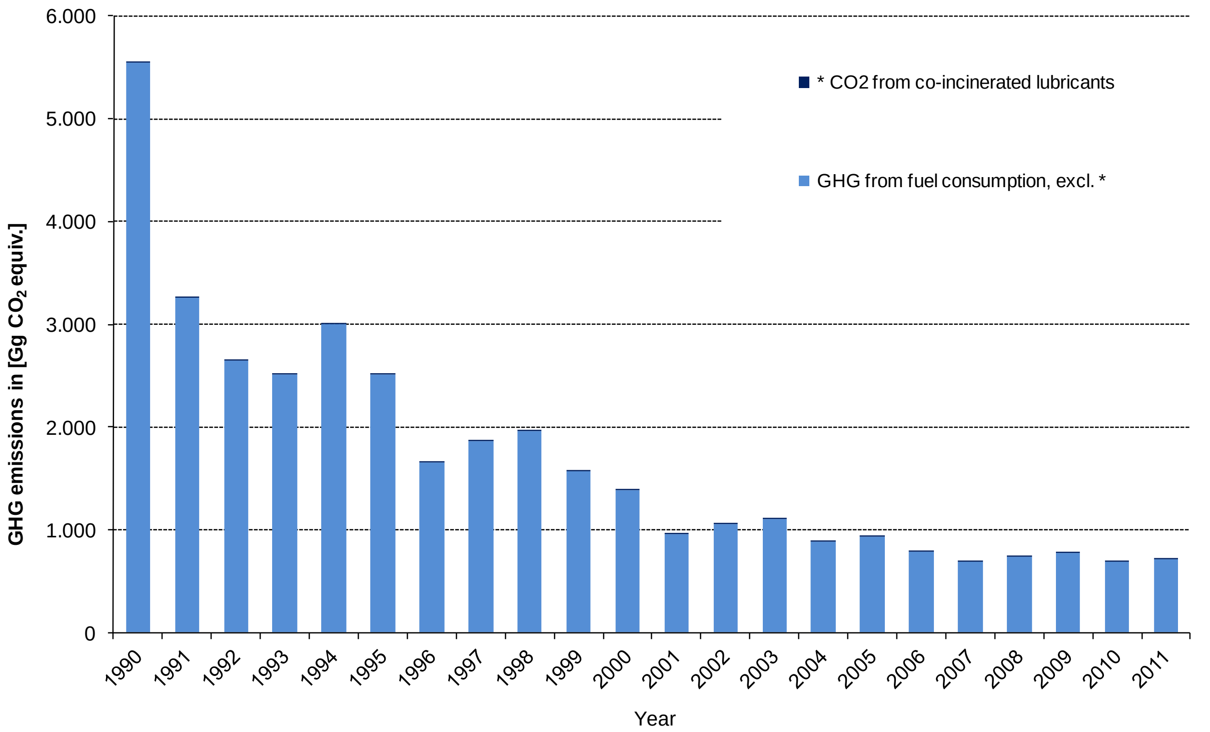


Figure 37: Development of greenhouse-gas emissions in military transports, 1990 – 2011

3.2.12.3 Uncertainties and time-series consistency (1.A.5)

Information regarding the uncertainties for the emission factors is provided in the description for source category 1.A.4. Annex 2 Chapter 13.6 in the NIR 2007 describes how the uncertainties for the activity data were determined.

3.2.12.4 Source-specific quality assurance / control and verification (1.A.5)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

In addition, the implied emission factors (IEF) for military transports were compared with those of other countries. The country-specific emission factors for CO_2 compare well with the IPCC default figures and with the values used by other countries. Such comparisons are extremely difficult to carry out for methane and nitrous oxide, however, due to this source category's highly heterogeneous composition.

Since no other sources of data for Germany are known, it is currently not possible to verify the emissions reported here via comparison.

3.2.12.5 Source-specific recalculations (1.A.5)

In the category **1.A.5.a Stationary**, only slight recalculations were carried out, for the years 2009 and 2010, to take account of changed applicable net calorific values.

No recalculations were carried out, with respect to the data provided in the 2012 Submission, in the area of **military transports (1.A.5.b Mobile)**.

3.2.13 Military

Emissions from international deployments by the Federal Armed Forces, under a UN mandate, are not recorded as a separate activity for purposes of German emission inventories. Such recording will be again be a matter for discussion in the framework of the National Emissions Reporting System. For various reasons, the relevant required activity data are not provided.

This practice does not lead to any omissions in the inventories, since the fuel inputs associated with such deployments are included in national military consumption figures.

The basis for activity data for military fuels consists of the Official Mineral Oil Statistics for the Federal Republic of Germany (BAFA, 2012).

In the CSE, source category 1.A.5 includes, under stationary sources, heat production of military agences; under mobile sources, it includes military transports and aviation.

3.3 Fugitive emissions from fuels (1.B)

During all stages of fuel production and use, from extraction of fossil fuels to their final use, fuel components can escape or be released as fugitive emissions.

While methane emissions are the most important emissions within the source category "solid fuels", fugitive emissions of oil and natural gas also include substantial amounts of NMVOC. Source category 1.B. is not a source for fluorinated gases.

Carbon dioxide emissions have decreased by 20 % with respect to 1990. The important factors in this development include processing of acid gas (1.B.2.b.ii) and flaring (1.B.2.c).

Emissions of **nitrous oxide** originate in flaring (1.B.2.c) in oil and gas production, and in gas processing. They are very low. As a result of improvements in extraction equipment, emissions decreased by 81 % with respect to 1990.

Methane emissions have been influenced primarily by sharp emissions decreases in the area of active mining (1.B.1.a) – caused mainly by reduced mining activity – and by increasing use of methane from decommissioned mines (1.B.1.c). With respect to 1990, methane emissions decreased by 88% in this area and, in category 1.B overall, decreased by 70 %.

Emissions of volatile organic compounds (**VOC**) have decreased by about 67 % since 1990. The decrease is due to implementation of the Technical Instructions on Air Quality Control (TA-Luft 2002), to decreases in emissions from petrol storage and from fuelling of motor vehicles (1.B.2.a.v) – as a result of implementation of the 20th and 21st Ordinances on the Implementation of the Federal Immission Control Act (BImSchV) – and to reduced petrol consumption. Figure 38 shows trends for non-methane-containing volatile organic compounds (**NMVOC**).

Sulphur dioxide emissions have decreased by over 73 % since 1990. The sharp reductions in such emissions seen especially at the beginning of the 1990s were due especially to closures in the eastern German industrial sector, to use of improved filters and to switching from lignite to other fuels. In subsequent years, decreasing production of hard-coal coke (1.B.1.b) and improved filter technologies in desulphurisation of natural gas (1.B.2.b.ii) had the largest effects on emissions.

Carbon monoxide emissions have decreased by 94 % since 1990, primarily as a result of decreasing production of hard-coal coke (1.B.1.b) and discontinuation of city-gas deliveries via the public gas-distribution network (1.B.2.b.iv).

Additional details relative to sulphur dioxide, carbon monoxide and NMVOC are described in the "Informative Inventory Report", available at iir.umweltbundesamt.de. Those details are not presented in the present report, since those gases are not greenhouse gases.

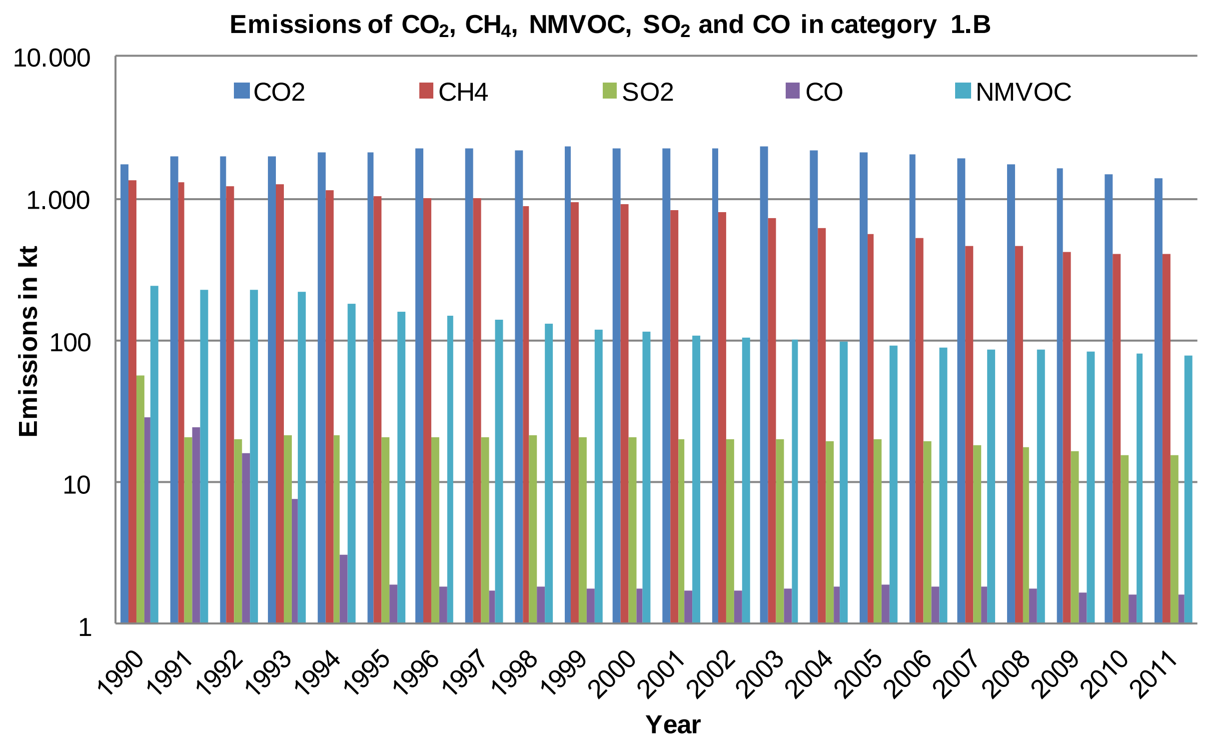


Figure 38: Emissions of CO_2, CH_4, NMVOC, SO_2 and CO in source category 1.B[28].

[28] For the sake of clarity, N_2O emissions are not included here. They decreased from 3,555 kg in 1990 to 660 kg in 2011.

3.3.1 Solid fuels (1.B.1)

The source category "Solid fuels" (1.B.1) consists of three sub- source categories – the source category "Coal mining" (1.B.1.a), the source category "Coal transformation" (1.B.1.b) and the source category "Other" (1.B.1.c).

Table 85 presents the scheme for source category allocation and the relevant calculation methods (Table 86).

Table 85: Allocation of methane emissions to areas of the CRF

Source category			Included emissions
1.B.1.a. Coal mining			
	i.	**Underground mining**	
		Mining activities	Emissions from active underground hard-coal mining. The total emissions from pit gas flows and pit-gas removal are reduced by the amount of pit gas used.
		Follow-up mining activities	Emissions from processing, storage and transport of hard coal
	ii.	**Open-pit mining**	
		Mining activities	Emissions from active open-pit lignite mining. Here, the entire potential methane content of German lignite is used as the basis – this methane is assumed to be emitted, in its entirety, during mining. Any later emissions of methane, during further processing, are thus already taken into account. No pit-gas collection or use takes place in open-pit mining.
		Follow-up mining activities	No separate listing – the emissions are already included in "mining activities"
1.B.1.b. Coal transformation – processing			Emissions from coal processing. This area takes account of specific emissions that occur in hard-coal processing (hard-coal coke, hard-coal briquettes). Emissions from lignite processing (lignite coke, coal dust, dry coal, fluidised-bed coal, lignite briquettes, lignite granulate) are already included in 1.B.1.a.ii "Mining activities". The assumed activity data cover the total for all processed products from hard coal and lignite.
1.B.1.c. Other			
		Decommissioned coal mines	Methane emissions for decommissioned hard-coal mines are listed here. No methane emissions from decommissioned lignite mines are recorded. Specification of activity data is not required.

In keeping with allocation of emissions to the various areas of the CRF table for "1.B.1 – Fugitive emissions from solid fuels", the following Table 86 presents calculated values for 2011 activity data, along with information regarding the origin of the data.

Table 86: Calculation of methane emissions from coal mining for 2009

			Activity data [Mt]	CH_4 emissions [Gg]
1.B.1.a. Coal mining			**188.60** (= 1.B.1.a.i + 1.B.1.a.ii)	(= 1.B.1.a.i + 1.B.1.a.ii) 122.48 + +1.94 **= 124.42**
	i.	**Underground mining**	**12.10**[29] Hard-coal production 1)	= **mining and follow-up mining-related activities** = 115.51 + 6.97 **= 122.48**
		Mining activities		= AD * EF = 12.10 * 9.55 **= 115.51**
		Follow-up mining activities		**= 6.97**
	ii.	**Open-pit mining**	**176.5** Lignite mining 1)	= **mining activities** **= 1.94**
		Mining activities		= AD * EF = 176.5 * 0.011 **= 1.94**
		Follow-up mining activities		(included in 1.B.1.a.ii) IE
1.B.1.b. Coal transformation – processing			**14.91** Total for processed products 2) 1)	$AD_{hard\text{-}coal\ prod.} * EF_{hard\text{-}coal\ prod.} + AD_{lignite\ prod.} * EF_{lignite\ prod.}$ = 7.99 * 0.049 + 6.92 * 0 **= 0.39**
1.B.1.c. Other				= **Decommissioned coal mines** **= 0.7**
		Decommissioned coal mines	**NO**	Potential emissions, minus gas usage **= 0.7**

1) pursuant to STATISTIK DER KOHLENWIRTSCHAFT (n.y.)
2) Hard-coal coke, hard-coal briquettes, lignite coke, coal dust, dry coal, fluidised-bed coal, lignite briquettes, lignite granulate

3.3.1.1 Coal mining and handling (1.B.1.a)

3.3.1.1.1 General description of the source category Coal mining and handling (1.B.1.a)

CRF 1.B.1.a	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Solid fuels	**CH_4**	**L**	**T/T2**	18,415.2	(1.51%)	2,612.3	(0.28%)	-85.81%

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 2	AS	CS

The source category *Coal production* is a key category for CH_4 emissions in terms of emissions level and trend.

For the source category Coal mining and handling (1.B.1.a), the only truly significant emissions tend to be those from ongoing extraction (coal-seam methane, CSM). Emissions from hard-coal processing are listed in source category 1.B.1.b, while emissions from decomissioned hard-coal mines (coal-mine methane, CMM) are listed in source category

[29] Not including small mines

1.B.1.c. This breakdown applies only to hard coal. For lignite, the chosen calculation procedure places all emissions in 1.B.1.a(ii).

During coal production, transport and storage, methane can escape from coal and the rock surrounding it. The amount of methane released depends primarily on the amount of methane stored in the coal. All of the emissions that result from this relationship – but not the greenhouse gases caused by coal combustion – are to be recorded in this source category.

In the mining sector, a distinction is made between open-pit mines, in which raw materials are extracted from pits open to the surface, and closed-pit mines, in which seams are mined underground. In Germany, hard coal is mined in 3 coal fields (Reviere), in a total of 5 mines (all closed-pit), while lignite is mined in 4 coal fields, primarily with the open-pit method (11 pits; since 2003 all lignite mining has been open-pit).

In underground coal mining, ventilation systems are used to keep mine methane concentrations within safe limits for mining. Such systems can emit significant amounts of methane into the atmosphere as they ventilate the air and gas mixtures prevailing in underground mines. Hard-coal mining is the principal source of fugitive emissions of CH_4. Some methane is suctioned off directly from seams and ancillary rocks and used, as pit gas.

Since mid-2009, a fraction of non-usable pit gas has been converted into CO_2, via combustion in a high-temperature flare. In 2011, that JI project combusted 0.594 Gg CH_4, thereby preventing about 0.46 Gg of CH_4 emissions (cf. also 1.B.1.c Flaring, Chapter 3.3.1.3.1).

Hard-coal production in 2010 amounted to some 12 million t of marketable production. Lignite production in 2011 totalled 177 million t (STATISTIK DER KOHLENWIRTSCHAFT, n.y.). As a result, hard-coal production decreased by about 6 % from the previous year, while lignite production increased by about 4 %.

Methane emissions from hard-coal mining have decreased since 1990 as a result of decreasing production and increasing use of pit gas. Emissions from open-pit lignite mining have also decreased, also as a result of production decreases.

3.3.1.1.2 Methodological issues (1.B.1.a)

For calculation of CH_4 emissions from coal mining, emissions are determined for the areas of underground hard-coal mining, pit-gas use, hard-coal storage and open-pit lignite mining.

Emissions from underground hard-coal mining are calculated pursuant to the Tier 3 method, in a procedure that meets requirements pertaining to mine-specific emissions determination. For safety reasons, gas compositions and air flows are measured continuously in all pit systems. The resulting data is used to determine levels of methane emissions. The association of the German hard-coal mining industry (Gesamtverband Steinkohle) aggregates the individual measurements to determine total methane amounts. It then makes the resulting statistics available for the inventory (STATISTIK DER KOHLENWIRTSCHAFT,, n.y.). Expert review is carried out by the competent state supervisory authority (the mining authority – Bergamt).

An implied emission factor (IEF) of 9.55 kg/t (2011) has been derived from the total methane emissions figures and from the relevant activity data for hard-coal mining. This calculation takes pit-gas usage into account. The measurements show only actually emitted methane amounts.

For calculation of CH_4 emissions from hard-coal storage, the activity data for hard-coal production is used as a basis and then multiplied by the emission factor of 0.576 kg/t. That emission factor has been taken from a study of the Fraunhofer Institute for Systems and Innovation Research (FhG-ISI) (1993).

Emissions from open-pit lignite mining have been calculated, in keeping with the Tier 2 approach, pursuant to the relevant equation in the IPCC Reference Manual (IPCC, 1996b).

The activity data (crude lignite) have been taken from the STATISTIK DER KOHLENWIRTSCHAFT (n.y.). According to the DEBRIV German lignite-industry association (Deutscher Braunkohlen-Industrie-Verein e.V; DEBRIV 2004), an average emission factor of 0.015 m³ CH_4/t (corresponds to 0.011 kg CH_4/t) is assumed. This emission factor is based on a 1989 study of RWE Rheinbraun AG (DEBRIV, 2004) and is documented by publications of the Öko-Institut e.V. Institute for Applied Ecology and of the DGMK (German Society for Petroleum and Coal Science and Technology; research report / Forschungsbericht 448-2, 1992). This value is considerably lower than the emission factor used prior to 2005, 0.11 m³ CH_4/t, which was derived from the EF for American hard lignite. Such American EF cannot be applied to German soft lignite, since the latter's temperature did not exceed 50°C during the coalification process. Significant methane releases occur only at temperatures above 80°C.

No lignite storage takes place; usage is "mine-mouth", i.e. extracted coal is moved directly to processing and to power stations.

3.3.1.1.3 Uncertainties and time-series consistency (1.B.1.a)

The uncertainties in the activity data result primarily from inaccuracies in weighing of extracted coal. Via surveys of experts carried out during the NASE workshop of 11/2004, the relevant error has been quantified as <3 %.

Uncertainties in calculation of methane releases result from inaccuracies in methane measurements. As a result of the facts that underground measurements of methane concentrations are carried out primarily for safety reasons, and that their most precise measurement range does not fall within the range of common gas-release concentrations, the available measuring equipment can be expected to have a technical measurement inaccuracy of about 10 %.

Methane releases from hard coal, during storage and transport, fluctuate considerably in keeping with storage duration and grain-size distribution. An uncertainty of 15 % is assumed (LANGE 1988 / BATZ 1995, along with information communicated personally at the NASE workshop 11/2004).

The emission factor used for calculating methane emissions from lignite production is based on maximum methane content levels and thus represents the upper limit of possible methane emissions. It thus already includes possible emissions from transport and storage. Numerous studies have shown that a negative uncertainty of - 33 % must be assumed (DEBRIV / DGMK research report / Forschungsbericht 448-2, DGMK 1992).

Apart from the emission factor for pit-gas release from underground hard-coal mining, the emission factors are consistent in the time series, within the meaning of comparability throughout the time series. For the activity data, a consistent source is used throughout the entire time series.

3.3.1.1.4 Source-specific quality assurance / control and verification (1.B.1.a)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity.

For underground hard-coal mining, the IPCC Reference Manual (1996b) recommends emission factors on the order of 10 to 25 m³/t. Conversion of the German emission factors, using a conversion factor of 0.67 Gg/10^6 m³ (pursuant to IPCC Reference Manual, 1996b: at 20° C, 1 atmosphere) yields the individual values listed in Table 87. When production, storage and deductable pit-gas use are combined in one emission factor, the resulting value per tonne of coal (marketable production) lies within the recommended range.

Table 87: Emission factors for CH_4 from coal mining, for 2011

Emission factors	**Hard coal**		**Lignite**	
	EF m^3 CH_4/t	**EF kg/t**	**EF m^3 CH_4/t**	**EF kg/t**
CH_4 from extraction	27.90	18.70	0.016	0.011
CH_4 from extraction, minus pit gas used	14.25	9.55	-	-
CH_4 from storage	0.87	0.58	-	-
CH_4 from mining (extraction and storage, minus pit-gas used)	15.12	10.13	0.016	0.011

The IPCC Reference Manual (1996b) does not recommend any specific emission-factor levels for open-pit lignite mining.

In the framework of verification for the 2005 report, various data sources for activity data in coal mining, and the relevant EF used, were compared with the corresponding sources and EF of other countries.

A by-country comparison of specific emission factors for underground coal mining shows a broad range, with Germany in the lower part of the range, in a position comparable to that of the Czech Republic. France's EF lies considerably higher within the range, while Poland's is considerably lower. Both of these countries' EF lie outside of the UNFCCC's default values.

A by-country comparison of specific emission factors for open-pit coal mining shows that Poland, France (where production was discontinued in 2002) and Germany have relatively low emission factors that are below the default values. The reason for this is that the relevant coal in these countries has very low methane content, as a result of its degree of coalification and its geological history. Consequently, suitably low emission factors have to be applied to it. The comparison value for the Czech Republic is considerably higher, since its coal is not the "lignite" found in Germany, which has a low degree of coalification; instead, its coal is largely "sub-bituminous coal", which has a higher degree of coalification and higher methane content.

3.3.1.1.5 Source-specific recalculations (1.B.1.a)

No recalculations are required.

3.3.1.1.6 Source-specific planned improvements (1.B.1.a)

No improvements are planned at present.

3.3.1.2 Solid fuel transformation (1.B.1.b)

3.3.1.2.1 Source category description (1.B.1)

1.B.1.b.	Gas	Key category	1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Solid fuels	CH_4	- -	18.1	(0.00%)	8.2	(0.00%)	-54.55%

Gas	Method used	Source for the activity data	Emission factors used
CH_4	CS	AS	CS
CO, NMVOC, SO_2	CS	AS	CS

The source category *Solid fuel transformation* is not a key category.

3.3.1.2.2 Methodological issues (1.B.1.b)

The IPCC Reference Manual does not describe any methods for this source category (IPCC 1996b, p.1.110f). The country-specific method that is used is based on activity data from the STATISTIK DER KOHLENWIRTSCHAFT (n.y.) and on corresponding emission factors.

Production of low-temperature lignite coke took place solely in the new German Länder and, for purposes of the inventory, is of relevance only for the base year. Production was discontinued after 1992.

The majority of emission factors for non- greenhouse gases from coking plants have been obtained from BFI (2012). The emission factors for fugitive sources, as provided by that data source, have been allocated, by definition, to source category 1.B.1.b. That data source's emission factors for contained sources have been allocated to source category 1.A.1.c, however, since those emissions result primarily from bottom-heating of coke ovens. For some gases – including CO, for example – emissions from coking plants are calculated in both source categories.

Calculation procedure

Emissions from hard-coal-coke production have been calculated pursuant to the Tier 2 approach, in a manner similar to that of the IPCC Reference Manual's equation for CH_4 emissions from coal mining:

$$\text{Emissions } [\text{Gg } CH_4] =$$

$$EF\ [m^3\ CH_4\ /t] * AD_{\text{transformation product}} * \text{conversion factor } [Gg/10^6 m^3]$$

The activity data for hard-coal-coke production have been taken from the publication STATISTIK DER KOHLENWIRTSCHAFT (n.y.).

The methane emission factor used for calculation of CH_4 emissions from hard-coal-coke production (coking plants) is 0.049 kg methane per tonne of hard-coal coke (DMT 2005). It is used for the entire time series.

In the CSE, the source category "coal transformation" is covered by the time series for hard-coal-coke production (coking plants).

No emissions are to be expected from processed lignite products, since the EF used for 1.B.1.a corresponds to the gas content of the lignite occurring in Germany.

3.3.1.2.3 Uncertainties and time-series consistency (1.B.1.b)

The emission factors remain at the same level in the time series and are thus consistent within the meaning of comparability throughout the time series. For the activity data, a consistent source is used throughout the entire time series.

3.3.1.2.4 Source-specific quality assurance / control and verification (1.B.1.b)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity.

In consideration of emission factors, the IPCC conversion factor of 0.67 Gg/10^6m³ at 20°C and 1 atmosphere (IPCC et al; 1996, Reference Manual, p. 1.108) should be applied to the units used in Germany: normal cubic metres at 1.01325 bar and 0°C (DIN 2004, DIN No. 1343). The German practice of using normal cubic metres should also be noted in consideration of the IPCC default EF, and of figures from other published sources. In use of EF data published in Germany, it is assumed that the relevant figures use normal cubic metres (substantiated via survey of experts at the NaSE workshop 11/2004)

The guideline figures are oriented to 20°C and 1,013 mbar. In keeping with methane's isobaric proportionality, the factor 1.07 can be used to convert Nm³ into m³.

Conversion factor, normal cubic metres ⇔ kilogrammes:

0.717 Nm³/kg (1.01325 bar, 0°C) **= 0.67 Gg/10^6m³** (20°C, 1 atmosphere) *** 1.07 Nm³/m³**

3.3.1.2.5 Source-specific recalculations (1.B.1.b)

No recalculations are required.

3.3.1.2.6 Source-specific planned improvements (1.B.1.b)

No improvements are planned at present.

3.3.1.3 Other (1.B.1.c)

3.3.1.3.1 Source category description (1.B.1.c)

1.B.1.c.	Gas	Key category	1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Solid fuels	**CH_4**	**- T**	**1,806.8**	**(0.15%)**	**15.1**	**(0.00%)**	**-99.17%**
Solid fuels	CO_2		10.7	(0.00%)	2.9	(0.00%)	-72.59%

Gas	Method used	Source for the activity data	Emission factors used
CH_4	CS	AS	CS
CO, NMVOC, SO_2	CS	AS	CS

The source category *Other* is a key category for CH_4 emissions from solid fuels in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-99.17 %), and thus an extremely low emissions level has been attained, the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

Emissions from decommissioned hard-coal mines play a significant role in this sub- source category. As well as active mines, decommissioned hard coal mines (degassing) represent another relevant source of fugitive CH_4 emissions.

When a hard-coal mine is decommissioned, methane can escape from neighbouring rock, and from coal remaining in the mine, into the mine's network of shafts and passageways. Since the mine is no longer artificially ventilated, the methane collects and can then reach the surface via gas pathways in the overlying rock or via the mine's own shafts and passageways.

Such mine gas was long seen primarily as a source of danger (in active hard-coal mines) and as a negative environmental factor (in decommissioned hard-coal mines). Recently, increasing attention has been given to the gas' positive characteristics as a fuel (use for energy recovery). In the past, use of mine gas was rarely cost-effective (as shown by the example of the state of North Rhine – Westphalia). This situation changed fundamentally in 2000 with the Renewable Energy Sources Act (EEG). Although mine gas is a fossil fuel in finite supply, its use supports climate protection, and thus the gas was included in the EEG. The Act requires network operators to accept, and provide specified compensation for, electricity generated with mine gas and fed into the grid. As a result, the $AD_{CMM\ collection}$ increased from 1.429 million m³ in 1998 to 246 million m³ in 2011. The reason for the lower rate of mine-gas use, with respect to the previous year, is that the production of such gas dropped.

The following figure highlights the law's impacts on actual emissions. Such emissions have been decreasing considerably since 2000, primarily as a result of steadily increasing use of mine gas from decommissioned mines. The gas quantities being used from active mines have been decreasing, since the sector's gas production has been decreasing as decommissioning of numerous mines has continued. In qualitative terms, the gas quantity being used is still very high.

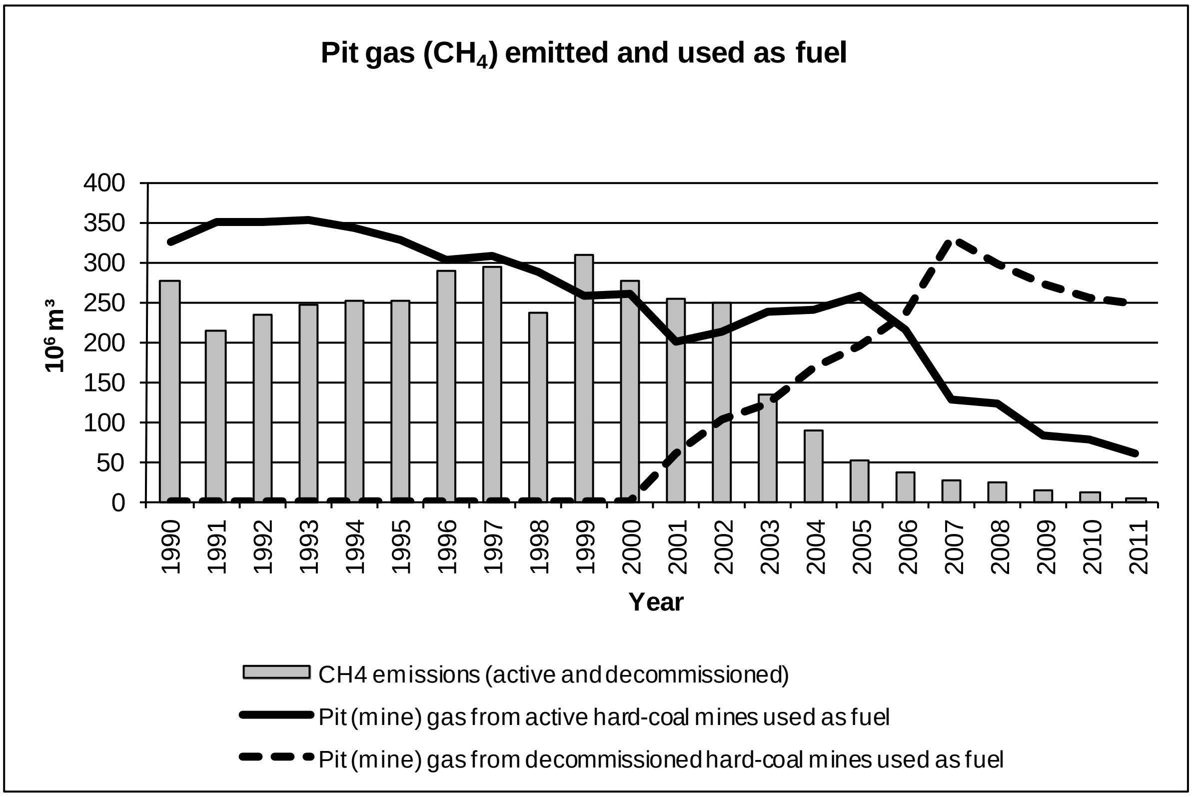


Figure 39: Comparison of used and emitted CH_4 from mine gas

In emissions reporting, quantities of mine gas used are determined separately from released quantities of CH_4, are referenced to a mine status (active or decommissioned) and are listed in source category 1.A. as energy production with relevant emissions.

Flaring

In its 2012 review, the "EU Technical Review Team of GHG inventories under the Effort Sharing Decision" called for a more detailed listing of emissions from flared mine gas. At present, only one high-temperature flare is in operation in Germany. It has been in operation since 2009, in the framework of a JI project. The facility's CO_2-eq. emissions amounted to 541 t in 2009 and to 1,239 t in 2010 [DEHSt 2012]. According to the Gesamtverband Steinkohle association of the German hard-coal-mining industry (GVSt), the facility's emissions reached 2,814 t in 2011.

Table 88: Emissions reductions via high-temperature flare (2009-10) [DEHSt 2012]; for 2011: notification of the Gesamtverband Steinkohle association of the German hard-coal-mining industry (GVSt)

Year	Baseline emissions	Project emissions	Emissions reduction
2009	2,361 t CO_2-eq.	541 t CO_2-eq.	1,820 t CO_2-eq.
2010	5,416 t CO_2-eq.	1,239 t CO_2-eq.	4,176 t CO_2-eq.
2011	12,474 t CO_2-eq.	2,814 t CO_2-eq.	9,660 t CO_2-eq.

3.3.1.3.2 Methodological issues (1.B.1.c)

The IPCC Reference Manual does not describe any methods for the sub- source category "Other" (IPCC et al, 1996, Reference Manual, p.1.110f).

As well as active mines and coal processing, decommissioned hard-coal mines (degassing) represent another relevant source of fugitive CH_4 emissions.

No emissions are to be expected from decommissioned open-pit lignite mines, since the EF used for 1.B.1.a corresponds to the gas content of the lignite occurring in Germany. Lignite that remains in decommissioned open-pit mines does not continue to release gas (DEBRIV).

This source category is subdivided into the following sub-areas:

- Underground mines, decommissioned hard-coal mines
- Decommissioned hard-coal mines, with pit-gas use

3.3.1.3.3 Uncertainties and time-series consistency (1.B.1.c)

It is quite practicable to determine the quantities of methane used; an uncertainty of < 3 % due to measurement inaccuracies is assumed. The total quantities of available methane in question have been estimated solely on the basis of experts' knowledge. In this area, an uncertainty of 50 % has been assumed.

The time series for potential methane emissions and amounts of methane used both originate from reliable sources and are consistent throughout.

3.3.1.3.4 Source-specific QA/QC and verification (1.B.1.c)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity.

In consideration of emissions, it must be noted that the IPCC conversion factor is 0.67 Gg/106 m3 at 20°C and 1 atmosphere (IPCC Reference Manual, 1996b: p. 1.108), while figures in Germany are given in normal cubic metres at 1.01325 bar and 0°C (DIN 2004, DIN No. 1343). Users of emissions data published in Germany should assume that the relevant figures are in normal cubic metres.

The IPCC Guideline figures are oriented to 20°C and 1,013 mbar. In keeping with methane's isobaric proportionality, the factor 1.07 can be used to convert Nm^3 into m^3.

3.3.1.3.5 Source-specific recalculations (1.B.1.c)

Recalculations were carried out on the basis of updated figures from the German hard-coal-mining association (Gesamtverband Steinkohle - GVSt).

The listed emissions quantity consists of a highly uncertain estimate of total emissions from decommissioned mines (experts' assessment: $\pm$ 50 %, source: Deutsche Montan Technologie GmbH, DMT 2005), minus the quantity of methane used. The figures have been verified via the research project "Potential for mine-gas releases and mine-gas use" ("Potential zur Freisetzung und Verwertung von Grubengas") (DMT, 2011). The relevant calculations were carried out for all regions with deposits in Germany. In addition, it was determined that a small CO_2 fraction escapes along with mine gas. These figures were calculated in the aforementioned research project. Such calculations take account of the emissions from the exhaust stream passing through degassing facilities, as well as the fugitive fraction escaping via the surface. Prior to the entry into force of the German Renewable Energy Act (EEG), carbon dioxide emissions via degassing facilities received the greatest attention in this connection.

Table 89: Overview of back-calculated emissions (DMT, 2011) – the values for 2010 were estimated by UBA experts

Year	1990	1995	2000	2005	2010	Units
CO_2 exhaust stream via degassing facilities	10,521	12,555	14,399	1,834	0	[t]
CO_2 exhaust stream via the surface	155	183	236	160	112	[t]
Total	**10,676**	**12,738**	**14,635**	**1,994**	**112**	**[t]**

3.3.1.3.6 Source-specific planned improvements (1.B.1.c)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

3.3.2 Oil and natural gas (1.B.2)

The overarching category 1.B.2 comprises a total of 14 source categories. These categories are further subdivided, in keeping with oil and gas industry criteria, and in keeping with the industry's process chains. In the emissions database, data on fugitive emissions from oil and natural gas are included with data for the pertinent source categories and sub- source categories. Emissions of source categories under the overarching CRF category 1.B.2 have been determined primarily via the Tier-2 method (IPCC).

3.3.2.1 Recalculations and time-series consistency (1.B.2 all)

New findings in the area of natural gas storage have led to recalculations in categories 1.B.2.b.iii and 1.B.2.b.iv, with regard to methane. Underground storage facilities, which tend to be used for longer-term storage, are assigned to category 1.B.2.b.iii. Above-ground storage facilities (spherical and pipe storage tanks, low-pressure storage facilities and vehicle-mounted tanks) are assigned to category 1.B.2.b.iv.

In addition, recalculations relative to methane, in the area of natural gas pipeline transport and distribution, were carried out to account for slight changes in pipeline lengths (1.B.2.b.iii and 1.B.2.b.iv).

3.3.2.2 Planned improvements (1.B.2, all)

A research project is currently underway with the aim of studying emissions from the gas network. The project's initial results indicate that the emissions figures reported to date have been much too high, since the emission factors used are based on a high assumed frequency of damage and since the materials used in pipelines have been considerably improved with regard to gas tightness.

Another ongoing project is currently reviewing all emission factors in the area 1.B.2.a Oil. The results of these efforts will enter into future reporting.

3.3.2.3 Oil (1.B.2.a)

CRF 1.B.2.a	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Liquid fuels	CH_4	-	-	716.7	(0.06%)	267.8	(0.03%)	-62.63%
Liquid fuels	CO_2	-	-	1.1	(0.00%)	0.8	(0.00%)	-31.97%

3.3.2.3.1 Oil, Exploration (1.B.2.a.i)

Gas	Method used	Source for the activity data	Emission factors used
CO_2, CH_4	Tier 1	AS	D
NMVOC	Tier 1	AS	CS

The source category 1.B.2.a.i "Oil, exploration" is not a key category.

3.3.2.3.1.1 Source category description (1.B.2.a.i)

This source category's emissions consist of emissions from activities of drilling companies and of other participants in the exploration sector. Gas and oil exploration takes place in Germany. In 2011, 29 successful drilling operations, with a total drilling distance of 73,272 m, were carried out. (annual report for 2011 (Jahresbericht 2011) of the Wirtschaftsverband Erdöl- und Erdgasgewinnung German oil and gas industry association, WEG 2012: – Table with overview of drilling success (Bohrerfolgsbilanz) p. 54). The underlying statistics on exploration are not broken down by the categories of oil and natural gas.

3.3.2.3.1.2 Methodological issues (1.B.2.a.i)

According to the WEG, virtually no fugitive emissions occur in connection with drilling operations, since relevant measurements are regularly carried out at well sites (with use of methane sensors in wellhead-protection structures, ultrasound measurements and annulus manometers), and since old / decommissioned wells are backfilled and normally covered with concrete caps. Since pertinent measurements are not available for individual wells, a conservative approach is used whereby well emissions (WEG 2012) are calculated on the basis of the default factor pursuant to IPCC GPG 2000 for CO_2, 0.48 kg / well, and the default factor (same source) for methane, 64 kg / well.

Table 90: Emission factors used for category 1.B.2.a.i

Gas	Emission factor	Method	Source
CO_2	0.48 kg / No[30]	T1	IPCC GPG 2000
CH_4	64 kg / No	T1	IPCC GPG 2000
NMVOC	576 kg / No	T1	Expert estimate

3.3.2.3.1.3 Uncertainties and time-series consistency (1.B.2.a.i)

The uncertainties for the emission factors in the source category are in keeping with the uncertainties for the default factors (IPCC GPG 2000; Chapter 2.7.1.6).

3.3.2.3.1.4 Source-specific quality assurance / control and verification (1.B.2.a.i)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

[30] No refers to the number of successful wells

The results of quality assurance were taken into account in determination and documentation of emissions.

Due to a lack of country-specific data, an external assessment (Müller-BBM, 2009a) was commissioned. In its source-category analysis, that assessment found that the default factors are applicable to Germany. It was not possible to carry out a comparison with the results for other countries, because the relevant data lack basic comparability – for example, they use a range of units that are not mutually convertible.

3.3.2.3.1.5 Source-specific recalculations (1.B.2.a.i)

Minimal recalculations were carried out to take account of minor changes in the activity data.

3.3.2.3.1.6 Source-specific planned improvements (1.B.2.a.i)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.2 Oil, production (1.B.2.a.ii)

Gas	Method used	Source for the activity data	Emission factors used
CO_2, CH_4	Tier 2	AS	CS
NMVOC	Tier 2	AS	CS

The source category 1.B.2.a.ii "Oil, production" is not a key category.

3.3.2.3.2.1 Source category description (1.B.2.a.ii)

This source category's emissions are produced in the petroleum industry's extraction (crude oil) and pre-treatment of raw materials (petroleum).

According to the annual report of the WEG German oil and gas industry association (WEG, 2012), German petroleum extraction in 2011 amounted to some 2.7 million tonnes.

The first treatment that extracted petroleum (crude oil) undergoes in processing facilities serves the purposes of removing gases, water and salt from the oil. Crude oil in the form in which it appears at wellheads contains impurities, gases and water, and thus does not conform to requirements for safe, easy transport in pipelines. No substance transformations take place. Impurities – especially gases (petroleum gas), salts and water – are removed, in order to yield crude oil of suitable quality for transport in pipelines.

3.3.2.3.2.2 Methodological issues (1.B.2.a.ii)

Because Germany's oil fields are old, oil production in Germany is highly energy-intensive (thermal extraction, operation of pumps to inject water into oil-bearing layers). Via discussions between experts of the Federal Environment Agency (UBA) and of WEG, it proved possible to determine emissions from extraction and pre-processing for reporting purposes, however.

Table 91: Emission factors used for category 1.B.2.a.ii, Production

Gas	Emission factor	Method	Source
CO_2	270 g/m³	T2	Expert estimate
CH_4	1.40 g/m³	T2	Expert estimate
NMVOC	12.6 g/m³	T2	Expert estimate

Table 92: Emission factors used for category 1.B.2.a.ii, Processing

Gas	Emission factor	Method	Source
CH_4	2.60 g/t	T2	Expert estimate
NMVOC	0.02 kg/t	T2	Expert estimate

3.3.2.3.2.3 Uncertainties and time-series consistency (1.B.2.a.ii)

In this source category, the uncertainty for the activity data is given as 5 to 10 %. The figures are based on estimates of WEG experts and national experts.

The uncertainties for the emission factors in the source category amount to 25%.

3.3.2.3.2.4 Source-specific quality assurance / control and verification (1.B.2.a.ii)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The results of quality assurance were taken into account in determination and documentation of emissions.

A source-category comparison with other countries reveals that the IEF for methane lies within the range seen in international reporting.

3.3.2.3.2.5 Source-specific recalculations (1.B.2.a.ii)

Due to a calculation error, overly high carbon dioxide emissions had been calculated. The entire time series was corrected, and this reduced emissions in this sub- source category by up to 25%.

3.3.2.3.2.6 Source-specific planned improvements (1.B.2.a.ii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.3 Oil, transport (1.B.2.a.iii)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 2	AS	CS
NMVOC	Tier 2	AS	CS

The source category 1.B.2.a.iii "Oil, transport" is not a key category.

3.3.2.3.3.1 Source category description (1.B.2.a.iii)

This source category's emissions are tied to activities of logistics companies and of operators of pipelines and pipeline networks. Following first treatment, crude oil is transported to refineries.

Almost all transports of crude oil take place via pipelines. Pipelines are stationary and, normally, run underground. In contrast to other types of transports, petroleum transports are not interrupted by handling processes.

As of 2011, the Federal Republic of Germany's network of long-distance pipelines for crude-oil imports had a total length of 1,834 km and a throughput of about 92.4 million tonnes of crude oil (MWV, 2012, p. 46ff).

In 2005, Germany had a total of 3,331 km of crude oil pipelines. A total of 33.6 million tonnes of oil passed through them in that year (MWV, 2006, Mineralölversorgung mit Pipelines).

Pursuant to *STATISTISCHES BUNDESAMT* (Federal Statistical Office) Fachserie 8, Reihe 4, Table 2.1, column on "total transports" (Gesamtverkehr), inland-waterway ships transported 15,700 t of crude oil in 2011.

3.3.2.3.3.2 Methodological issues (1.B.2.a.iii)

The **emission factor** for methane was estimated by experts to be 0.11 kg/t. That factor, which includes transfer processes at terminals and transfer stations, is extremely conservative, since long-distance pipelines are monitored continually and accidents / incidents are very seldom (CONCAWE – "Performance of European cross country oil pipelines").

Table 93: Emission factors used for category 1.B.2.a.iii, Transport

Gas	Emission factor	Method	Source
CH_4	0.11 kg/t	T2	Expert estimate
NMVOC	0.01 kg/t	T2	Expert estimate

3.3.2.3.3.3 Uncertainties and time-series consistency (1.B.2.a.iii)

The uncertainties for the emission factors amount to 20%.

3.3.2.3.3.4 Source-specific quality assurance / control and verification (1.B.2.a.iii)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

A source-category comparison with other countries reveals that the IEF for methane lies within the range seen in international reporting.

3.3.2.3.3.5 Source-specific recalculations (1.B.2.a.iii)

No recalculations are required.

3.3.2.3.3.6 Source-specific planned improvements (1.B.2.a.iii)

The emission factor for methane that is currently being used has been estimated by experts, on the basis of association data collected since 1998. The earlier data used for this context have been obtained from the literature (SCHÖN, WALZ et al., 1993). Currently, a project is underway in which the existing emission factors are being reviewed and proposals for consolidating the time series are being prepared.

3.3.2.3.4 Oil, refining and storage (1.B.2.a.iv)

Gas	Method used	Source for the activity data	Emission factors used
CO_2, CH_4	Tier 2	AS	CS
SO_2	Tier 2	AS	CS
NMVOC	Tier 2 Tier 1 (cleaning)	AS M (cleaning)	CS M (cleaning)

The source category 1.B.2.a.iv "Oil, refining and storage" is not a key category.

3.3.2.3.4.1 Source category description (1.B.2.a.iv)

This source category's emissions consist of emissions from activities of refineries and of refining companies in the petroleum industry. Crude oil and intermediate petroleum products are processed in Germany. For the most part, the companies concerned receive crude oil for refining and processing. Such processing takes place in state-of-the-art plants. In 2009, a total of 14 crude-oil refineries, and 9 lubricating-oil and used-oil refineries, were in operation in Germany. The total inputs (crude oil and petroleum products) amounted to 105.6 million t in 2011. (MWV, 2012: p. 55).

Storage

Tank-storage facilities in refineries

Refinery tank storage systems are used to store both crude oil and intermediate and finished petroleum products. They thus differ from non-refinery tank storage systems in terms of both the products they store and the quantities they handle. The storage capacity of refinery tank-storage facilities in Germany was 21,600,775 m³ in 2011 (BAFA, 2012).

The relevant emissions originate primarily in the conveyance and sealing systems used in refineries.

With regard to tank-storage systems in refineries, interim results can be taken from the research project[31] "Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV; Bereich Lageranlagen" ("Processing of data from emissions declarations pursuant to the 11th Ordinance on the Implementation of the Federal Immission Control Act; the area of storage systems"); Müller-BBM, FKZ 3707 42 103/01, 2009b).

Tank-storage facilities outside of refineries

Tank-storage facilities outside of refineries are used especially for interim storage of heating oil, petrol and diesel fuel. All in all, the storage capacity of petroleum-storage facilities in Germany amounted to 41,659,196 m³ in 2011 (BAFA, 2012).

Cleaning

Tanks are emptied and cleaned for purposes of tank inspections and repairs. In tank cleaning, a distinction is made between crude-oil tanks and product tanks. Because of the sediment deposits involved, cleaning of crude-oil tanks, in comparison to cleaning of product tanks, is a considerably more involved process. Product tanks contain no sedimentable substances and thus are cleaned only when the products they contain are changed.

[31] Müller-BBM (2009b): Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV aus dem Jahre 2004 für die Verwendung bei der UNFCC- und UNECE-Berichterstattung; Bereich Lageranlagen", Bericht Nr. (report number) M74 244/7, UBA FKZ 3707 42 103/01, 31 p..

Pursuant to a research report of the German Society for Petroleum and Coal Science and Technology (DGMK; research report 499-01 (2000)), a total of 30 to 35 cleaning operations for crude-oil tanks in 2000 produced some 50,000 kg of NMVOC emissions. Emissions from product-tank cleaning are estimated to amount to 666 kg of NMVOC. No more-recent pertinent findings are currently available.

3.3.2.3.4.2 Methodological issues (1.B.2.a.iv)

Refining

With regard to emissions of NMVOC and CH_4 in the area of processing, the activity data are taken from the "Jahresbericht Mineralöl-Zahlen" ("Annual report on petroleum data") of the Association of the German Petroleum Industry (Mineralölwirtschaftsverband e.V.; MWV). The emission factors used are based on experts' estimates.

The SO_2 emissions occurring in desulphurisation of crude oil and petroleum are calculated as the product of the activity data (quantity of sulphur produced by refineries) and the estimated emission factor.

Storage

Tank-storage facilities in refineries

Pursuant to Müller-BBM (sub-project on storage facilities, 2009b), crude-oil-distillation capacity (in 2011, about 103.5 million t; MWV, 2012, p. 35) is used as the activity data for purposes of estimating emissions from storage in refineries.

The fugitive-VOC-emissions value specified in VDI Guideline 2440, 0.16 kg/t, may be used as the emission factor. For 2011, this leads to NMVOC emissions of 14,904 t and CH_4 emissions of 1,656 t.

Table 94: Emission factors used for category 1.B.2.a.iii, Storage of crude oil in tank-storage facilities of refineries

Gas	Emission factor	Method	Source
CH_4	16 g/t	T2	Expert estimate
NMVOC	144 g/t	T2	Expert estimate

Tank-storage facilities outside of refineries

According to Müller-BBM (sub-project on storage systems, 2009b), no emission factors can be derived, via evaluation of emissions declarations for storage systems, that would be representative of individual systems. This is due, so the same source, to the clearly widely differing emissions behaviour of different individual systems.

It was possible, however, to form aggregated emission factors. For each relevant group of data, this was done by correlating the sums of all emissions with the sums of all capacities.

For non-refinery tank-storage systems, storage of liquid petroleum products can be differentiated from storage of gaseous petroleum products, since the relevant data are suitably differentiated. (Müller-BBM, 2009a)

Table 95: Emission factors used for category 1.B.2.a.iii, Storage of liquid petroleum products in tank-storage facilities outside of refineries

Gas	Emission factor	Method	Source
CH_4	5 g/m³	T2	Expert estimate
NMVOC	100 g/m³	T2	Expert estimate

Table 96: Emission factors used for category 1.B.2.a.iii, Storage of gaseous petroleum products in tank-storage facilities outside of refineries

Gas	Emission factor	Method	Source
CH_4	150 g/m³	T2	Expert estimate
NMVOC	500 g/m³	T2	Expert estimate

3.3.2.3.4.3 Uncertainties and time-series consistency (1.B.2.a.iv)

For the emissions data, the source-category uncertainties are given as 20 to 25 %. These figures are based on estimates of national experts, as well as on estimates of experts involved in the research project FKZ 3707 42 103/01 of Müller-BBM from 2009(b). The uncertainties for the area of cleaning are given as 50%, since they are based on older estimates.

3.3.2.3.4.4 Source-specific quality assurance / control and verification (1.B.2.a.iv)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

A source-category comparison with other countries reveals that the IEF for methane lies within the range seen in international reporting.

According to Müller-BBM, the emission factors for NMVOC are confirmed – at least in terms of their order of magnitude – via results of independent analysis. For example, in the framework of a bottom-up analysis of a refinery tank-storage system, carried out by Müller-BBM, a value of 300 g/m³ was obtained, while a value of 200 g/m³ was obtained via measurements of middle-distillate tanks.

3.3.2.3.4.5 Source-specific recalculations (1.B.2.a.iv)

No recalculations are required.

3.3.2.3.4.6 Source-specific planned improvements (1.B.2.a.iv)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.5 Oil, distribution of oil products (1.B.2.a.v)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 2	AS	CS
NMVOC	Tier 2	AS	CS

The source category 1.B.2.a.v "Oil, distribution of oil products" is not a key category.

No decision tree is available for determining emissions from distribution (transport and transfer), nor is any relevant method prescribed (IPCC GPG 2000: Chapter 2 Energy). The only recourse in this case is to proceed by analogy to source category 1.B.2.a.iii.

3.3.2.3.5.1 Source category description (1.B.2.a.v)

Distribution

General information

Petroleum products are transported by inland-waterway tanker ships, product pipelines, railway tank cars and road tankers, and they are transferred from tanks to other tanks. Germany's domestic sales of petroleum products totalled 109,345,000 t in 2011 (MWV, 2012, p. 60). Domestic sales of petrol, pursuant to MWV (ibid.), amounted to 19,601,000 t in 2011.

Inland-waterway tanker ships

Such ships' tanks retain considerable quantities of petrol vapours after their petrol has been unloaded. When the ships change loads or spend time in port, their tanks have to be ventilated. For an average number of 277 instances of ventilation per year, so BiPRO (research project: "Evaluierung der Anforderungen der 20. BImSchV für Binnentankschiffe im Hinblick auf die Wirksamkeit der Emissionsminderung klimarelevanter Gase" ("Evaluation of the requirements of the 20th Ordinance on the Implementation of the Federal Immission Control Act with regard to the effectiveness of control of emissions of climate-relevant gases"), FKZ 3709 45 326, 2010), the emitted quantities amount to 336 - 650 t NMVOC.

Tanker cars

About 13 million m³ of petrol fuels are transported annually in Germany via railway tank cars. Transfer/handling (filling/unloading) and tank losses result in emissions of only 1,260 t NMVOC and of 140 t CH_4 (total of 1,400 t VOC) per year (UBA, 2004b).

The emissions situation points to the high technical standards that have been attained in railway tank cars and pertinent handling facilities.

Cleaning of transport vehicles

Tank interiors are cleaned prior to tank repairs, prior to safety inspections, in connection with product changes and with lease changes.

The inventory currently covers cleaning of railway tank cars. The residual amounts remaining in railway tank cars' tanks after the tanks have been emptied – normally, between 0 and 30 litres (up to several hundred litres in exceptional cases) – are not normally able to evaporate completely. They thus produce emissions when the insides of tanks are cleaned.

Each year, some 2,500 cleaning operations are carried out on railway tank cars that transport petrol. The emissions released, via exhaust air, in connection with cleaning of tank cars' interiors amount to about 36,000 kg NMVOC and 4,000 kg CH_4 per year (a total of 40,000 kg/a VOC) (UBA 2004b, p.34).

On the whole, oil consumption is expected to stagnate or decrease. As a result, numbers of oil storage facilities can be expected to decrease as well. In light of these trends, a long-term increase in the average transport distance for petroleum products – currently 200 km (loc. cit.) – can be expected.

Any additional measures for prevention and reduction measures could affect emissions in this source category only slightly. At the same time, emissions can be somewhat further reduced from their current levels via a combination of various technical and organizational measures. Emissions during handling – for example, during transfer to railway tank cars – are produced especially by residual amounts of petrol that remain after tanks have been emptied. Such left-over quantities in tanks can release emissions via manholes the next time the tanks are filled. Study is thus underway to determine the extent to which "best practice" is being followed at all handling stations, and whether this extent has to be taken into account in emissions determination. In addition, improvements of fill nozzles enhance efficiency in prevention of VOC emissions during fuelling.

Petrol stations

Germany currently has 14,723 petrol stations (MWV 2012). In 2011, the stations sold some 19.6 million t of petrol and 32.9 million t of diesel fuel.

Table 97: Activity data for calculation of emissions in 1.B.2.a.v

Activity data	1990	2011	Change
Number of petrol stations	19,317	14,723	- 24 %
Petrol distribution	31,257 kt	19,601 kt	- 37 %
Diesel-fuel distribution	21,817 kt	32,964 kt	+ 51 %

Significant quantities of fugitive VOC emissions are released into the environment during transfers from tanker vehicles to storage facilities and during refueling of vehicles. The applicable regulations for petrol stations, under immissions-control law, for limiting such emissions are set forth in two Ordinances for Implementation of the Federal Immissions Control Act (BImSchV) that were issued in 1992 and 1993. The relevant provisions cover the areas of both transfer and storage of petrol (20th BImSchV) and of refueling of vehicles with petrol at petrol stations (21st BImSchV).

Successful use of required emissions-control equipment, such as gas-balancing (20th BImSchV) and gas-recovery (21st BImSchV) systems, along with use of automatic monitoring systems (via the amendment of the 21st BImSchV of 6 May 2002), have brought about a continual decrease in VOC emissions.

In the main, the emissions are fugitive emissions that occur in transfers (filling/unloading) and as losses from containers (tank breathing losses). In the area regulated by the 20th BImSchV, such emissions have decreased from about 86,000 tonnes (1993) to about 5,500 tonnes (2011), and in the area regulated by the 21st BImSchV, they have dropped from nearly 60,000 tonnes (1993) to about 8,500 tonnes (2011).

3.3.2.3.5.2 Methodological issues (1.B.2.a.v)

Distribution

Currently, the inventory covers emissions relative to distribution of petrol, diesel fuel, jet fuel and light heating oil. Emissions from distribution of petrol predominate within that group. The emission factors for petrol have been obtained via estimates of UBA experts, while those for the other fuels have been obtained from the publication of M. Winkler (2004). The IPCC Synthesis and Assessment Report Part I (IPCC, 2004) noted that the IEF of the source category *Refining / storage* is the lowest among those of Annex I countries. The low IEF for this source category is due to implementation of technical requirements from national legal provisions relative to equipping of systems for storage, transfer and transport of volatile petroleum products. The *Technical Instructions on Air Quality Control* (TA luft, 2002) require the use of structurally tight valves, flanged joints and connections, pumps and compressors, as well as storage of petroleum products in fixed-roof tanks with connections to gas-collection lines.

The calculation procedures use country-specific emission factors and activity data for NMVOC and methane emissions.

Table 98: Emission factors used for category 1.B.2.a.iv, Transfer of petrol from tanker cars to tank-storage facilities (pursuant to the 20th Ordinance Implementing the Federal Immission Control Act (20.BImSchV))"

Gas	Emission factor	Method	Source
CH_4	0.52 kg/t	T2	Expert estimate
NMVOC	4.68 kg/t	T2	Expert estimate

Cleaning

Pursuant to the UBA text (2004b), a total of 1/3 of all relevant transports are carried out with railway tank cars. The remaining 2/3 of all transports are carried out by other means – primarily with road tankers.

The 1/3 to 2/3 relationship given by the report is assumed to be also applicable to the emissions occurring in connection with cleaning. Currently, the inventory includes 36,000 kg of NMVOC emissions from cleaning of railway tank cars. Emissions from cleaning of other transport equipment – primarily road tankers – are derived from that figure; they amount to about 70,000 kg NMVOC.

More-thorough emissions collection upon opening of manholes of railway tank cars (a volume of about 14.6 m³ escapes), along with more-thorough treatment of exhaust from cleaning of tanks' interiors, could further reduce VOC emissions. Exhaust cleansing is assumed to be carried out via one-stage active-charcoal adsorption. For an initial load of 1 kg/m³, exhaust concentration levels can be reduced by 99.5 %, to less than 5 g/m³. As a result, the remaining emissions amount to only 1.1 t. This is equivalent to a reduction of about 97 % (UBA, 2004b, p. 34) from the determined level of 36.5 t/a (without adsorption).

Other transfer processes

Emissions from refueling of aircraft are also of interest with regard to this source category. Experts consider such emissions to be very low, however, since the equipment used for such refueling is fitted with dry couplings.

Emissions from filling of private (residential) heating-oil tanks are also considered in this category. Thanks to high safety standards, those emissions are also very low, however. With heating sales (light heating oil) of 17.9 million t (MWV 2012) and an emission factor of 0.74 g/t, a total of only 13 t of methane are emitted in such processes.

Table 99: Emission factors used for category 1.B.2.a.iv, Refuelling of vehicles and filling of heating-system tanks

Fuel	Gas	Emission factor	Method	Source
Diesel fuel	CH_4	0.3 g/t	T2	Expert estimate
Diesel fuel	NMVOC	2.7 g/t	T2	Expert estimate
Avgas	CH_4	0.2 g/t	T2	Expert estimate
Avgas	NMVOC	18.0 g/t	T2	Expert estimate
Light heating oil	CH_4	0.7 g/t	T2	Expert estimate
Light heating oil	NMVOC	6.7 g/t	T2	Expert estimate
Petrol	CH_4	205.3 g/t	T2	Expert estimate
Petrol	NMVOC	1,848.0 g/t	T2	Expert estimate

3.3.2.3.5.3 Uncertainties and time-series consistency (1.B.2.a.v)

For the emissions data, the source-category uncertainties are given as 20 %. That figure is based on estimates of national experts, and it lies within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.3.5.4 Source-specific quality assurance / control and verification (1.B.2.a.v)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Currently, only a few countries report emissions in this source category. The only IEF for methane that is available for comparison is that for Croatia. It has the same order of magnitude as that for Germany (Germany: IEF= 0.027 g/t; Croatia: 745 kg/PJ ~ 0.030 g/t).

NMVOC emissions from filling, within refineries, of vehicles for road, railway and waterway transports (EMEP/CORINAIR Emission Inventory Guidebook – 2005 SNAP 050501) account for an average of 0.2 % of all NMVOC emissions throughout Europe. Emissions from the actual relevant transport processes, and from fuel storage outside of refineries (but not in petrol stations), account for an additional 0.9 % of such emissions (SNAP 050502). Emissions from fuel storage in the area of petrol stations account for 2.3 % of such emissions. The listed emission factors are 200-500 g/t of transferred petrol for SNAP 050501, 600-3120 g/t for SNAP 050502 and 2000-4500 g/t for SNAP 050503. No further verification results are available at present.

3.3.2.3.5.5 Source-specific recalculations (1.B.2.a.v)

No recalculations are required.

3.3.2.3.5.6 Source-specific planned improvements (1.B.2.a.v)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

3.3.2.3.6 Oil, other (1.B.2.a.vi)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	IE	IE	IE
NMVOC	IE	IE	IE

The source category 1.B.2.a.vi "Oil, other" is not a key source.

3.3.2.3.6.1 Source category description (1.B.2.a.vi)

No decision tree or other guidelines for determining distribution emissions are available. Pursuant to the reporting guidelines of the EMEP Emission Inventory Guidebook, no instructions relative to other emissions are available.

3.3.2.3.6.2 Methodological issues (1.B.2.a.vi)

No results are available for this source category.

3.3.2.3.6.3 Uncertainties and time-series consistency (1.B.2.a.vi)

No information relative to uncertainties and time-series consistency is required.

3.3.2.3.6.4 Source-specific quality assurance / control and verification (1.B.2.a.vi)

No quality control is required.

3.3.2.3.6.5 Source-specific recalculations (1.B.2.a.vi)

No recalculations are required.

3.3.2.3.6.6 Source-specific planned improvements (1.B.2.a.vi)

No improvements are planned at present.

3.3.2.4 Natural gas (1.B.2.b)

CRF 1.B.2.b	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Gaseous fuels	**CH_4**	**L**	**-/T2**	**6,966.1**	**(0.57%)**	**5,372.5**	**(0.58%)**	**-22.88%**
Gaseous fuels	CO_2	-	-	1,404.1	(0.12%)	1,095.1	(0.12%)	-22.01%

The source category 1.B.2.b "Natural gas" is a key category of CH_4 emissions in terms of emissions level and trend.

3.3.2.4.1 Natural gas, exploration (1.B.2.b.i)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	IE	IE	IE
NMVOC	IE	IE	IE

The source category 1.B.2.b.i "Natural gas, exploration" is a key category of CH_4, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

3.3.2.4.1.1 Source category description (1.B.2.b.i)

Source category 1.B.2.b.i is considered together with source category 1.B.2.a.i (Oil, exploration). Consequently, the aggregated, non-subdivided data of 1.B.2.b.i are included in source category 1.B.2.a.i.

3.3.2.4.1.2 Methodological issues (1.B.2.b.i)

The approach used in the calculation procedures is equivalent to that used for source category 1.B.2.a.i.

3.3.2.4.1.3 Uncertainties and time-series consistency (1.B.2.b.i)

See 1.B.2.a.i for explanations of uncertainties and time-series consistency.

3.3.2.4.1.4 Source-specific quality assurance / control and verification (1.B.2.b.i)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

See 1.B.2.a.i for an explanation of source-specific quality assurance / control and verification.

3.3.2.4.1.5 Source-specific recalculations (1.B.2.b.i)

The recalculations are described under 1.B.2.a.i.

3.3.2.4.1.6 Source-specific planned improvements (1.B.2.b.i)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.2 Natural gas, production and processing (1.B.2.b.ii)

Gas	Method used	Source for the activity data	Emission factors used
CO_2, CH_4	Tier 2	AS	CS
CO (only processing)	Tier 1	AS	CS
SO_2, NMVOC	Tier 2	AS	CS

The source category 1.B.2.b.ii "Natural gas, production and processing" is a key category for CH_4, in terms of level, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

Emissions were determined using the methods set forth in IPCC GPG (2000: Figure 2.12 Decision Tree for Natural Gas Systems, page 2.80; here, "Box 4", and "Box 3" where applicable).

3.3.2.4.2.1 Source category description (1.B.2.b.ii)

The emissions of this source category consist of emissions from the activities of extraction, pretreatment and processing. In 2011, a total of 11.9 billion m³ of natural gas were extracted in Germany (WEG 2012, p. 40, natural gas extraction). Of that quantity, 40 % was acid gas. In Germany, pretreatment is carried out in near-wellhead systems directly at gas fields. Emissions can be produced by various types of plants, throughout a spectrum ranging from pretreatment to completion of processing.

Pretreatment systems (processing)

After being brought up from underground reserves, natural gas is first treated in drying plants. Such plants separate out associated water from reserves, liquid hydrocarbons and various solids. Glycol is then used to remove the water vapour remaining in the gas (WEG 2008a[32], p. 25).

Acid gas

The natural gas drawn from Germany's Zechstein geological formation contains hydrogen sulphide. In this original state, the gas, known as "acid gas", has to be subjected to special treatment. Such gas is transported via separate, specially protected pipelines (due the hazardousness of hydrogen sulphide) to central processing plants that wash out its hydrogen sulphide via chemical and physical processes.

[32] WEG 2008a: Erdgas-Erdöl, Entstehung-Suche-Förderung, Hannover, 34 p.

The natural gas that leaves these processing plants is ready for use. The hydrogen sulphide is converted into elementary sulphur and is used primarily by the chemical industry, as a basic raw material. Sulphur production from natural gas production in Germany amounted to about 874,640 tonnes in 2011 (WEG, 2012, p. 46).

3.3.2.4.2.2 Methodological issues (1.B.2.b.ii)

Natural gas

The specific emission factors were derived by the Federal Environment Agency, on the basis of research in the literature (SCHÖN, WALZ et al., 1993) and queries to relevant companies. They have been carried forward continuously for the years 1990 to 1994. For years as of 1995, specific emission factors have been determined with the support of the WEG association. Research has shown the resulting emission factors for methane to be considerably lower than the corresponding values given in the literature.

Table 100: Emission factors used for category 1.B.2.b.ii, Drying and processing of natural gas

Gas	Emission factor	Method	Source
CH_4	0.15 kg / 1,000 m³	T2	Expert estimate

Acid gas

For calculation of emissions from acid-gas processing, a split factor of 0.4 relative to the activity data is applied (total natural gas extraction in 2011 = 11.9 billion m³). That split factor is based on the WEG report on acid-gas processing (WEG, 2008a).

The CO_2 emission factor used for acid-gas processing, 0.23 t / 1,000 m³, is the emission factor from Austria; according to the WEG, the two desulphurisation plants operated in Germany are comparable to the Austrian plant.

Table 101: Emission factors used for category 1.B.2.b.ii, Processing of natural gas

Gas	Value	Method	Source
CO_2	0.23 t / 1,000 m³	T2	Expert estimate

3.3.2.4.2.3 Uncertainties and time-series consistency (1.B.2.b.ii)

For the emissions data, the source-category uncertainties are given as 10 to 30 %. Those figures are based on estimates of national experts, and they lie within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.4.2.4 Source-specific quality assurance / control and verification (1.B.2.b.ii)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

The results of quality assurance were taken into account in determination and documentation of emissions.

A source-category comparison with other countries reveals that the IEF for methane lies within the range seen in international reporting. The IEF for carbon dioxide lies at the upper end of the range.

3.3.2.4.2.5 Source-specific recalculations (1.B.2.b.ii)

Due to a calculation error, overly high carbon dioxide emissions had been calculated. The entire time series was corrected, and this reduced emissions in this sub- source category by up to 1%.

3.3.2.4.2.6 Source-specific planned improvements (1.B.2.b.ii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.3 Gas, transmission (1.B.2.b.iii)

Gas	Method used	Source for the activity data	Emission factors used
CH_4 (transmission)	Tier 3	AS	CS
CH_4 (storage)	Tier 2	AS	CS

The source category 1.B.2.b.iii "Natural gas, transmission" is a key category for CH_4, in terms of level, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

Emissions were determined using the methods set forth in IPCC GPG (2000: Figure 2.12 Decision Tree for Natural Gas Systems, page 2.80; here, "Box 4", and "Box 3" where applicable).

3.3.2.4.3.1 Source category description (1.B.2.b.iii)

This source category's emissions consist of emissions from activities of gas producers and suppliers. In Germany, natural gases (natural gas and oil gas) are transported from production and processing companies/plants to gas suppliers and other processors. In practice, such transports take place via both pipelines (high-pressure pipelines) and containers (tanks). Until 1997, significant amounts of city gas were transported via pipelines.

Gas is moved via high-pressure pipelines (with pressure exceeding 1 bar) made of special plastics and steel / ductile-cast iron parts.

Some of the natural gas is stored in underground reservoirs to permit, and guard against, interruptions of pipeline transports.

Gas is also transported in tanks, via tanker ships, on inland waterways.

3.3.2.4.3.2 Methodological issues (1.B.2.b.iii)

Pipelines (high-pressure pipelines)

Some of the gas extracted in Germany is moved via pipelines from gas fields and their pumping stations (either on land or offshore). The companies that operate the most important long-distance gas pipelines in Germany are all members of the *Wirtschaftsverband Erdöl- und Erdgasgewinnung German oil and gas industry association* (WEG), the *German Technical and Scientific Association for Gas and Water* (DVGW) and the *German Association of Energy and Water Industries (BDEW)*.

Table 102: Emission factors used for methane emissions in category 1.B.2.a.iii, Transport

Pipeline material	Pressure level	Value	Method	Source
Steel and ductile cast iron	High-pressure	241 kg/km	T3	Expert estimate
Plastic	High-pressure	44 kg/km	T3	Expert estimate

Storage reservoirs

Both natural and man-made underground storage reservoirs are used for safe storage of large amounts of natural gas. Germany has some 40 underground storage reservoirs. Many of these storage reservoirs are located in depleted oil and natural-gas fields. In such fields, the natural cavities in porous rock provide the storage capacity. Depending on the size of the geological structures concerned, porous-rock reservoirs can hold between 100 million m³ and several billions of m³ of gas. About half of the stored gas is used for purposes of load balancing. It is referred to as *working gas*. The remaining gas, known as *cushion gas*, functions as a pressure buffer and keeps water in the reservoir from seeping into wellholes. Cavern reservoirs consist of caverns that have formed in underground salt formations via leaching processes. An average-sized cavern can hold about 30 million m³ of usable gas. In addition, it will hold a gas cushion ranging from 10 million m³ to 30 million m³ in size. As of the end of 2010, Germany's underground gas-storage reservoirs had a working-gas volume of over 20.4 billion m³. Further expansions are currently in progress (cf. WEG, 2011: p. 20ff).

Results from a relevant research project (Müller-BBM 2012) have made it possible to derive new country-specific emission factors. The original emission factor, 9 kg CH_4 / TJ, which was based on studies carried out in the late 1980s, is much too high for the present situation, it was derived at a time when a great many above-ground storage facilities were in operation, especially in the former GDR. The new emission factor, which was derived via surveys of operators and analysis of statistics on accidents / incidents (Müller-BBM 2012), is valid for pore-storage and cavern-storage facilities. Other types of gas storage facilities are reported in 1.B.2.b.iv.

Table 103: Emission factors used for category 1.B.2.b.iii, Storage of natural gas

Gas	Value	Method	Source
CH_4	0.07 kg / 1,000 m³ (Vn)[33]	T2	Expert estimate

3.3.2.4.3.3 Uncertainties and time-series consistency (1.B.2.b.iii)

See 1.B.2. for explanations of uncertainties and time-series consistency.

3.3.2.4.3.4 Source-specific quality assurance / control and verification (1.B.2.b.iii)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

A source-category comparison with other countries reveals that the IEF for methane lies within the range seen in international reporting.

[33] Available volume of working gas, normed to 273 K and 1013 hPa.

3.3.2.4.3.5 Source-specific recalculations (1.B.2.b.iii)

Recalculations were carried out for the entire time series, to take account of new emission factors for natural gas storage.

In addition, the CRF tables now list the kilometer lengths for the pipeline network as activity data. The previously reported quantities consumed no longer enter into calculation of emissions for this sub- source category.

3.3.2.4.3.6 Source-specific planned improvements (1.B.2.b.iii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.4 Natural gas, distribution (1.B.2.b.iv)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 3	AS	CS

The source category 1.B.2.b.iv "Natural gas, transmission" is a key category for CH_4, in terms of level, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

3.3.2.4.4.1 Source category description (1.B.2.b.iv)

This source category's emissions consist of emissions from activities of companies that supply gas to customers. In Germany, natural gas is distributed to users primarily via pipeline networks. Gas is distributed via low-pressure pipelines (with pressure up to 100 mbar) and medium-pressure pipelines (with pressure between 100 mbar and 1 bar), made of special plastics, steel / ductile-cast iron and grey cast iron. To prevent double-counting, the entire high-pressure pipeline network of companies involved in gas production and long-distance gas transports has been combined within 1.B.2.b.iii.

Emissions caused by gas distribution have decreased by some 7 %, even though gas throughput has increased considerably and the distribution network has been enlarged by over 76 % with respect to its size in 1990. One important reason for this improvement is that the gas-distribution network has been modernised, especially in eastern Germany. In particular, the share of grey cast iron lines in the low-pressure network has been reduced, with such lines being supplanted by low-emissions plastic pipelines. Another reason for the reduction is that fugitive losses in distribution have been reduced through a range of technical improvements (tightly sealing fittings such as flanges, valves, pumps, compressors) undertaken in keeping with emissions-control provisions in relevant regulations (TA Luft 1986 and 2002; VDI-Richtlinie (VDI Guideline) 2440, 11-2000). The main framework data relative to such measures are summarised in the following table.

Table 104: Gas-distribution network and its methane emissions

Parameter	1990	1995	2000	2005	2010	2011
Total length of pipeline network [km]	245,852	320,878	369,390	411,955	405,234	433,035
Total methane emissions [t]	199,567	204,309	192,281	185,874	183,427	206,250
Implied emission factor [kg/km]	811.7	636.7	520.5	451.2	452.6	476.3
Change in the emission factor with respect to the base year	0 %	22 %	36 %	44 %	44 %	41 %

Some of the natural gas is stored in above-ground reservoirs (spherical tanks) to permit, and guard against, interruptions of pipeline transports. Tanks filled with gas, for distribution and transport, are transported via railway tank cars and tanker trucks.

Gas is also sold in special containers (small tanks, flasks). Such containers are transported as unit loads, usually in larger packages, bunches or containers.

Distribution via pipelines

Relevant calculations are carried out on the basis of available network statistics on the composition of distribution networks in the low-pressure and medium-pressure sectors. In the early 1990s, emissions from distribution of city gas were also taken into account in calculations. In 1990, the city-gas distribution network accounted for a total of 16 % of the entire gas network. Of that share, 15 % consisted of grey cast iron lines and 84 % consisted of steel and ductile cast iron lines. The following table provides an overview of trends in the way the network is structured. The table includes an overview of distribution networks for city gas. A particularly noticeable development is that the plastic pipeline network in the medium-pressure sector has been expanded by 400 %.

Table 105: Structure of the gas-distribution network

Gas-distribution network		Length of the distribution network		
Pressure level	**Material**	**1990 [km]**	**2011 [km]**	**Change [%]**
Low pressure	Grey cast iron	17,260	500	-97
	Plastic	23,894	42,346	+77
	Steel and ductile cast iron	119,761	165,106	+38
Medium pressure	Plastic	43,307	159,862	+369
	Steel and ductile cast iron	41,622	65,221	+57
Total		**245,844**	**433,035**	**+76**

General information relative to fulfillment of good inventory practice, pursuant to the Guidelines, is provided in the section for 1.B.2 (cf. Chapter 3.3.2).

3.3.2.4.4.2 Methodological issues (1.B.2.b.iv)

Distribution via containers

Containers used to distribute gas (tanks of transport equipment, and flasks) are filled at filling plants. Filled tanks are transported via railway tank cars and road tankers. Gas in containers (flasks) is also transported by customers (i.e. not as commercial cargo) prior to being used. To a small extent, gas consumers also store gas temporarily before using it (cf. the consumption information, for the various source categories, provided under 1.A).

Storage reservoirs

Man-made above-ground storage facilities, for storage of medium-sized quantities of natural gas, help meet and balance rapid fluctuations in demand. In Germany, spherical and pipe storage tanks, and other types of low-pressure containers, are used for this purpose. Results from a relevant research project (Müller-BBM 2012) have made it possible to derive new country-specific emission factors for this area.

Table 106: Emission factors used for category 1.B.2.b.iv, Interim storage of natural gas

Gas	Value	Method	Source
CH_4	5 kg / 1,000 m³ (Vn)[34]	T2	Expert estimate

Natural-gas-powered vehicles, and CNG fueling stations

Use of vehicles running on natural gas continues to increase in Germany. Pursuant to the Federal Motor Transport Authority, a total of some 93,300 natural-gas-powered vehicles were in service in Germany as of 1 January 2012. Such vehicles are refueled at CNG fueling stations connected to the public gas network. In such refueling, compressors move gas from high-pressure on-site tanks. Some 900 CNG fueling stations are now in operation nationwide [Müller-BBM 2012].

Table 107: Emission factors used for category 1.B.2.b.iv, CNG fueling stations and natural gas tanks in vehicles

Gas	Value	Method	Source
CH_4	0.33 kg / vehicle	T2	Expert estimate

In keeping with the stringent safety standards applying to refueling operations and to the tanks themselves, the pertinent emissions are very low – about 30 t per year. In the main, emissions result via tank pressure tests and emptying processes.

Liquefied natural gas (LNG)

Natural gas can be liquefied, at a temperature of -161°C, for ease of transport. The liquefication process is highly energy-intensive, however, and is normally used only in connection with long-distance transports. Germany has no LNG terminals at present [Müller-BBM 2012]. Gas imports arrive mostly in gaseous form, via long-distance pipelines, and they are included in 1.B.2.b.iii.

Germany now has one natural gas liquefaction facility and two satellite LNG storage facilities. Since the storage and transfer processes at those facilities are subject to the most stringent standards possible, emissions there can be ruled out. Gas can escape only in connection with maintenance work, and the gas quantities involved are extremely small. The quantities do not exceed more than a few hundred kilograms [Müller-BBM 2012].

3.3.2.4.4.3 Uncertainties and time-series consistency (1.B.2.b.iv)

See 1.B.2. for explanations of uncertainties and time-series consistency.

3.3.2.4.4.4 Source-specific quality assurance / control and verification (1.B.2.b.iv)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried

[34] Available volume of working gas, normed to 273 K and 1013 hPa.

out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

A source-category comparison with other countries reveals that the IEF for methane lies within the range seen in international reporting.

3.3.2.4.4.5 Source-specific recalculations (1.B.2.b.iv)

Recalculations were carried out for the entire time series, to take account of new emission factors for natural gas storage.

3.3.2.4.4.6 Source-specific planned improvements (1.B.2.b.iv)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.5 Natural gas, other leaks (1.B.2.b.v)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 2	AS	CS

The source category 1.B.2.b.v "Natural gas, other leakage" is a key category for CH_4, in terms of level, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

No decision tree or other guidelines are available for determination of emissions from distribution (cf. IPCC GPG 2000: Chapter 2 Energy).

Pursuant to the reporting guidelines of the EMEP Emission Inventory Guidebook, no instructions relative to "other" emissions are available (EMEP 2005: Group 5: Extraction & distribution of fossil fuels and geothermal energy).

3.3.2.4.5.1 Source category description (1.B.2.b.v)

The source category describes emissions from leakage in the industrial sector and in the areas of private households and commerce/trade/services. The activity data are based on results obtained by the Working Group on Energy Balances (AGEB) and on the current gas statistics of the German Association of Energy and Water Industries (BDEW).

No city gas has been fed into the grid in Germany since 1997.

3.3.2.4.5.2 Methodological issues (1.B.2.b.v)

The emission factors are country-specific. They were determined via the research project "Methanemissionen durch den Einsatz von Gas in Deutschland von 1990 bis 1997 mit einem Ausblick auf 2010" ("Methane emissions via gas use in Germany from 1990 to 1997, with an outlook for 2010"); Frauenhofer ISI, 2000.

Table 108: Methane emission factors used for category 1.B.2.b.v, Fugitive emissions at sites of natural gas use

Operational site	Gas	Value	Method	Source
Gas meters and fittings in the residential, institutional and commercial (small consumers) sectors	CH_4	4.5 kg / No[35]	T2	Expert estimate
Fittings in industrial facilities	CH_4	$410*10^{-6}$ m³/m³	T2	Expert estimate

3.3.2.4.5.3 Uncertainties and time-series consistency (1.B.2.b)

For the emissions data, the source-category uncertainties are given as 20 %. That figure is based on estimates of experts, and it lies within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.4.5.4 Source-specific quality assurance / control and verification (1.B.2.b.v)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

A source-category comparison with other countries reveals that the IEF for methane lies within the range seen in international reporting.

3.3.2.4.5.5 Source-specific recalculations (1.B.2.b.v)

For this source category, this year recalculations were carried out for the year 2010, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance.

3.3.2.4.5.6 Source-specific planned improvements (1.B.2.b.v)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.6 Venting and flaring (1.B.2.c)

CRF 1.B.2.c	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Venting & flaring	CH_4	-	-	409.3	(0.03%)	179.52	(0.02%)	-56.15%
Venting & flaring	CO_2	-	-	336.7	(0.03%)	296.9	(0.03%)	-11.83%
Venting & flaring	N_2O	-	-	1.1	(0.00%)	0.2	(0.00%)	-81.44%

The source category 1.B.2.c "Venting and flaring" is not a key source.

The source categories in the overarching group of fugitive emissions from 1.B.2.c "Venting and flaring" cover greenhouse-gas and pollutant emissions either vented or flared directly into the atmosphere.

[35] Number of gas meters and fittings

3.3.2.4.7 Venting and flaring, oil (1.B.2.c.i)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	AS	CS
CH_4 (extraction)	Tier 2	AS	CS
CH_4 (refineries)	Tier 1	AS	D
N_2O (only extraction)	Tier 2	AS	CS
NMVOC (only refineries)	Tier 1	AS	D

The source category 1.B.2.c.i "Venting and flaring, oil" is not a key category.

No methods for determining the relevant emissions have been prescribed (cf. IPCC GPG, 2000); only the decision tree for refineries (cf. 1.B.2.a.iii) includes venting and flaring as a criterion.

3.3.2.4.7.1 Source category description (1.B.2.c.i)

Pursuant to general requirements of the Technical Instructions on Air Quality Control (TA Luft; 2002), gases, steam, hydrogen and hydrogen sulphide released from pressure valves and venting equipment must be collected in a gas-collection system. Wherever possible, gases so collected are burned in process combustion. Where such use is not possible, the gases are piped to a flare. Flares used for flaring of such gases must fulfill at least the requirements for flares for combustion of gases from operational disruptions and from safety valves. For refineries and other types of plants in source categories 1.B.2, flares are indispensable safety components. In crude-oil refining, excessive pressures can build up in process systems, for various reasons. Such excessive pressures have to be reduced via safety valves, to prevent tanks and pipelines from bursting. Safety valves release relevant products into pipelines that lead to flares. Flares carry out controlled burning of gases released via excessive pressures. When in place, flare-gas recovery systems liquify the majority of such gases and return them to refining processes or to refinery combustion systems. In the process, more than 99 % of the hydrocarbons in the gases are converted to CO_2 and H_2O. When a plant has such systems are in operation, therefore, its flarehead will seldom show more than a small pilot flame.

3.3.2.4.7.2 Methodological issues (1.B.2.c.i)

The source category's emissions include flaring losses of onshore installations. Venting emissions are taken into account in 1.B.2.a.iv. In addition, flaring emissions in refineries are determined with emission factors developed by experts.

The results of quality assurance are taken into account in determination and documentation of emissions.

Table 109: Emission factors used for category 1.B.2.c.i, Flaring emissions at petroleum production facilities

Gas	Value	Method	Source
CH_4	0.558 g/m³	T2	Expert estimate
CO_2	90.4 g/t	T2	Expert estimate
N_2O	64 g / 1,000 m³	T2	Expert estimate
CO	0.074 g/t	T2	Expert estimate
NMVOC	0.457 g/m³	T2	Expert estimate

Table 110: Emission factors used for category 1.B.2.c.i, Flaring emissions at refineries

Gas	Value	Method	Source
CH_4	0.5 g/t	T2	Expert estimate
CO_2	2.55 kg/t	T2	Expert estimate
N_2O	54 g/m³	T1	GPG 2000
CO	12 g/m³	T1	EEA Guidebook 2006
NMVOC	2 g/m³	T1	EEA Guidebook 2006
SO_2	77 kg/m³	T1	EEA Guidebook 2006

3.3.2.4.7.3 Uncertainties and time-series consistency (1.B.2.c.i)

For the emissions data, the source-category uncertainties are given as 10 to 25 %. Those figures are based on estimates of national experts, and they lie within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.4.7.4 Source-specific quality assurance / control and verification (1.B.2.c.i)

See 1.B.2.a (Chapter 3.3.2.3) for an explanation of source-specific quality assurance / control and verification.

A source-category comparison with other countries reveals that the IEF for methane and that for carbon dioxide lie within the range seen in international reporting. The IEF for nitrous oxide lies at the upper end of the range. This is due to the conservative calculation approach used, using the default factor.

3.3.2.4.7.5 Source-specific recalculations (1.B.2.c.i)

Recalculations were carried out for carbon dioxide, NMVOC and methane, to take account of new emission factors.

An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

3.3.2.4.7.6 Source-specific planned improvements (1.B.2.c.i)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.8 Venting and flaring, gas (1.B.2.c.ii)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	AS	CS
CH_4	Tier 2	AS	CS
N_2O	Tier 2	AS	CS
NMVOC	Tier 2	AS	CS

Pursuant to the classification of the aggregated source category 1.B.2.c "Venting and flaring", the source category 1.B.2.c.ii "Venting and flaring, gas" is not a key category.

No methods for determining the relevant emissions have been prescribed (cf. IPCC GPG, 2000); only the decision tree for refineries (cf. 1.B.2.a.iv) includes venting and flaring as a criterion.

3.3.2.4.8.1 Source category description (1.B.2.c.ii)

For a description of the source category, see 1.B.2.c.i.

3.3.2.4.8.2 Methodological issues (1.B.2.c.ii)

For a description of the source category, see 1.B.2.c.i.

Venting emissions are taken into account in source category 1.B.2.b.iii. The SO_2 emissions are obtained from the activity data of 15,729,000 m³ of flared natural gas (WEG 2012, p. 45) and an emission factor of 0.140 kg / 1,000 m³, a factor based on an average H_2S content of 5 % by volume.

Table 111: Emission factors used for category 1.B.2.c.i, Flaring emissions in natural gas extraction

Gas	Value	Method	Source
CH_4	0.5 kg/m³	T2	Expert estimate
CO_2	0.056 t / GJ	T2	Expert estimate
N_2O	$2*10^{-8}$ kg/m³	T2	Expert estimate
CO	0.7 g/m³	T2	Expert estimate
NMVOC	0.62 mg/m³	T2	Expert estimate
SO_2	140 g / 1,000 m³	T2	Expert estimate

3.3.2.4.8.3 Uncertainties and time-series consistency (1.B.2.c.ii)

For the emissions data, the source-category uncertainties are given as 25 %. That figure is based on estimates of national experts, and it lies within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.4.8.4 Source-specific quality assurance / control and verification (1.B.2.c.ii)

See 1.B.2.b (Chapter 3.3.2.4) for an explanation of source-specific quality assurance / control and verification. A source-category comparison with other countries reveals that the IEF for methane lies within the range seen in international reporting.

3.3.2.4.8.5 Source-specific recalculations (1.B.2.c.ii)

An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 10.1.1.

3.3.2.4.8.6 Source-specific planned improvements (1.B.2.c.ii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.5 Geothermal energy (1.B.2.d)

3.3.2.5.1 Source category description (1.B.2.d)

The source category 1.B.2.d "Geothermal energy" is not a key category.

Geothermal energy is a renewable form of energy. Geothermal energy systems that tap geothermal heat to a depth of 400 metres are classified as "near-surface" geothermal energy systems. Near-surface geothermal systems generate heating and cooling energy by means of heat pumps. They are also used for heating service water. Geothermal energy systems that tap geothermal heat at depths greater than 400 metres are classified as "deep" geothermal energy systems. Geothermal heating stations use the heat in their thermal-water flows directly, and provide heating and cooling to end consumers, via district / local heating and cooling networks. Geothermal power stations convert the heat in their thermal-water flows into electricity. In most cases, they produce heat as well, via processes for combined heat/power (CHP) production.

As of the end of 2011, a total of 19 deep geothermal energy systems, with electricity output of 7.31 MW and thermal output of 176 MW, were in operation. A total of 19 systems, with electricity output of 43 MW and thermal output of 119 MW, are under construction. An additional 70 systems are planned, with planned capacity of 89 MW of electrical output and 352 MW of thermal output.

Operation of geothermal power stations and heat stations in Germany produces no emissions of climate-relevant gases. The thermal-water circuits of such installations are closed and airtight, both above and below ground level. As a result, no emissions occur during their operation. What is more, releases of the gases dissolved in their heat-carrying fluids – primarily H_2, CH_4, CO_2 and H_2S – would not produce concentrations that would require reporting (cf. "Umwelteffekte einer geothermischen Stromerzeugung, Analyse und Bewertung der klein- und großräumigen Umwelteffekte einer geothermischen Stromerzeugung" ("Environmental effects of geothermal power generation; analysis and assessment of small-scale and large-scale environmental impacts of geothermal power generation")), FKZ 205 42 110, Chapter A.2.3.5). For this reason, the emissions are reported as "NO". In 2011, all geothermal energy systems met their own power requirements (primarily power for operating pumps) by drawing electricity from the grid. In the report, that use is included in the relevant source categories.

3.3.2.5.2 Methodological issues (1.B.2.d)

The IPCC Reference Manual does not describe any methods for source category 1.B.2.d "Other" (IPCC, 1996b: p. 1.132f).

No emission factors for greenhouse gases and pollutants that could escape in connection with drilling for tapping of geothermal energy (both near-surface and deep energy) are known for Germany at present. As is known from oil and gas exploration, however, it is clear that virtually any drilling will lead to releases of gases bound in underground layers – and the gases involved can include H_2, CH_4, CO_2, H_2S and Rn (cf. "Environmental effects of geothermal electricity production; analysis and assessment of the small-scale and large-scale environmental effects of geothermal electricity production", FKZ 205 42 110, Chapter A.2.1.5). Drilling to tap near-surface geothermal energy can be expected to produce only very slight emissions. In all drilling to tap deep geothermal energy, blow-out preventers are used to prevent gas releases. In addition, drilling fluids are used to drive any gases released into boreholes back into the rock layers traversed in drilling.

3.3.2.5.3 Uncertainties and time-series consistency (1.B.2.d)

No explanations of uncertainties and time-series consistency are required.

3.3.2.5.4 Source-specific quality assurance / control and verification (1.B.2.d)

No explanations relative to source-specific quality assurance / control and verification are required. Verification is not possible at present.

3.3.2.5.5 Source-specific recalculations (1.B.2.d)

No recalculations are required.

3.3.2.5.6 Planned improvements (1.B.2.d)

No improvements are planned at present.

4 INDUSTRIALM PROCESSES (CRF SECTOR 2)

4.1 Overview (CRF Sector 2)

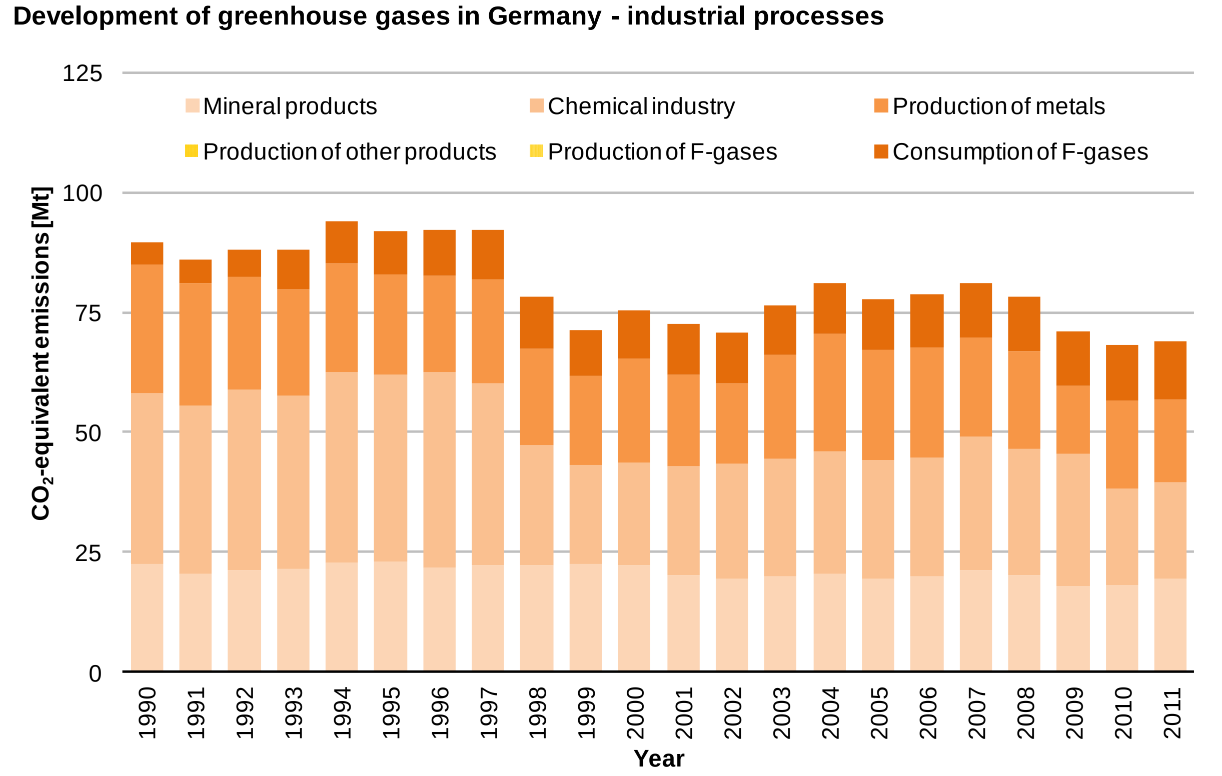


Figure 40: Overview of greenhouse-gas emissions in CRF Sector 2

4.2 Mineral products (2.A)

Source category 2.A Mineral products is divided into sub- source categories 2.A.1 through 2.A.7. These fields include:

- Cement clinker production (2.A.1),
- Lime burning (2.A.2),
- Limestone and dolomite use (2.A.3),
- Soda ash production and use (2.A.4),
- Bitumen roofing (2.A.5),
- Road paving with asphalt (2.A.6), and,
- in Other, Glass production (2.A.7.a) and Ceramics production (2.A.7.b).

4.2.1 Mineral Products: Cement production (2.A.1)

4.2.1.1 Source category description (2.A.1)

CRF 2.A.1	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Clinker production	**CO_2**	**L**	**T**	**15,145.8**	**(1.24%)**	**13,130.8**	**(1.42%)**	**-13.30%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	AS	CS
NO_X, SO_2	CS	AS	CS

The source category *Cement production* is a key category for CO_2 emissions in terms of emissions level and trend.

The remarks below refer only to production of cement clinkers, because clinker grinding is not relevant as a dust source in the present context. In Table 112, cement production is included solely for reference purposes, without emissions relevance in this context.

The clinker-burning process emits climate-relevant gases. CO_2 accounts for the great majority of these emissions. The CO_2 emissions from pertinent raw materials are tied directly to the quantities of cement clinkers that are produced. Pursuant to the *German Cement Works Association* (VDZ, 2011), clinker production in 2011 amounted to 24,775 kt[36]. Raw-material-related CO_2 emissions are calculated with a country-specific emission factor, as determined by the VDZ from plant-specific data, of 0.53 t CO_2/t cement clinkers. Clinker production produced raw-material-related CO_2 emissions of 13,131 kt CO_2 in 2011.

[36] Provisional value (rounded off).

Table 112: Production and CO_2 emissions in the German cement industry

Year	Clinker production [kt/a]	Emission factor [t CO_2/t]	Raw-material-related CO_2 emissions [kt/a]	Cement production (kt/a)
1990	28,577		15,146	37,772
1991	25,670		13,605	34,341
1992	26,983		14,301	37,331
1993	27,146		14,387	36,649
1994	28,658		15,189	40,512
1995	29,072		15,408	35,862
1996	27,669		14,664	34,318
1997	28,535		15,124	34,148
1998	29,039		15,391	35,601
1999	29,462		15,615	37,438
2000	28,494	0.53	15,102	35,414
2001	25,227		13,370	32,118
2002	23,954		12,696	31,009
2003	25,233		13,373	32,749
2004	26,281		13,929	31,854
2005	24,379		12,921	31,009
2006	24,921		13,208	33,630
2007	26,992		14,306	33,382
2008	25,366		13,444	33,581
2009	23,232		12,313	30,441
2010	22,996		12,188	29,915
2011	24,775		13,131	33,540

Source: BdZ 1995 (until 1994); VDZ, 2011 (as of 1995)

4.2.1.2 Methodological issues (2.A.1)

Activity data

Activity data are determined via summation of figures for individual plants (until 1994, activity data were determined on the basis of data of the BDZ). As of 1995, following optimisation of data collection within the association, activity data were compiled by the VDZ, and by its cement-industry research institute (located in Düsseldorf), via surveys of German cement works and use of BDZ figures. In the main, the data consists of data published in the framework of CO_2 monitoring, supplemented with data for plants that are not BDZ members (in part, also VDZ estimates).

Table 112 summarises the activity data for cement clinkers and cement, and the raw-material-related CO_2 emissions as determined from clinker production, for the years 1990 through 2010.

Emission factors

The emission factor used for emissions calculation, 0.53 t CO_2 / t cement clinkers, is based on mass-weighted figures for individual plants, i.e. the VDZ determined the emission factor by aggregating plant-specific data relative to fractions of CaO and other metal oxides (MgO; in raw materials, and containing carbonate) in clinkers. The emission factor was confirmed in the framework of a research project (VdZ, 2009).

In the German cement industry, dust separated from exhaust gas is returned to the burning process. As a result, carbonate release from clinker raw materials can be determined directly from clinkers' metal-oxide content, without any need to take account of significant losses via the exhaust-gas pathway.

The emission factor of 0.53 t CO_2 / t cement clinkers was applied to the entire time series.

Raw-material-related CO_2 emissions in the cement industry are determined, in accordance with the *IPCC-GPG*, via the following equation:

CO_2 emissions = emission factor ($EF_{clinkers}$) x clinker production

(Table 112 shows calculated CO_2 emissions for the German cement industry for the years covered by the report.)

4.2.1.3 Uncertainties and time-series consistency (2.A.1)

For the activity data, time-series consistency is assured by the long period of time over which the association has collected pertinent data; for the emission factor, it is assured via use of a standard approach for all relevant years.

The listed uncertainties were determined via expert assessment pursuant to Tier 1 of the IPCC GPG rules (2000: Chapter 6.3 p. 6.12).

Most companies are required to report clinker-production data within the framework of CO_2-emissions trading. The EU monitoring guidelines for emissions trading specify a maximum accuracy of 2.5 %. The uncertainties for the activity data used were thus estimated as -2.5 % and +2.5 %.

The uncertainty for the emission factor used was estimated as +/- 2 %. This was confirmed via surveys in the framework of a research project (VdZ, 2009).

4.2.1.4 Source-specific quality assurance / control and verification (2.A.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For purposes of quality assurance, all data used, including data from the BDZ, from the VDZ and comparative data from the literature, were checked for plausibility. The determined emission factor for raw-material-related CO_2 emissions has been compared with the relevant figures of other countries. The small deviation (< 5 %) from the IPCC Tier 1 default factor of the IPCC Reference Manual, 0.5071 t CO_2 / t clinkers (IPCC 1996b: Chapter 2.3.2, p. 2.6), results from the sometimes-higher lime content of German clinkers (64 % to 67 % CaO) and an average MgO content, which is not taken into account in the default value, of 1.5 %. The procedure used corresponds to the Tier 2 method of the IPCC-GPG (IPCC, 2000), and it is considered to be more precise than utilisation of default emission factors.

The emission factor used differs only slightly (1 %) from the emission factor used in connection with the ETS in Germany, an emission factor which is checked by authorities and reviewed in light of companies' obligations to provide records. To date, no calculations relative to the emission factor prior to the year 2000 are available. The same figure – the result of an expert assessment – has been used for all relevant years in that period.

4.2.1.5 Source-specific recalculations (2.A.1)

No recalculations are required.

4.2.1.6 Planned improvements (source-specific) (2.A.1)

No source-category-specific improvements are planned.

4.2.2 Mineral Products: Lime production (2.A.2)

4.2.2.1 Source category description (2.A.2)

CRF 2.A.2	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Limestone and dolomite	**CO_2**	**L**	**-/T2**	**5,867.6**	**(0.48%)**	**4,926.6**	**(0.53%)**	**-16.04%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	AS	D
NO_X, SO_2	CS	AS	CS

The source category *Lime production* is a key category for CO_2 emissions in terms of emissions level.

The statements made below regarding source category 2.A.2 refer solely to the amounts of burnt lime and dolomite lime produced in German lime works. Information about other lime-producing and lime-using sectors is provided in Chapter 4.2.3 (CRF 2.A.3), in the interest of preserving the international comparability of Chapter 4.2.2 (CRF 2.A.2).

Because of the wide range of applications covered by the sector's products, lime production is normally more insulated from economic fluctuations than is production of other mineral products, such as cement. Production has fluctuated relatively little since the end of the 1990s, with the exception of the fluctuation seen in 2009. In 2009, production decreased by more than 20 % from the previous year, as a result of economic factors. As a result of economic recovery, production increased by 11 % in 2011, to somewhat more than 6.2 million t. Nonetheless, it is still about 8 % below the corresponding production quantity in 2008.

Table 113: Production and CO_2 emissions in the German lime industry (following recalculations – cf. 4.2.2.5)

Year	Lime		Dolomite lime	
	Production [t]	CO_2 emissions [Millions of t]	Production [t]	CO_2 emissions [Millions of t]
1990	7,180,057	5.355	591,595	0.513
1991	6,347,938	4.734	593,321	0.515
1992	6,434,344	4.798	575,955	0.500
1993	6,718,472	5.010	516,470	0.448
1994	7,365,100	5.493	505,995	0.439
1995	7,461,872	5.565	545,026	0.473
1996	6,881,431	5.132	545,575	0.473
1997	6,975,146	5.202	531,268	0.461
1998	6,666,164	4.971	558,373	0.484
1999	6,681,273	4.983	481,123	0.417
2000	6,856,478	5.113	525,522	0.456
2001	6,534,447	4.873	512,527	0.445
2002	6,462,040	4.819	516,271	0.448
2003	6,599,930	4.922	436,887	0.379
2004	6,561,720	4.893	459,679	0.399
2005	6,407,324	4.778	464,345	0.403
2006	6,515,915	4.859	462,533	0.401
2007	6,738,764	5.025	459,405	0.398
2008	6,733,805	5.022	455,066	0.395
2009	5,393,103	4.022	335,013	0.291
2010	6,004,296	4.478	335,077	0.291
2011	6,206,546	4.629	343,610	0.298

Source: Own extrapolation on the basis of BV KALK, 2011

Production of dolomite lime, of which significantly smaller amounts are produced, basically exhibits similar fluctuations. On the other hand, production in the years 2003 to 2008 was considerably lower than in 2002 and the years before then (in 2003, production decreased by about 15 %). Between 1990 (the base year) and 2008, production decreased by about 23 %. Between 1990 and 2009, production decreased by 43 % (in 2009 alone, production decreased by more than 26 %, due to economic factors; while production increased again in 2011, it was unable to compensate for the decrease in 2009).

With a constant emission factor, CO_2 emissions and lime / dolomite-lime production depend linearly on each other; as a result, the above statements apply to CO_2 emissions mutatis mutandis.

4.2.2.2 Methodological issues (2.A.2)

In burning of limestone and dolomite, CO_2 is released, and it reaches the atmosphere via the exhaust gas of the process. The pertinent emissions level is obtained by multiplying the amount of product in question (lime or dolomite lime) and the relevant emission factor.

Emission factors

As of this year, the pertinent CO_2 emissions are calculated with the following factors:

EF_{lime} 0.746 t CO_2/t lime (stoichiometric 0.785 * oxide fraction 0.95)
$EF_{dolomite\ lime}$ 0.867 t CO_2/t dolomite lime (stoichiometric 0.913 * oxide fraction 0.95)

In the process, it is assumed that 95 % of the lime consists of CaO, that 95 % of the dolomite lime consists of CaO • MgO and that 5 % of the total mass consists of impurities that are not CO_2-relevant. This approach is in keeping with the provisions of the *IPCC Good Practice*

Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC2000, Chapter 3.1.2, Table 3.4). Since the intra-EU inventory review of 2012, it has been applied in conformance with the review report (Umweltbundesamt GmbH, 2012).

Activity data

The German Lime Association (BVK) collects the production data for the entire time series, on a plant-specific basis, and makes them available for reporting purposes. As of this year, the quantities produced by plants that are not included in the German Lime Association's association statistics are estimated on the basis of existing information (such as operator figures, data published in the framework of emissions trading) and then added to the German Lime Association's figures. This ensures that all of German lime production is taken into account.

4.2.2.3 Uncertainties and time-series consistency (2.A.2)

The EU monitoring guidelines for emissions trading call for activity data to have an accuracy of 2.5 %. Since the German Lime Association's (BV Kalk's) lime-production data are based on operators' figures as provided in the framework of CO_2-emissions trading, and since the plants not included in the association's statistics (and thus assessed after the fact) represent only a small share of the total number of plants concerned, the **uncertainties** for the **activity data** used are estimated to be 2.5 % and +2.5 %. These figures apply to both burnt lime and dolomite lime.

The uncertainties for the emission factors used for burnt lime were estimated as -11 % and +5 %. The uncertainties for the emission factors used for dolomite lime were estimated as -30 % and +2 %.

4.2.2.4 Source-specific quality assurance / control and verification (2.A.2)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Production amounts are determined, by the German Lime Association (BV Kalk), via several different concurrent procedures; their quality is thus adequately assured (Tier 2).

The estimated emissions and collected production-quantity data were compared with findings from emissions trading and with national statistical data. The IPCC default factors used are suitable for the country-specific method.

4.2.2.5 Source-specific recalculations (2.A.2)

Source-specific recalculations of the emission factors were carried out for the entire time series. This yielded a 5 % reduction in the relevant CO_2 emissions. The new emission factors are in keeping with the default factors of the IPCC Guidelines, and they take a 5 % impurities level in the raw material into account.

	Emission factor (old)	Emission factor (new)
Lime	0.785 t CO_2/t_{burnt} lime	0.746 t CO_2/t_{burnt} lime
Dolomite lime	0.913 t $CO_2/t_{dolomite}$ lime	0.867 t $CO_2/t_{dolomite}$ lime

4.2.2.6 Planned improvements (source-specific) (2.A.2)

No source-category-specific improvements are planned.

4.2.3 Mineral Products: Limestone and dolomite use (2.A.3)

4.2.3.1 Source category description (2.A.3)

CRF 2.A.3	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
IE	CO_2	-	-	IE	IE	IE	IE	IE

Gas	Method used	Source for the activity data	Emission factors used
CO_2		IE	

At present, emissions of this source category are not reported separately; instead, they are reported in the source categories that use limestone and dolomite. For the sake of simplicity, reference will be made to "limestone" (except in special cases requiring explanation), even where the sum of limestone and dolomite is meant.

In this source category, all production and use of limestone and dolomite are considered in balance form, and the results are compared with the inventory source categories (cf. Table 114). The "limestone balance" project provides a substance-flow analysis, in the form of amounts balance sheets that can be combined into time series. This methodological work was carried out in a research project that drew on all of the Federal Environment Agency's available expertise (UBA 2006). In 2010, this balance was updated through the last available data year for the complete data set, 2008. While this balance-evaluation process identified data-availability problems, it was able to derive relevant solutions and to identify the impacts of using the 1996 and 2006 IPCC Guidelines as alternatives. A pertinent short report that was prepared co-operatively, by the Federal Institute for Geosciences and Natural Resources (BGR) and the Federal Environment Agency, includes completely recalculated time series for limestone use (UBA 2010).

Table 114: Limestone balance sheet for use of limestone in areas with, and without, relevance with regard to carbon-dioxide emissions

Limestone use in Germany, in millions of tonnes [Millions of t]	1990	1995	2000	2008	CRF reference
Production					
Domestic production (change in statistics from 1994 to 1995)	110.500	76.790	95.100	91.659	2.A.3
Imports	1.299	2.275	3.301	5.214	2.A.3
Exports	0.201	0.389	0.278	1.367	2.A.3
Total production	**111.598**	**78.676**	**98.123**	**95.506**	2.A.3
Use					
Cement industry	34.203	35.131	34.522	29.601	2.A.1
Lime industry	13.733	14.143	13.031	12.319	2.A.2
Soda ash production	2.275	1.831	1.706	1.745	2.A.4.a
Glass production	0.700	0.890	0.970	0.902	2.A.7.a
Sintering (preparation of iron ores)	4.681	4.600	4.273	4.541	2.C.1
Pig iron (blast furnace)	0.756	0.751	0.924	0.790	2.C.1
Sugar production (lime furnaces)	0.686	0.784	0.796	0.655	2.D.2
Flue-gas desulphurisation in power stations	1.362	1.401	2.580	2.303	1.A.1.a
Agriculture and forestry	2.437	3.233	3.469	3.410	LULUCF
Water and sludge treatment	0.051	0.062	0.047	0.226	NE
Other sectors (such as construction, other construction-materials industry and chemical industry, etc.)	50.716	15.851	35.804	39.014	NE
Total use	**111.598**	**78.676**	**98.123**	**95.506**	2.A.3
Auxiliary balance (limestone included in raw materials)					
Ceramics production					
- Brick production	1.028	1.384	1.190	0.751	2.A.7.b

Source: Compilation of the Federal Environment Agency, from UBA 2006 (Tab. 3-23, direct link http://www.uba.de/uba-info-medien/3102.html) and UBA 2010 (Tab. 1-2), without updating relative to studies – data were most recently available for 2008

In terms of quantity, and taken together, emissions-related uses of limestone in cement and lime production have a significance similar to that of so-called "other areas". At the same time, emissions-related uses are showing a slightly decreasing trend, although their overall order of magnitude has not changed.

For overview purposes, the following table shows those CO_2 emissions calculated within the inventory that cannot always be separately drawn from the CRF tables (2.C.1, 1.A.1.a) and that do not appear as sums in the CRF tables:

Table 115: CO_2 emissions from limestone use (overview, 2.A.3)

[Millions of t]	1990	1995	2000	2010	2011	CRF reference
Cement industry	15.1	15.4	15.1	12.2	13.1	2.A.1
Lime industry	5.9	6.0	5.6	4.8	4.9	2.A.2
Glass production	0.7	0.8	0.7	0.7	0.7	2.A.7.a
Brick production	0.5	0.6	0.5	0.3	0.3	2.A.7.b
Iron and steel industry	2.4	2.4	2.3	2.1	1.9	2.C.1, aggregated
Flue-gas desulphurisation in power stations	0.6	0.7	1.1	1.0	1.0	1.A.1.a, aggregated
Agriculture and forestry	1.3	1.6	2.1	1.7	1.8	LULUCF
Total from limestone use	**26.5**	**27.5**	**27.5**	**22.8**	**23.9**	

Source: Compilation of the Federal Environment Agency, from the various source categories

4.2.3.2 Methodological issues (2.A.3)

The purpose of the balance account is to provide an overview of national limestone use (activity data). Emissions calculations are carried out for those source categories in which CO_2 emissions are produced via limestone use:

- 1.A.1.a Flue-gas desulphurisation in power stations (addition of limestone)
- 2.A.1 Cement-clinker production (limestone fraction in the relevant raw materials)
- 2.A.2 Limestone production (limestone inputs)
- 2.A.7.a Glass production (limestone fraction in the relevant raw materials)
- 2.A.7.b Ceramic-brick production (limestone fraction in the relevant raw materials)
- 2.C.1 Iron and steel production (limestone input for pig iron and sinter)
- 5.B+5.G Soil liming in agriculture and forestry (LULUCF)

Limestone is also used in other sectors that are not mentioned in the present section. Such uses either a) involve kilns for lime-burning, and thus are subsumed in the data compilation in 2.A.2, or b) produce no direct emissions, as is the case in soda and sugar production[37]. With the exception of quantities used in production of ceramic products, all limestone quantities used are included in production as determined and thus can be derived from the limestone balance (sheet).

In spite of the consistency of the limestone balance (sheet), the resulting CO_2 emissions can be calculated more precisely, and in ways that are more specifically suitable, in source categories with a sectoral focus. For example, the natural limestone fraction in raw materials used for clinker production can be estimated. That fraction is taken into account source-category-specifically in 2.A.7.b, along with emissions-causing porosity agents. The uses considered source-category-specifically for the glass industry, in 2.A.7.a, include much more than limestone use – for example, they also include use of soda ash and other carbonates.

As a result, the pertinent data are updated in the relevant source categories (cf. the above list). In addition, pertinent methodological aspects are explained in the relevant source-category chapters (cf. chapters 19.1.2.3, 4.2.1, 4.2.2, 4.2.7, 4.2.8, 4.4.1 and 7.3.4.5).

To prevent double-counting with other source categories, and to ensure comparability with future inventories, in keeping with IPCC GL 2006, no CO_2 emissions are aggregated for purposes of presentation in CRF tables. In this regard, cf. also the following comparison:

[37] This refers to the process in which limestone is burned to obtain CO_2, which then recarbonises in cleaning processes. The pertinent CO_2 emissions occur only when lime is applied in agriculture (carbolic lime); this is reported under CRF 4 and 5.

Orientation with regard to the IPCC Guidelines

The IPCC Guidelines 2006 (GL 2006), which are not yet applicable, but are methodologically more refined than earlier guidelines, call for emissions from use of limestone and other carbonates to be calculated in the context of those source categories in which the relevant uses occur. All emissions-related balance entries are calculated and reported at suitable locations in the global consideration pursuant to GL 2006. Separate designation as "limestone use", in addition to inclusion within category-specific calculations, is no longer required in such calculation and reporting[38].

When, in CRF category 2.A.3, the rules of the IPCC Guidelines 1996 (GL 1996) are strictly followed, all explicitly specified limestone uses are described and the emissions for all such uses are calculated and summed, a distorted picture of the importance of emissions from limestone use results. In updating of the limestone balance sheet, such distortion was studied, also with regard to different possibilities for deriving limestone-input quantities. If source-category-specific circumstances were not taken into account, only balance-sheet positions based on statistical data could be aggregated under 2.A.3. In the source categories themselves, by contrast, limestone inputs can be calculated on the basis of actual requirements, although such quantities can hardly be entered into the balance in any transparent manner.

Table 116: Comparison of balance-sheet positions with emissions relevance pursuant to GL 1996 (report category 2.A.3), for 2008, as gained from model calculations with specific key figures ("from key figures") and from statistical information ("statistical")

	CO_2	2.A.3[39]	From key figures	Statistical
Balance-sheet position (limestone use, in millions of tonnes of limestone)				
1.A.1.a Flue-gas desulphurisation (REA) in large combustion installations	x	x	2.303	1.745
2.A.7.a Glass production (total)	x	x	0.902	0.356
2.A.7.b Ceramics production (external "auxiliary balance")	x	x	0.751	0.000
2.C.1 Iron and steel production	x	x	5.331	3.437
CO_2 emissions from limestone, in millions of tonnes (for simplicity, calculated with dolomite included)	**x**	**x**	**4.1 (CO_2)**	**2.4 (CO_2)**

Source: Calculation of Federal Environment Agency (UBA); Table 3 from UBA 2010

The comparative emissions described here are not included in aggregated form in the CRF tables for 2.A.3, and they not included, in aggregated form, in key-category determination. The source-category-specifically calculated emissions are included in the aforementioned source categories, however, and they have been included in key-category determination for those categories[40].

4.2.3.3 Uncertainties and time-series consistency (2.A.3)

Information regarding uncertainties for activity data and emission factors for the relevant limestone uses is provided in the relevant source-category chapters.

[38] There does continue to be a separate position 2A4 "Other Process Uses of Carbonates", but that position would have no application within the context of German emissions inventories.

[39] IPCC 1996

[40] Limestone use under 1.A.1.a and under 2.C.1 is included in key categories determined pursuant to Tier 1.

4.2.3.4 Source-specific quality assurance / control and verification (2.A.3)

General quality control and quality assurance, in keeping with the requirements of the QSE manual and its associated documents, have been carried out in those source categories into which source category 2.A.3 was divided, pursuant to the IPCC Guidelines.

The activity data and the emission factors for the relevant limestone uses are verified and updated in the relevant source categories.

The data surveys from the limestone-balance research project, and the updating carried out by the Federal Institute for Geosciences and Natural Resources (BGR) and the Federal Environment Agency, do not point to any persisting inventory gaps, and thus the surveys are considered adequate.

Allocation of limestone uses was intensively discussed in connection with the 2010 and 2011 inventory reviews, but no inventory adjustments, relative to emissions levels, were derived from such discussion.

4.2.3.5 Source-specific recalculations (2.A.3)

Recalculations for individual balance-sheet entries are described and explained in those source categories in which limestone inputs are significant. For purposes of the present report, (moderate) recalculations were carried out solely in the area of lime-burning, for that area's entire time series (Chapter 4.2.2.5).

4.2.3.6 Source-specific planned improvements (2.A.3)

No improvements, and no annual updating of the limestone balance sheet, are planned at present.

4.2.4 Mineral Products: Soda ash production and use (2.A.4)

4.2.4.1 Source category description (2.A.4)

CRF 2.A.4	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Soda ash use	CO_2	-	-	426.7	(0.04%)	361.6	(0.04%)	-15.27%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS/D

The source category *Soda ash production and use* is not a key category.

In Germany, soda ash is produced only chemically. The country has 3 production facilities, all of which use the Solvay process[41]. With respect to the calcium carbonate it uses, that process is CO_2-neutral, since the carbon dioxide in the limestone is bound within the product, soda ash (Na_2CO_3), and is released only during product use.

On the other hand, coke is used in the calcination part of the process, and this produces additional carbon-dioxide emissions. An amount of some 100 kg of coke is assumed per tonne of soda ash; this was determined in a research project for the preparation of relevant Best Available Technique Reference Documents (BREF) (UBA, 2001). While this

[41] Ammonia-soda process pursuant to Ernst Solvay

corresponds to an amount of some 380 kg CO_2 / t soda ash, these emissions are reported not here but together with energy-related emissions.

Soda ash is used in a wide range of industrial applications. The most important areas of use include the glass industry, production of detergents and cleansers and the chemical industry. It is assumed that the carbon contained in soda ash is released sooner or later, regardless of the use involved, into the air as CO_2.

Emissions resulting solely from use of soda ash correlate in a fixed way to the pertinent calculated quantities used (cf. the methodological issues in the following):

Table 117: Activity data and use-related CO_2 emissions outside of the glass industry, since 1990

Year	Activity data [t]	CO_2 emissions [kt]
1990	1,028,243	426.7
1991	833,285	345.8
1992	674,159	279.8
1993	669,874	278.0
1994	784,273	325.5
1995	615,403	255.4
1996	616,105	255.7
1997	693,994	288.0
1998	745,031	309.2
1999	708,245	293.9
2000	724,926	300.8
2001	763,405	316.8
2002	725,483	301.1
2003	774,433	321.4
2004	741,587	307.8
2005	753,075	312.5
2006	754,603	313.2
2007	858,694	356.4
2008	842,691	349.7
2009	752,530	312.3
2010	845,126	350.7
2011	871,228	361.6

Source: Calculations of the Federal Environment Agency (UBA)

4.2.4.2 Methodological issues (2.A.4)

Activity data

The *Federal Statistical Office* determines the total amounts of soda ash produced in Germany. From 1995 to 2008, the sum total has comprised the categories of *light soda* (production number 2413 33 103, disodium carbonate in powder form, with a fill density of less than 700 g/l) and *heavy soda* (production number 2413 33 109, other disodium carbonate). Since 2009, light and heavy soda are reported in combination, in one position (notification number 2013 43 100). Of that quantity, only the portion "intended for sale" ("zum Absatz bestimmt") is taken into account. This prevents double-counting, since heavy soda is produced from light soda.

Since the 2010 inventory review, those soda ash inputs are determined that are not taken into account, for emissions calculations, in other source categories. The relevant calculations are oriented to the greatest possible emissions from the applicable soda ash use. The total quantity of soda ash used in Germany is determined via balancing (quantity produced plus imports and less exports). The relevant import and export quantities are taken from the foreign-trade statistics of the Federal Statistical Office (STATISTISCHES BUNDESAMT, 2011). Emissions from soda ash use in the glass industry are already taken into account, source-specifically, under source category 2.A.7.a (Glass industry). The soda ash quantities used in that category are calculated from the mixtures of glass types used, and then deducted from the soda ash use of relevance in the present section.

Since Germany has only two producers, these newly structured data must be kept confidential. Only the production quantities reported by the Federal Statistical Office through 2008 continue to be published.

Emission factor

Since the Solvay production process is neutral with regard to CO_2, an emission factor of "0" is used for production.

The quantities of coke that are used during lime burning are already taken into account in the Energy Balance, without being listed separately with regard to their CO_2 emissions.

Stoichiometrically, the emission factor for soda ash use is 415 kg CO_2 per tonne of soda ash, under the assumption that release is complete (a conservative approach). The emission factor is in keeping with the relevant IPCC requirements (IPCC, 1996b).

4.2.4.3 Uncertainties and time-series consistency (2.A.4)

Activity data

There are uncertainties regarding the production statistics given by the Federal Statistical Office, since – for example – the relation between light and heavy soda ash fluctuates widely, especially in the first years for which separate statistics are provided.

The calculations of the relevant quantities of soda ash used exhibit large uncertainties (maximally, -50%/+50%), as a result of both statistical fluctuation ranges and the assumptions on which the calculations are based.

Emission factor

Since the emission factor for production of soda ash is a substantiated "zero", there is no uncertainty. The emission factor for soda ash use is subject to small, justified uncertainties in the area of product purity and the completeness of the chemical transformations involved.

4.2.4.4 Source-specific QA/QC and verification (2.A.4)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the area "production of soda ash / sodium carbonate".

The IEF for the entire time series for production of soda ash is in keeping with the IEFs of other countries that use the Solvay process. Pertinent data that could be used for comparison are not yet available from emissions trading, which is to begin in 2013 for soda ash production.

Due to a lack of assigned expert resources, it was not possible to have source-category experts carry out QA/QC for the area "use of soda ash / sodium carbonate". Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

It is not possible at present to verify quantitatively the input quantities of soda ash that cannot be allocated to the glass industry. The pertinent estimates are conservative, however; they do not underestimate the quantities of relevance for the inventory. Qualitatively, the pertinent calculation results do not contradict the sales figures of soda-ash producers obtained on a sample basis.

4.2.4.5 Source-specific recalculations (2.A.4)

Recalculations for the years as of 2007 had to be carried out to take account of corrected calculations relative to soda-ash inputs in the glass industry. The quantities of soda ash reported in the present context, and the relevant emissions, increased slightly as a result.

4.2.4.6 Source-specific planned improvements (2.A.4)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

4.2.5 Mineral Products: Bitumen for roofing (2.A.5)

CRF 2.A.5	Gas	Key category	1990 Total emissions (Gg) & percentage (%)	2011 Total emissions (Gg) & percentage (%)	Trend
		- -			

Gas	Method used	Source for the activity data	Emission factors used
NMVOC	T1	AS	CS

As far as is currently known, the source category *Bitumen for roofing* produces no greenhouse-gas emissions and is thus not a key category.

4.2.5.1 Source category description (2.A.5)

Bitumen is used in production and laying of roof and sealing sheeting.

In 2011, some 181 million m^2 of roof and sealing sheeting were produced in Germany, and some 155 million m^2 of such sheeting were used (export surplus). In such production, liquid bitumen is applied, at temperatures of 150°C to 220°C, as a saturating or coating agent. This process produces emissions of organic substances (combined here as NMVOC).

Roof and sealing sheeting is laid by means of both hot and cold processes. The hot process, involving welding of sheeting, produces significant emissions of organic substances. The relevant emissions trends depend primarily on trends in quantities of polymer bitumen sheeting produced. Use of solvent-containing primers is not considered here; it is covered via the solvents model – cf. Chapter 5.2.

Emissions from production of roof and sealing sheeting have been decreasing slightly, in keeping with decreasing production quantities. Emissions from laying of roof and sealing sheeting have remained about the same, although the quantities used have been decreasing.

Substances other than NMVOC are of only subordinate relevance in terms of emissions.

4.2.5.2 Methodological issues (2.A.5)

Data on quantities of roof and sealing sheeting that are produced and used (**activity data**) are provided by the VDD association of the bitumen, roof sheeting and sealing sheeting industry (VDD, 2012), on the basis of a cooperation agreement dating from 2009. At present, no data supplementation or extrapolation is being carried out. To obtain internationally comparable figures, production quantities are converted into quantities of input bitumen (the conversion relationship, depending on the type of sheeting concerned, varies from 1.3 to 3.3 bitumen kg/m^2).

Because of their predominating importance, only NMVOC emissions are considered and taken into account in the emissions inventory. In the process, a distinction is made between emissions from production and emissions from laying of roof and sealing sheeting.

The **emission factor** for production of roof and sealing sheeting was obtained via a calculation in accordance with current technological standards of German manufacturers (VDD, 2009). The emission factor for laying of polymer bitumen sheeting has been taken from an ecological balance sheet (IKP, 1996). That emission factor has also been adopted, by analogy, for sheeting glued primarily with hot bitumen. Thin sheeting is not glued; it is attached via nailing and produces no emissions. The implied emission factor for the source category has been increasing slightly, as a result of the increasing importance of polymer bitumen sheeting.

NMVOC emissions are calculated in keeping with a Tier 1 method, since no pertinent detailed data are available.

Table 118: Production and laying of roof and sealing sheeting with bitumen, and relevant activity data and emission factors

	Produced or used area in 2011 [millions of m^2]	**EF/ IEF [kg/ m^2]**
Production of roof and sealing sheeting with bitumen	181	NMVOC 0.00035795
Laying of roof and sealing sheeting with bitumen	155	NMVOC 0.000027 – 0.000038

4.2.5.3 Uncertainties and time-series consistency (2.A.5)

Information relative to the uncertainty of the data of the VDD was obtained via consultation between the VDD and the Federal Environment Agency. The total uncertainty for the activity data for production and laying of sheeting is estimated to be about +/-1 %. That figure, in turn, leads to a higher uncertainty, of about +/-2.5 %, for the calculated bitumen consumption.

The uncertainty for the combined emission factors for production and laying of roof and sealing sheeting is estimated to be about +/-5 %.

4.2.5.4 Source-specific quality assurance / control and verification (2.A.5)

Quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

The manner in which the activity data were determined is considered to be plausible. The emission factors accord with findings from pertinent Federal Environment Agency research projects and are plausible. In particular, the validity of the emission factors is justified in that no emissions from use of solvent-containing coatings and primers have to be taken into account in this section (that takes place in the solvents model, as noted above).

4.2.5.5 Source-specific recalculations (2.A.5)

No source-specific recalculations were required.

4.2.5.6 Source-specific planned improvements (2.A.5)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

4.2.6 Mineral Products: Road paving with asphalt (2.A.6)

CRF 2.A.6	Gas	Key category	1990 Total emissions (Gg) & percentage (%)	2011 Total emissions (Gg) & percentage (%)	Trend
		-	-		

Gas	Method used	Source for the activity data	Emission factors used
CO	T1	AS	IE
NO_X, NMVOC, SO_2	T1	AS	CS

As far as is currently known, the source category "Road paving with asphalt" produces no greenhouse-gas emissions and is thus not a key category.

4.2.6.1 Source category description (2.A.6)

Currently, the report tables list produced quantities of mixed asphalt products and NMVOC, NO_X and SO_2 emissions.

In 2011, a total of about 50 million t of asphalt (DAV, 2012) was produced in Germany, in a total of some 660 asphalt-mixing plants. Asphalt is used primarily in road construction, where it competes directly with hydraulically bound concrete. In 1991, total production increased considerably; since 2000 it has been decreasing again.

The relevant emissions trends depend primarily on trends in production quantities. Production increased by 5 million tonnes in 2011, but that increase was not large enough to compensate for the production decrease that occurred in 2010.

4.2.6.2 Methodological issues (2.A.6)

No special calculation procedure is available for calculating fuel inputs in source category 1.A.2. Nonetheless, fuel inputs are taken into account via Energy Balance evaluation, and they are coupled with suitable emission factors.

The applicable quantity of mixed asphalt products produced (**activity data**) has been taken from communications of the Deutscher Asphaltverband (DAV; German asphalt association).

The **emission factors** were determined country-specifically, in accordance with Tier 2 criteria. Emission factors for substances other than CO_2 were determined on the basis of emissions measurements for over 400 asphalt-mixing plants, for the period 1989 to 2000. The majority of the emissions occur during drying of pertinent mineral substances. Almost all of the NMVOC emissions originate in the organic raw materials used, and they are released primarily in parallel-drum operation, as well as from mixers and loading areas. On average, about 50% of the NO_X and SO_2 involved come from the mineral substances used (proportional process emissions). CO occurs primarily in incomplete combustion processes. CO emissions are calculated solely in connection with fuel inputs.

Table 119: Emission factors for production of mixed asphalt products

	NOx	NMVOC	SO_2
EF [kg/ t]	0.015	0.030	0.030

Only emissions from asphalt production are reported. Figures relative to emissions released during laying of asphalt have not yet been adequately reviewed.

4.2.6.3 Uncertainties and time-series consistency (2.A.6)

As the extensive measurement data show, the emissions lie within a comparatively narrow range. The large volume of measurement data available makes it possible to form highly reliable mean values. The only large uncertainties are found in breakdown of emissions amounts into fuel-related and process-related emissions.

The production-amount data may be considered very accurate, since the product in question is a sale-ready product, and operators report the relevant amounts to the DAV.

4.2.6.4 Source-specific quality assurance / control and verification (2.A.6)

Quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

The relevant country-specific emission factors are being evaluated in a research project.

4.2.6.5 Source-specific recalculations (2.A.6)

No source-specific recalculations were required.

4.2.6.6 Source-specific planned improvements (2.A.6)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

4.2.7 Mineral Products: Glass production (2.A.7.a Glass)

CRF 2.A.7.a Glass	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Glass products	CO_2	-	-	695.6	(0.06%)	741.3	(0.08%)	6.57%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	AS	CS
NO_X, NMVOC, SO_2	CS	AS	CS

The source category *Mineral products*: *Glass production* is not a key category.

4.2.7.1 Source category description (2.A.7 Glass production)

Germany's glass industry produces a wide range of different glass types with different chemical compositions. Germany's glass sector comprises the following sub-sectors: container glass, flat glass, domestic glass, special glass and mineral fibres (glass and stone wool). The largest production quantities, by percentage, are found in the sectors of container glass (about 54 % of total glass production in 2011) and flat glass (about 27 % of total glass production in 2011). Together, these sectors account for 81 % of total glass production (BV Glas, 2012).

A large number of primary and secondary raw materials are used. A distinction is made between natural raw materials, synthetic raw materials and the additives used in small amounts (refining agents, colouring agents and decolouring agents). The most important natural raw materials include sand, limestone, dolomite, feldspar and igneous rocks. The most important synthetic raw material used in production of high-volume glasses such as flat glass and container glass is soda ash (cf. also 4.2.4.1). Glass cullet (including cullet from within production operations and from outside sources) is an important secondary raw material.

In production, homogeneous glass mixtures combining primary and secondary raw materials are melted down at temperatures between 1,450 °C and 1,650 °C. The process-related CO_2 emissions under consideration here are released from the raw-material carbonates during the melting process in the oven. CO_2 emissions – in small amounts – also occur in neutralisation of HF, HCL and SO_2 in exhaust gases, with the help of limestone or other carbonates. Because the amounts involved are so small, these emissions are not considered here.

The following table shows the trends, since 1990, in activity data, process-related CO_2 emissions and the implied emission factors resulting for all glass types overall.

Table 120: Activity data and process-related CO_2 emissions since 1990

Year	Activity data [t]	Process-related CO_2 emissions [t]	IEF for all glass types [t CO_2/ t $_{glass}$]
1990	6,561,849	695,617	0.106
1991	7,202,807	733,252	0.102
1992	7,228,752	718,117	0.099
1993	7,074,837	684,797	0.097
1994	7,760,000	651,580	0.084
1995	7,621,300	774,525	0.102
1996	7,519,600	750,079	0.100
1997	7,392,000	717,713	0.097
1998	7,314,000	694,763	0.095
1999	7,442,239	703,752	0.095
2000	7,505,000	731,039	0.097
2001	7,293,000	733,511	0.101
2002	7,084,000	690,484	0.097
2003	7,205,720	694,407	0.096
2004	7,088,900	696,613	0.098
2005	6,948,400	705,910	0.102
2006	7,285,600	734,991	0.101
2007	7,535,300	718,592	0.095
2008	7,513,900	714,384	0.095
2009	6,784,100	639,224	0.094
2010	7,163,600	708,597	0.099
2011	7,475,800	742,286	0.099

It is clear that emissions tend to follow the trend in activity data. At the same time, the implied emission factors indicate that the correlation is not rigid; some discrepancies do occur. The discrepancies are due to annual fluctuations in production quantities of various individual glass types, and in cullet inputs. They are thus logical and calculatorily correct.

4.2.7.2 Methodological issues (2.A.7.a Glass)

The currently valid *IPCC Good Practice Guidance* (2000) contains no proposals or information relative to calculation of process-related CO_2 emissions for the glass industry. In keeping with the general recommendations of the *IPCC Good Practice Guidance*, therefore, a special method had to be developed. The NIR 2007 provides a detailed discussion of the relevant methods (Chapter 4.1.7.2, p. 251ff).

The CO_2 emissions (the main pollutant) are calculated via a Tier 2 method, because the activity data are tied to specific emission factors (that are in keeping with the relevant carbonate concentrations). The following carbonates are taken into account as the main sources of CO_2 formation during the melting process: Calcium carbonate ($CaCO_3$), soda ash / sodium carbonate (Na_2CO_3), magnesium carbonate ($MgCO_3$) and barium carbonate ($BaCO_3$). The CO_2 emissions are reported in the present context; raw-materials inputs – limestone and soda ash – are considered under 2.A.3 (cf. 4.2.3) and 2.A.4 (cf. 4.2.4), respectively.

The production figures (**activity data**) are taken from the regularly appearing annual reports of the Federal Association of the German Glass Industry (Bundesverband Glasindustrie; BV Glas, 2012). "Production" refers to the amount of glass produced, which is considered to be equivalent to the amount of glass melted down. Further processing and treatment of glass and glass objects are not considered.

The following activity data were determined for 2011:

Table 121: Glass: Activity data for the various industry sectors (types of glass)

Industry sector	Activity data for 2011 [thousands of t]
Container glass	4,065.5
Flat glass	2,000.1
Domestic glass	148.3
Special glass	341.7
Glass fibre and wool	320.8
Stone wool	599.3

Source: BV Glas, 2012

The following sector-specific cullet percentages are assumed:

Table 122: Cullet percentages for the various types of glass

Industry sector	Cullet percentage [%] in the input raw material
Container glass	59 – 65 (annually varying)
Flat glass	35 (entire time series)
Domestic glass	20 (entire time series)
Special glass	30 (entire time series)
Glass fibre and wool	40 (entire time series)
Stone wool	40 (entire time series)

Source: HVG, 2008

The cullet percentage for container glass is known only for the western German Länder as of 1990. For Germany as a whole, it is known for the period since 1995. No data are available for the new German Länder for the period from 1990 to 1994. For that reason, an average cullet percentage input was estimated on the basis of the various glass sectors' average percentages of total glass production. In 2007, the firm of Gesellschaft für Glasrecycling und Abfallvermeidung mbH (GGA) was forced to cease operations, under cartel law. As a result, no reliable cullet-input data have been available from that source since 2007. For the time being, the relevant data have been cross-checked against quantity surveys pursuant to the Ordinance on Packaging (Verpackungs-Verordnung) and against waste-management data provided by the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, Fachserie (specialised series) 19 Reihe (series) 1, Table 1.2). The Federal Association of the German Glass Industry (BV Glas) has provided data, from association surveys, on cullet inputs in the container-glass industry for the period as of 2007. While the relevant percentages are broken down by companies' own cullet and cullet from outside sources, they cover only the area of container glass. They do not include flat-glass cullet, which contributes only very small percentages of the cullet used in container-glass production.

Since the exhaust gases occurring during the melting process are drawn off together with combustion-related exhaust gases – i.e. as a collective exhaust-gas stream – measurements cannot be used to determine the CO_2 quantities produced by the German glass industry. For this reason, a calculation procedure is used that is based on the weight shares for the aforementioned carbonates and on cullet input in the container-glass and flat-glass industry. Figures on the chemical composition of the various types of glass produced in Germany have been taken from VDI-Richtlinie (guideline) 2578 (VDI, 1999) and from the ATV-DVWK Merkblatt (standards sheet of the German Association for Water, Wastewater and Waste) 374 (ATV, 2004).

The procedure used to determine **emission factors** for the various glass oxides involved and the pertinent emissions is described in detail in the NIR 2007 (Chapter 4.1.7.2, p. 251ff).

The following emission factors were calculated for the various industry sectors. The factors vary annually in keeping with variations in cullet inputs (and thus ranges are given):

Table 123: CO_2-emission factors for various glass types (calculated in comparison with figures from the CORINAIR manual)

Glass type	Calculated emission factor [kg CO_2/ t $_{molten\ glass}$] - stoichiometric / incl. cullet input-			Default emission factors [kg CO_2/ t $_{molten\ glass}$] - pursuant to CORINAIR -		
Container glass	193	/	49 - 86	171	-	229
Flat glass	208	/	135		210	
Domestic glass	120	/	96		-	
Special glass	113	/	79	0	-	178
Glass fibre	198	/	119	0	-	470
Stone wool	299	/	179	238	-	527
Unspecified	174	/	139		-	

4.2.7.3 Uncertainties and time-series consistency (2.A.7.a Glass)

The production data have been taken from the internal statistics of the Federal Association of the German Glass Industry (BV Glas). Since that association represents nearly all of Germany's container-glass and flat-glass manufacturers, the sectoral data it provides are highly accurate. An uncertainty of 5 % was thus assumed. The association's representation of all other glass sectors is incomplete, and thus the association cannot guarantee the completeness of the data for such other sectors. For this reason, an uncertainty of 10 % was assumed for those areas. Until about 2002, BV Glas also cross-checked the data against data of the *Federal Statistical Office*.

The uncertainty in the cullet figures for container glass lies within the customary range for statistical determinations. For the new German Länder, an uncertainty of 20 % has been assumed, because no statistical survey has been carried out; only an estimate is available. Use of data from the association's own internal surveys, relative to cullet use as of 2007, increases the uncertainties. For example, surveys take account only of production sites' own cullet and external container-glass cullet, and do not cover any quantities of flat glass that may be used in container-glass production. .

The figures on cullet use for all other glass types are considerably less precise, however, since only estimates are available for those areas. An uncertainty of 20 % was thus assumed. That uncertainty is also assumed for container glass as of 2007.

As to CO_2-emission factors, an uncertainty of 10 % was assumed, for all industry sectors.

4.2.7.4 Source-specific quality assurance / control and verification (2.A.7.a Glass)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The calculated emission factors were compared with several different sources, including the CORINAIR manual and the "Baden-Württemberg 2004 emissions declaration" ("Emissionserklärung 2004 Baden-Württemberg"; UMEG 2004). According to that comparison, the calculated emission factors may be considered accurate. In addition, the IEF was compared with those of the following countries, which also consider soda-ash use only as an integrated part of glass production, i.e. do not consider such use separately: Austria (0.10), Italy (0.11) and the Netherlands (0.13). These values are comparable to the German IEF for the glass industry (0.1).

The calculated emissions were also cross-checked against the ETS data for Germany. In the process, a need for further checking was determined, since slightly higher carbon-dioxide emissions are reported in the framework of emissions trading than can be calculated via the inventory methods described here. On the other hand, the ETS data also include the emissions that occur in production of water glass. When those emissions are deduced from the ETS data, only a very small difference remains, a difference that lies within the uncertainty for the emission factors. The inventory calculations' failure to include water-glass production is not a shortcoming. All relevant soda-ash quantities – and, thus, those for water-glass production – are taken into account under 2.A.4.b (Chapter 4.2.4).

The information provided regarding the chemical composition of the various glass types continues to be considered correct in the present context. The applicable rate of cullet input, for which inadequate data are available (cf. Chapter 4.2.7.3 Uncertainties and time-series consistency (2.A.7.a Glass)), has considerable influence in this regard.

4.2.7.5 Source-specific recalculations (2.A.7.a Glass)

Minimal source-specific recalculations were carried out with regard to the activity data for 2010 and to cullet inputs in the sub-sector container-glass industry use as of 2007.

4.2.7.6 Planned improvements (source-specific) (2.A.7.a, Glass)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

4.2.8 Mineral Products: Ceramics production (2.A.7.b Ceramics)

CRF 2.A.7.b Ceramics	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Bricks and tiles	CO_2	-	-	531.1	(0.04%)	338.3	(0.04%)	-36.31%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
NO_X, NMVOC, SO_2	CS	NS	CS

The source category *Mineral products*: *ceramics production* is not a key category.

4.2.8.1 Source category description (2.A.7.b Ceramics)

The process-related emissions in the ceramics industry originate in the following sub-category elements:

1. <u>"Production of ceramic products":</u> This time series shows the quantity produced by the entire ceramics industry in Germany. The non-CO_2 emissions for the entire ceramics industry are calculated via these activity data. Process-related CO_2 emissions, on the other hand, are calculated only for the sub-quantities "roof tiles" and " masonry bricks" (see below).

2. "Brick production" (CO_2); "roof tile" product: Production of roof tiles is a subset of the aforementioned activity data for the entire ceramics industry. It is used only for calculation of process-related CO_2 emissions (with consideration of proportions of limestone and organic impurities).
3. "Brick production" (CO_2); "roof tile" product: Production of masonry bricks is also a subset of the aforementioned activity data for the entire ceramics industry. This production figure is also used only for calculation of process-related CO_2 emissions (with consideration of porosity agents, as well as of proportions of limestone and organic impurities in the pertinent raw materials).

Table 124: Activity data and process-related CO_2 emissions in the ceramics industry (CRF 2.A.7.b)(rounded)

	1990	1991	1992	1993	1994	1995 [kt]	1996	1997	1998	1999	2000
Ceramics products	21595	20772	22769	24534	30458	24730	22663	22939	22798	22395	21199
of which:											
Masonry bricks	16524	15691	17302	18827	23925	18827	16965	17298	17048	16591	15383
Roof tiles	1758	1946	2216	2349	2611	2466	2598	2521	2658	2849	2924
Process-related CO_2 emissions											
Masonry bricks	481	457	503	548	696	548	494	503	496	483	448
Roof tiles	50	56	63	67	75	71	74	72	76	81	84
Total	**531**	**512**	**567**	**615**	**771**	**618**	**568**	**575**	**572**	**564**	**531**
	2001	**2002**	**2003**	**2004**	**2005 [kt]**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Ceramics products	18003	16500	16443	16796	14643	16019	16035	13867	12866	12653	13860
of which:											
Masonry bricks	12771	11686	11631	11697	9881	10883	10885	9302	9058	8463	9377
Roof tiles	2642	2381	2383	2601	2485	2648	2618	2254	1919	2179	2286
Process-related CO_2 emissions											
Masonry bricks	372	340	338	340	288	316	317	271	264	246	273
Roof tiles	76	68	68	74	71	76	75	64	55	62	65
Total	**447**	**408**	**407**	**415**	**359**	**392**	**392**	**335**	**319**	**308**	338

4.2.8.2 Methodological issues (2.A.7.b Ceramics)

The IPCC Good Practice Guidance contains no proposals or information relative to calculation of process-related CO_2 emissions for the ceramics industry.

The CO_2 emissions are calculated via a Tier 1 method, because no detailed data are available and because this source category is not a key category.

Activity data

Official statistics are of limited use in determining actual production trends in the brick industry, in terms of weights, since such statistics list masonry-brick production in cubic metres and roof tiles in numbers of tiles. Produced weight quantities can be determined only via conversion factors. The conversion factors used for masonry bricks and roof tiles consist of values obtained by the Bundesverband der Deutschen Ziegelindustrie (German brick-industry association) from experience.

Emission factors

Process-related CO_2 emissions originate in the raw materials for production of roof tiles and masonry bricks (normally, locally available loams and clays with varying concentrations of $CaCO_3$ (limestone) and, in some cases, with organic impurities). On the basis of information from the German brick-industry association (Bundesverband der deutschen Ziegelindustrie), an emission factor of 28.6 kg / $t_{product}$ is assumed for process-related CO_2 emissions from

$CaCO_3$ and organic impurities in raw materials. That figure corresponds to a mean $CaCO_3$ fraction of 65 kg/t in the raw meal.

Porous masonry bricks account for about half of all masonry bricks produced in Germany. They are produced by adding organic porosity agents to the raw materials. When the bricks are fired, these agents burn, creating hollows. Most of the porosity agents used are renewable resources (such as sludges from the paper industry, spent liquors from pulp production). Non-renewable substances (especially polystyrene) are also used, however. The resulting CO_2 emissions are minimal by comparison to those from the limestone fractions in the raw materials. Nonetheless, they are taken into account in the inventory via a slightly higher CO_2-emission factor for masonry bricks (29.1 kg CO_2/t masonry bricks, as opposed to 28.6 kg CO_2/t for roof tiles).

The determined activity data and resulting CO_2 emissions are shown in Table 124. The process-related CO_2 emissions for this sub - source category, at considerably less than one million tonnes of carbon dioxide, are not particularly important.

4.2.8.3 Uncertainties and time-series consistency (2.A.7.b Ceramics)

Due to the need for conversion of area and volume figures into produced quantities, the uncertainty for the three sets of activity data is estimated at +/- 20 %; no other uncertainty factors are relevant.

The uncertainties for the **CO_2-emission factors** used for production of masonry bricks and roof tiles are determined primarily by the uncertainty relative to the $CaCO_3$ quantities contained in the raw materials (+/- 30 %).

The time series are consistent for activity data for production of masonry bricks and roof tiles, and the related CO_2-emission factors are consistent as well. Some changes have occurred, throughout the time series, in availability of statistics for various product types. These changes accounted for only about 1 % of the amounts of bricks produced, and for less than 0.5 % of total ceramics production, however.

The **activity data** for total ceramics production contain a methodological discontinuity that results from a substantial change in the available statistical data. For masonry bricks and roof tiles, figures in thousands of t were available until 1994. As of 1995, the figures are only in thousands of m^3 or thousands of units (piece count). In the NIR 2007, the relevant impacts are discussed in detail. On the other hand, the methods discontinuity is irrelevant with regard to CO_2 emissions.

4.2.8.4 Source-specific quality assurance / control and verification (2.A.7.b Ceramics)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data from greenhouse-gas emissions trading cannot be compared directly with relevant emissions data from the National Inventory. The reason for this is that, in emissions trading, installations (plants) are included and grouped in accordance with threshold values, and thus data are available for only part of the ceramics industry – and only for some brick and roof-tile producers.

4.2.8.5 Source-specific recalculations (2.A.7.b Ceramics)

No recalculations are required.

4.2.8.6 Planned improvements (source-specific) (2.A.7.b ceramics)

No source-category-specific improvements are planned.

4.3 Chemical industry (2.B)

Source category 2.B is divided into the sub-categories 2.B.1 through 2.B.5. These include Ammonia production (2.B.1), Nitric acid production (2.B.2), Adipic acid production (2.B.3) and Carbide production (2.B.4).

In addition, emissions from soot production and from coke burn-off in catalyst regeneration in refineries are reported under *Other* (2.B.5). With regard to production of fertilisers, organic products, titanium dioxide and sulphuric acid, reporting covers only the pertinent precursor substances.

4.3.1 Chemical industry: Ammonia production (2.B.1)

4.3.1.1 Source category description (2.B.1)

CRF 2.B.1	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Ammonia production	**CO_2**	**L**	**T**	**5,745.0**	**(0.47%)**	**7,450.0**	**(0.80%)**	**29.68%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 3	PS	PS
NO_X			D

The source category *Chemical industry*: *ammonia production* is a key category for CO_2 emissions in terms of emissions level and trend.

Ammonia is produced on the basis of hydrogen and nitrogen, using the Haber-Bosch process, which also forms CO_2. Hydrogen is produced from synthetic gas (usually) based on natural gas, via a highly integrated process, *steam reforming*, while nitrogen is produced via air dissociation.

The various plant types for the production of ammonia cannot be divided into individual units and be compared as independent process parts, due to the highly integrated character of the procedure. In *steam reforming*, the following processes are distinguished:

- ACP – *advanced conventional process* with a fired primary reformer and secondary reforming with excess air (stoichiometric H/N ratio)
- RPR – *reduced primary reformer process*, carried out under mild conditions in a fired primary reformer, and with secondary splitting with excess air (sub-stoichiometric H/N ratio)
- HPR – *heat exchange primary reformer process* – autothermic splitting with heat exchange using a steam reformer heated with process gas (heat exchange reformer) and a separate secondary reformer or a combined autothermic reformer using excess air or enriched air (sub-stoichiometric or stoichiometric H/N ratio).

The following procedure is also used:

- Partial oxidation – Gasification of fractions of heavy mineral oil or vacuum residues in production of synthetic gas.

Ammonia is produced at five locations in Germany. The production operations use both the steam-reforming and partial-oxidation processes.

The production decrease of more than 15 % (corresponding to an amount of nearly 300 kt) in the first year after German reunification was the result of a market shake-up, over 2/3 of which was borne by the new German Länder. The production level then remained nearly constant in the succeeding years until 1994. It has not been possible to determine the reason for the renewed growth as of 1995, which returned production to the level seen in 1990. However, the growth could be due to resumption of production processes in the new German Länder, following extensive modernisations. Since 1995, production levels have fluctuated only slightly. The nearly 8% production decrease that occurred in 2009 was due to the global economic crisis. The higher IEF is higher than that of other countries, since heavy fuel oil is used in Germany, in addition to natural gas. Heavy fuel oil produces significantly higher CO_2 emissions than natural gas does.

4.3.1.2 Methodological issues (2.B.1)

In keeping with this source category's categorisation as a key category for CO_2 emissions, as of the 2010 report, emissions data for this source category are being collected and reported in accordance with the Tier 3 standard. This is being carried out on the basis of a co-operation agreement with the relevant plant operators for delivery of plant-specific data.

The operators transmit their data to the Industrieverband Agrar (IVA) agrochemical industry association. After carrying out quality assurance, that association then aggregates the data, to protect confidentiality, and forwards the resulting aggregated data to the Federal Environment Agency.

Plant operators report the following to the IVA:

- Ammonia quantities produced (**activity data**),
- The quantities of raw materials used in the process (natural gas, heavy mineral oil), less the pertinent fuel quantities used for energy purposes and so reported in the Energy Balance (TFR_i),
- The raw materials' carbon content factor (CCF_i) and carbon oxidization factor (COF_i),
- The quantity of CO_2 that undergoes further processing (R_{CO2}),

Following quality assurance, the IVA aggregates the data and communicates to the Federal Environment Agency the pertinent activity data, quantities of CO_2 subjected to further processing and process-related CO_2 emissions.

CO_2 emissions:

The IVA calculates the CO_2 emissions in keeping with Equation 3.3 in the 2006 IPPC Guidelines:

$$E_{CO2} = \sum (TFR_i * CCF_i * COF_i * 44/12)$$

The recovered quantity of CO_2 that is used in other production processes – such as urea production – is included in the reported emissions.

Emission factor for NO_x:

For the NO_X emission factor, the default emission factor given in the *CORINAIR Guidebook*, 1 kg/t NH_3, is used (EMEP EEA Emission Inventory Guidebook, TFEIP-endorsed draft, May 2009).

4.3.1.3 Uncertainties and time-series consistency (2.B.1)

Using a procedure in keeping with equation 6.3 in IPCC GPGAUM, the IVA aggregates the uncertainties reported by the operators and communicates the result to the Federal Environment Agency.

The uncertainty for the activity data is ± 0.6 %. The uncertainty for the emissions is ± 1 %.

4.3.1.4 Source-specific quality assurance / control and verification (2.B.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.3.1.5 Source-specific recalculations (2.B.1)

No recalculations are required.

4.3.1.6 Planned improvements (source-specific) (2.B.1)

In keeping with the IPCC Guidelines, reporting is to be plant-specific, in accordance with the Tier 3 reporting standard, as of the 2010 report. Consequently, no further improvements are planned.

4.3.2 Chemical industry: Nitric acid production (2.B.2)

4.3.2.1 Source category description (2.B.2)

CRF 2.B.2	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Nitric acid production	N_2O	-	-	3,384.4	(0.28%)	2,935.6	(0.32%)	-13.26%

Gas	Method used	Source for the activity data	Emission factors used
N_2O	Tier 3	PS	PS
HFC, PFC, SF_6	NA	NA	NA
NO_X			D

The source category *Chemical industry*: *nitric acid production* is not a key category.

In production of nitric acid, nitrous oxide occurs in a secondary reaction. In Germany, there are currently seven nitric acid production plants.

HNO_3 production occurs in two process stages:

- **Oxidation** of NH_3 to NO and
- **Conversion of** NO to NO_2 and **absorption** in H_2O.

Details of the process are outlined below:

Catalytic oxidation of ammonia

A mixture of ammonia and air at a ratio of 1:9 is oxidised, in the presence of a platinum catalyst alloyed with rhodium and/or palladium, at a temperature of between 800 and 950 °C. The relevant reaction, according to the Oswald process, is as follows:

$$4\ NH_3 \quad + \quad 5\ O_2 \quad \rightarrow \quad 4\ NO \quad + \quad 6\ H_2O$$

Simultaneously, nitrogen, nitrous oxide and water are formed by the following undesired secondary reactions:

$$4\ NH_3 \quad + \quad 3\ O_2 \quad \rightarrow \quad 2\ N_2 \quad + \quad 6\ H_2O$$

$$\mathbf{4\ NH_3 \quad + \quad 4\ O_2 \quad \rightarrow \quad 2\ N_2O \quad + \quad 6\ H_2O}$$

All three oxidation reactions are exothermic. Heat may be recovered to produce steam for the process and for export to other plants and/or to preheat the residual gas. The reaction water is condensed in a cooling condenser, during the cooling of the reaction gases, and is then conveyed into the absorption column.

4.3.2.2 Methodological issues (2.B.2)

As of the 2010 reporting round, and in keeping with the IPCC Guidelines, nitric-acid production is now reported plant-specifically, in accordance with the Tier 3 standard. This is being carried out on the basis of a co-operation agreement with the relevant plant operators for delivery of plant-specific data.

The operators of six plants transmit their data to the Industrieverband Agrar (IVA) industry association.

Plant operators report the following to the IVA:

- Nitric acid quantities produced (**activity data**),
- The EF,
- The N_2O emissions measured in the raw gas,
- Where emissions-reduction equipment is used, also the N_2O emissions measured in the emissions-reduced exhaust gas.

After carrying out quality assurance, the IVA aggregates the data, to protect confidentiality, and then transmits the so-aggregated data to the Federal Environment Agency (AD and EF). Pursuant to the IVA, the emissions-control technologies used include catalytic decomposition directly following ammonia combustion. The N_2O emissions are then calculated in keeping with the formula EM = AD * EF.

One company sends its data (AD, EF, N_2O emissions and information about any reduction equipment used) directly to the Federal Environment Agency. After carrying out quality assurance, the Federal Environment Agency then aggregates that company's data with the data provided by the IVA and enters the resulting so-aggregated data into the CSE emissions database.

Until 2006, production quantities correlated with the N_2O emissions. Subsequently, a decoupling of production quantities and N_2O emissions has become apparent that is due to use of emissions-reduction equipment.

NO_X **emission factor:**

For the NO_X emission factor, the default emission factor given in the *CORINAIR Guidebook*, 10 kg/t NH_3, is used (EMEP EEA Emission Inventory Guidebook, TFEIP-endorsed draft, May 2009).

4.3.2.3 Uncertainties and time-series consistency (2.B.2)

Activity data:

The activity-rate uncertainty, as provided by the operators, has been determined, as specified by the IVA / the Federal Environment Agency, in keeping with Equation 6.3 in IPCC GPGAUM. The pertinent uncertainty is ± 1 %.

Emission factor:

For the N_2O emission factor, the operators give an uncertainty of ± 5 %.

4.3.2.4 Source-specific quality assurance / control and verification (2.B.2)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.3.2.5 Source-specific recalculations (2.B.2)

No recalculations are required.

4.3.2.6 Planned improvements (source-specific) (2.B.2)

In keeping with the IPCC Guidelines, reporting is to be plant-specific, in accordance with the Tier 3 reporting standard, as of the 2010 report. Consequently, no further improvements are planned.

4.3.3 Chemical industry: Adipic acid production (2.B.3)

4.3.3.1 Source category description (2.B.3)

CRF 2.B.3	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Adipic acid production	**N_2O**	**L**	**T**	**18,804.6**	**(1.54%)**	**521.6**	**(0.06%)**	**-97.23%**

Gas	Method used	Source for the activity data	Emission factors used
N_2O	T3	PS	D, PS
NO_X, CO			NE

The source category *Chemical industry*: *adipic acid production* is a key category for N_2O emissions in terms of emissions level and trend.

The EF calculation for N_2O emissions from adipic acid production conforms to the Tier 3a method specified in the IPCC Guidelines for National Greenhouse Gas Inventories 2006.

On an industrial scale, adipic acid is produced via oxidation of a mixture of cyclohexanol and cyclohexanone (ratio: 93/7). Pursuant to IPCC-GPG (2000: Tab. 3.7, note a), only one facility, located in Japan, is presumed to use pure cyclohexanol (the EF there is 264 kg/t); at other facilities, adipic acid is produced from cyclohexanol, with varying amounts of ketone and nitric acid. In that reaction, considerable amounts of nitrous oxide (N_2O) are formed. Until the end of 1993, the two sole German producers emitted all of their nitrous oxide directly into the atmosphere. One producer has since patented, and put into operation, a system for thermal decomposition of nitrous oxide into nitrogen and oxygen. Decomposition takes place nearly completely. At the end of 1997, the other producer put a catalytic reactor system into operation that, in constant operation, achieves an N_2O-decomposition rate of 96-98 %. In March 2002, operations were begun with a plant, from another producer, that also uses thermal N_2O decomposition. Following initial technical problems, the system has been in constant operation since 2003. The overall fluctuations in decomposition rates – and, thus, the remaining emissions – are maintenance-related and production-dependent. In 2009, one producer commissioned a second, additional (i.e. redundant) thermal N_2O-decomposition facility. Since that facility went into operation, N_2O-decomposition rates of over 99% have been achieved. At the end of 2009, a second producer commissioned a second, additional (i.e. redundant) decomposition reactor. Since 2010, N_2O emissions have decreased further, significantly, as a result of the installation of the two redundant waste-gas treatment facilities.

From 1990 to the present, production has more than doubled, as a result of growth in demand.

4.3.3.2 Methodological issues (2.B.3)

Until around the mid-1990s, producers provided data only on amounts produced. The IPCC default emission factors have been used to calculate nitrous oxide emissions for that period. For the subsequent period, in addition to reporting their production figures, producers also confidentially reported their N_2O emissions, along with necessary background information. This fact is highly significant with regard to the precision of the reported data; without data on technically unavoidable N_2O production, and – especially – without information as to the operating period of the relevant decomposition facilities, estimates of the reduction in nitrous oxide emissions would have been so imprecise that it would have been necessary to continue using the default EF.

The fluctuations in the emissions data are the result of disruptions of emissions-reduction systems (maintenance work, fire damage, other failures of system components) and of production increases.

4.3.3.3 Uncertainties and time-series consistency (2.B.3)

The uncertainties in time-series consistency have been eliminated, since all manufacturers now provide the relevant data. IPCC GL 2006 specifies uncertainties of +/- 0.05% for plants with thermal decomposition and of +/- 2.5% for plants with catalytic decomposition. According to producers' information, the uncertainties, regardless of what reduction process is used, lie within a range of +/- 5 to 5.9 %. The range for uncertainties relative to production quantities is given as +/-0.06 to 1 %. The EF is thus assumed to have an uncertainty of 5.9 %.

4.3.3.4 Source-specific quality assurance / control and verification (2.B.3)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Information provided by producers enjoys a high degree of confidentiality protection. For this reason, only emissions figures can be listed in the CRF tables. The reported emissions and activity data have been reviewed by a Federal Environment Agency expert and compared with industry figures and figures from other publications.

Two of the three producers have taken part in a JI project. The results of that project were compared with the inventory data, and the inventory data confirmed the project results.

4.3.3.5 Source-specific recalculations (2.B.3)

No recalculations are required.

4.3.3.6 Source-specific planned improvements (2.B.3)

No improvements are planned at present.

4.3.4 Chemical industry: Carbide production (2.B.4)

4.3.4.1 Source category description (2.B.4)

CRF 2.B.4	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Carbide production	CO_2	-	-	443.2	(0.04%)	18.6	(0.00%)	-95.80%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	T3	PS	PS (CaC_2) NO (SiC)

The source category *Chemical industry*: *Carbide production* is not a key category.

During the reunification period, calcium carbide production took place primarily in the new German Länder. A short time later, production there was discontinued, while only one producer remained in the old German Länder. In the period under consideration, this producer cut his production by about half.

According to the responsible specialised association within the VCI, no silicon carbide has been produced in Germany since 1993. Emissions from this sector thus no longer occur.

4.3.4.2 Methodological issues (2.B.4)

Activity data:

Since Germany has only one producer, the relevant data must be kept confidential. The only published data consists of that for amounts produced in the former GDR. That data was published, until 1989, by that country's central statistical authority. Those figures were used, in combination with existing estimates for 1991 and 1992, to interpolate production in the new German Länder in 1990.

Emission factor:

The stoichiometric emission factor for CO_2 is 688 kg per tonne of calcium carbide (44 g mol^{-1} / 64 g mol^{-1}). Until 1992, this emission factor was used for production in the new German Länder.

Using covered furnaces, producers collect all of the carbon monoxide produced in the process and use it for energy generation. The resulting carbon dioxide serves as auxiliary material in production of calcium cyanamide and derived products. Reactions in these processes yield carbon dioxide in mineral form, as black chalk. In this form, it is used in agriculture.

Such use substantially lowers the emission factor for carbon dioxide from calcium carbide production.

Upon request, the relevant producer provides the Federal Environment Agency with data on the degree of reduction achieved – and, thus, on the emission factor involved – and on amounts produced. The total emissions are calculated as the product of activity data and emission factor.

4.3.4.3 Uncertainties and time-series consistency (2.B.4)

Consistency is not complete, due to the described need to estimate production amounts in the new German Länder.

The uncertainties relative to the data provided by the producer are considered slight overall. The assumed reduction rate should be seen as an average value for the time period in question. As a result of use of green petrol coke, the composition of gas in carbide furnaces has changed, and this keeps the reduction rate from climbing still higher.

4.3.4.4 Source-specific quality assurance / control and verification (2.B.4)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Producers' relevant figures enjoy a high degree of confidentiality protection. For this reason, only emissions figures can be listed in the CRF tables. No calculations for verification could be carried out. It may be noted, however, that some of the figures have also been provided to licensing authorities and thus are considered trustworthy.

4.3.4.5 Source-specific recalculations (2.B.4)

No recalculations are required.

4.3.4.6 Planned improvements (source-specific) (2.B.4)

No improvements are planned at present.

4.3.5 Chemical industry – other: Emissions from other production processes (2.B.5)

4.3.5.1 Source category description (2.B.5)

CRF 2.B.5	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Other	**CO_2**	**L**	**T/T2**	**6,888.2**	**(0.57%)**	**9,211.8**	**(0.99%)**	**33.73%**
Other	N_2O	-	-	292.7	(0.02%)	62.0	(0.01%)	-78.82%
Other	CH_4	-	-	0.3	(0.00%)	0.6	(0.00%)	126.17%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	T2 (carbon black, methanol) CS (all other)	AS (coke burn-off in catalyst regeneration) NS (all other)	CS
CH_4	T2 (carbon black) CS (all other)	NS	CS (carbon black) D (ethylene, styrene, methanol, 1.2-dichloroethane)
CO, SO_2 NMVOC			D (carbon black) CS (ethylene, styrene)

The source category *Chemical industry*: *Emissions from other production processes* is a key category for CO_2 emissions in terms of both emissions level and trend.

A range of different chemical production processes are potential sources of CO_2, CH_4 and NMVOC emissions. These processes include production of carbon black, ethylene (ethene), ethylene dichloride (1,2-dichloroethane), styrene and methanol, and, in refineries, coke burn-off for catalyst regeneration.

In refinery operations, coke burn-off for catalyst regeneration occurs in catalytic cracking plants in which desulphurised vacuum and other gasoil distillates are broken down at temperatures of about 550°C, in a water-vapour atmosphere, into refinery gas, liquid gases, gasoline fractions and medium distillates. CO_2 emissions also occur in catalyst regeneration in the reforming process, which is designed to increase octane levels in raw gasoline and to generate hydrocarbon aromates via isomerisation and ring formation. The fluid catalytic cracking (FCC) process is now the leading process used for this purpose. During cracking reactions in an FCC reactor, coke is deposited on the catalyst. That coke is then burned off, via air input, in the regenerator. In the reforming process, platinum is used as the catalyst, in combination with rhenium and tin, and applied to acidic aluminium oxide. The catalyst grows ineffective as a result of process-related deposition of coke on its active centres. In catalyst regeneration, coke is burned-off to restore proper catalytic function. CO_2 is released in these combustion processes.

Since the early 1990s, German caprolactam producers have used thermal waste-gas treatment in their production operations. N_2O emissions no longer occur in those operations.

4.3.5.2 Methodological issues (2.B.5)

CO_2 emissions

In the 2006 reporting year, reporting on CO_2 emissions into the atmosphere was added for the sources carbon-black production, methanol production, transformation processes and coke burn-off for catalyst regeneration in refineries.

For CO_2 from carbon-black production, the default emission factor from the IPCC Guidelines 2006 is used (Table 3.23, Furnace black process (default process), primary feedstock).

The emission factor for methanol is confidential.

With regard to refineries, only catalyst regeneration is taken into account. Reviews to date indicate that other emissions sources from refineries (heavy-oil gasification, calcination and hydrogen production) are already covered as part of refineries' own consumption (cf. Chapter 3.2.7).

CH_4 emission factors

The international guidelines give very little attention to this source category. The IPCC Guidelines list as potential sources – without any claim to completeness – production of carbon black, ethylene, dichloroethylene (1,2-dichloroethane), styrene and methanol.

Pursuant to Point 5.2.5 of the TA Luft (Technical Instructions on Air Quality Control), German plants subject to the TA Luft must meet a standard of 50 mg/m³ (total carbon) for total mass concentration of organic substances (NMVOC and CH_4, but not including organic substances in dust form). The current state of the art provides for thermal post-combustion of volatile organic substances from plants for production of primary organic chemicals.

In keeping with these technical standards, the three German producers of carbon black report an emission factor of 0.027 kg methane per tonne of carbon black. Since the relevant technology has been in service since the 1970s, this EF is rounded off to 0.03 kg/t and applied to the entire time series.

As to the other four products, the largest German producer reports that no further methane emissions occur in those areas, thanks to thermal post-combustion. This technology has been in service since the 1980s, and thus the pertinent emission factors can be applied to the entire time series.

Table 125: National emission factors for CH_4 from other chemical industry processes

Carbon black	Styrene	Ethylene	1,2-dichloroethane	Methanol
[kg CH_4/t]				
0.03	0	0	0	0

Emission factors for NMVOC, CO and SO_2

For pollutants other than the methane considered above, the emission factors listed in Table 126 were used for Germany.

Table 126: Emission factors used in Germany for other pollutants

	Carbon black [kg CO / t]	Carbon black [kg SO_2/t][42]	Ethylene [kg NMVOC / t]	1,2 - dichloroethane [kg NMVOC / t]	Polystyrene [kg NMVOC / t]	Styrene [kg NMVOC / t]
1990	4.8 / 5	19.5 / [(43)]	5	C	1	0.02
1991	4.6 / 5	19 / 20	5	C	1	0.02
1992	4.4 / 5	18.5 / 20	5	C	1	0.02
1993	4.2	18	5	C	1	0.02
1994	4	17.5	5	C	1	0.02
1995	3.75	17	0.4	C	0.6	0.02
1996	3.5	16	0.3	C	0.4	0.02
1997	3.25	15	0.3	C	0.4	0.02
1998	3	14	0.25	C	0.32	0.02
1999	2.9	13.4	0.25	C	0.32	0.02
2000	2.8	12.8	0.2	C	0.27	0.02
2001	2.7	12.54	0.2	C	0.27	0.02
2002	2.65	12.28	0.2	C	0.27	0.02
2003	2.6	12.0	0.2	C	0.27	0.02
2004	2.55	11.7	0.2	C	0.27	0.02
2005	2.5	11.5	0.2	C	0.27	0.02
2006	2.5	11.2	0.2	C	0.27	0.02
2007	2.5	10.9	0.2	C	0.27	0.02
2008	2.5	10.6	0.2	C	0.27	0.02
2009	2.5	10.3	0.2	C	0.27	0.02
since 2010	2.5	10.0	0.2	C	0.27	0.02

The NMVOC emission factors for polystyrene were taken from the European Commission (EC, 2006a, BAT Reference Document (BREF), Production of Polymers), while for other products figures of German producers were used (these figures are available as confidential data). The default factors were used until 1994. The EF figures for CO and SO_2, for production of carbon black, are based on the BREF Large Volume Inorganic Chemicals - LVIC – S (EC, 2007) and are identical with the default values presented in the 2008 CORINAIR manual (first order draft).

Activity data

The production statistics of the Federal Statistical Office include the following products (Table 127):

Table 127: Reporting numbers (Meldenummern) from production statistics

Line	Polystyrene	Methanol	1,2-dichloroethane	Carbon black	Ethylene	Styrene
through 1994	4414 42	4232 11	4228 22	4113 70	4221 11	4224 60
since 1995	2416 20 350 and ...390	2414 22 100	2414 13 530	2413 11 300	2414 11 300	2414 12 500
since 2009				2013 21 300		

The figure for carbon-black production in the new German Länder in 1990 was taken from the Statistical Yearbook (Statistisches Jahrbuch) for the Federal Republic of Germany (*FEDERAL STATISTICAL OFFICE*, 1992: p. 234); the figures for 1991 and 1992 were estimated, due to confidentiality requirements. The other data for carbon-black production as

[42] Where two EF are listed, the second figure refers to the new German Länder.
[43] No EF is listed for the new German Länder, since these SO_2 emissions can be taken account of only as a lump sum.

of 1990 were obtained from the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe ("manufacturing industry; production in the manufacturing industry").

4.3.5.3 Uncertainties and time-series consistency (2.B.5)

The emission factors for ethylene, methanol, 1,2-dichloroethane and styrene are based on evaluations carried out by German producers. In the 1980s, thermal post-combustion was introduced on a large scale. As a result, emissions of organic substances from German plants are low enough to be neglected. The uncertainties cannot be estimated, however. The new emission factors are valid for the entire time series. Fluctuations in the activity data have occurred over the period under consideration. The reasons for this are unknown. Since the production-quantity data – apart from a few insignificant estimates – have come from a trustworthy source, the pertinent uncertainties may be considered small. Corrections to producers' figures might be made within a three-year period, however. In spite of the survey changes that have occurred within the period under consideration, the data are considered to be consistent.

4.3.5.4 Source-specific quality assurance / control and verification (2.B.5)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the areas of "carbon black" and "coke burn-off in catalyst regeneration".

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance for "methanol production" carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

Due to resources limitations, and to the area's minimal relevance, no QC/QA is carried out for reporting relative to precursors for ethylene, ethylene chloride and styrene.

4.3.5.5 Source-specific recalculations (2.B.5)

No recalculations are required.

4.3.5.6 Planned improvements (source-specific) (2.B.5)

No improvements are planned at present.

4.4 Metal production (2.C)

Source category 2.C is divided into the sub-categories 2.C.1 through 2.C.5. In the CSE emissions database, sub-category Iron and steel production (2.C.1) includes sinter production, pig-iron production, iron and steel production and tempered castings. Production of ferroalloys (2.C.2) has only minor importance in Germany. For this reason, it is not further subdivided in the present report. Aluminium production (2.C.3) is sub-divided into primary aluminium and resmelted aluminium. Use of SF_6 in aluminium and magnesium production (2.C.4) is not further sub-divided. In the CSE, sub-category Other (2.C.5) includes lead production, thermal galvanisation, copper production and zinc production.

4.4.1 Metal production: Iron and steel production (2.C.1)

4.4.1.1 Source category description (2.C.1)

CRF 2.C.1	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Steel (integrated production)	**CO_2**	**L**	**-/T2**	**22,711.9**	**(1.86%)**	**16,350.0**	**(1.77%)**	**-28.01%**
Steel (integrated production)	N_2O	-	-	27.6	(0.00%)	15.6	(0.00%)	-43.65%
Steel (integrated production)	CH_4	-	-	3.9	(0.00%)	4.7	(0.00%)	18.77%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	NS	CS
CH_4	IE	IE	IE
N_2O	IE	IE	IE
NO_X, CO, NMVOC, SO_2	Tier 2	NS	CS

The source category *Iron and steel production* is a key category for CO_2 emissions in terms of emissions level.

In 2011, a total of 30.1 million t of raw steel, from ore, was produced in Germany in six integrated steel works. Electric steel production amounted to 14.2 million t.

4.4.1.2 Methodological issues (2.C.1)

This sector comprises process-related emissions from primary steel production (via blast furnaces and oxygen-steel plants) and from electric steel plants.

Other structural elements in this source category (foundries: iron and steel casting (including malleable casting); steel production: rolled-steel production) are used for calculation of other pollutant emissions (not greenhouse-gas emissions).

Process-related CO_2 emissions from primary steel production in integrated smelters result primarily from use of reducing agents in blast furnaces. CO_2 emissions from limestone inputs in sinter plants and in pig-iron production, and CO_2 emissions from electrode consumption in electric steel production, are added to process-related emissions in sector 2.C.1.

Method for calculating the CO_2 emissions resulting from use of reducing agents in blast furnaces

Pursuant to the IPCC Guidelines, the CO_2 emissions in source category 2.C.1 are to be determined via a carbon balance. The reason for this requirement is that virtually all of the carbon used for primary steel production is subsequently released into the atmosphere, as CO^2, in later energy-related use, or in flaring, of the top gas that forms in the blast furnace or of the converter gas that forms in the oxygen steel converter. The share of carbon that remains in produced steel, or in that portion of pig iron that is not processed into steel, is not important by comparison to the CO_2 emissions related to use of reducing agents[44].

There are thus two ways of calculating the CO_2 emissions resulting from use of reducing agents: either via the quantity of reducing agents used (carbon input) or via the production of top gas and converter gas (carbon output). Relevant statistical information is available, at the national level, for both approaches. The two approaches produce different emissions results, however; the emissions as calculated via the quantities of top gas / converter gas used are higher, throughout, than those that result via calculation with quantities of reducing agents. That statistical difference, which has been growing in the years since 2003, cannot be logically explained. In keeping with the principle of conservative estimation, it was decided to use quantities of top gas and converter gas as the basis for the emissions calculation. That was also the procedure recommended by the Climate Secretariat's expert commission, which reviewed Germany's 2010 inventory report in September 2010.

Only part of all energy-related use of top gas and converter gas is found in source category 2.C.1. Such gas is used for other process combustion in the iron and steel industry (1.A.2.a); in coking plants, for bottom heating of coking furnaces (1.A.1.c); and for electricity generation in public power stations (1.A.1.a) and industrial power stations (1.A.2.f). The German Energy Balance provides information relative to top-gas and converter-gas consumption in all of the aforementioned source categories. Consequently, the CO_2 emissions resulting from reducing-agent inputs for primary steel production are divided among all source categories in which top gas and converter gas are burned and, thus, CO_2 is actually emitted (cf. the following figure).

[44] The average carbon fraction in the more than 2000 types of steel produced in Germany is normally considerably smaller than 2%. It is not recorded statistically, however. In any case, the pertinent deduction of non-energy-related carbon is extremely small (<1.5 %) in comparison to the total CO_2 emissions from primary steel production. Since only about 3% of the pig iron produced in Germany is not processed into oxygen steel, the pertinent deduction of non-energy-related carbon is also marginal (ca. 0.1%).

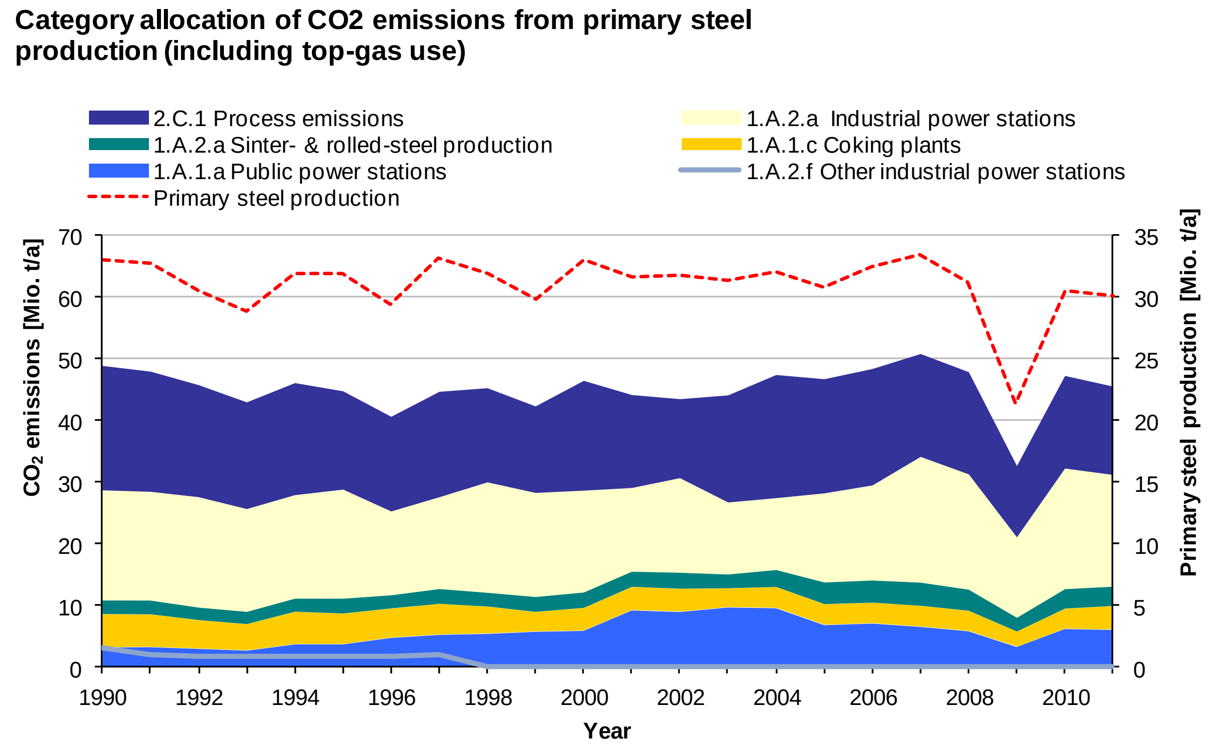


Figure 41: Chronological trend and source-category allocation of the CO_2 emissions resulting from use of reducing agents for primary steel production and from use of top gas

The sum of the CO_2 emissions shown shows good correlation with the activity data reported for primary steel production (cf. the broken red line). Annual fluctuations in the individual source categories are probably due to changes in allocation of individual plants within official statistics. Such fluctuations have practically no impact on the total sum of reported emissions, however.

Table 128: CO_2 emissions from primary steel production (including top-gas use)

Mt CO_2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1.A.1.a Public power stations	3.236	3.283	3.008	2.719	3.744	3.745	4.796	5.282	5.440	5.782
1.A.1.c Coking plants	5.328	5.234	4.579	4.220	5.201	4.899	4.686	4.947	4.342	3.131
1.A.2.a Sinter and rolled-steel production	2.223	2.251	2.041	2.001	2.136	2.433	2.142	2.408	2.245	2.433
1.A.2.a Industry power stations	17.845	17.619	17.885	16.639	16.761	17.670	13.565	14.870	17.896	16.857
1.A.2.f Other industry power stations	3.198	2.020	1.937	1.765	1.766	1.761	1.923	2.135	0.000	0.000
2.C.1 Process emissions	20.245	19.566	18.233	17.369	18.244	16.000	15.407	17.159	15.330	14.082
Mt CO_2	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1.A.1.a Public power stations	5.930	9.243	8.990	9.723	9.597	6.866	7.112	6.578	5.858	3.317
1.A.1.c Coking plants	3.636	3.725	3.668	3.015	3.341	3.308	3.293	3.332	3.230	2.421
1.A.2.a Sinter and rolled-steel production	2.508	2.476	2.618	2.255	2.776	3.526	3.616	3.761	3.441	2.242
1.A.2.a Industry power stations	16.500	13.567	15.337	11.657	11.643	14.432	15.406	20.395	18.698	13.004
1.A.2.f Other industry power stations	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.C.1 Process emissions	17.879	15.131	12.856	17.432	20.046	18.587	18.953	16.749	16.639	11.601
Mt CO_2	**2010**	**2011**								
1.A.1.a Public power stations	6.228	6.085								
1.A.1.c Coking plants	3.220	3.795								
1.A.2.a Sinter and rolled-steel production	3.174	3.135								
1.A.2.a Industry power stations	19.553	18.121								
1.A.2.f Other industry power stations	0.000	0.000								
2.C.1 Process emissions	15.075	14.380								

In the iron and steel industry, secondary fuels are used only in pig iron production in blast furnaces. To date, these materials have not yet been included in national statistics and the Energy Balance. For this reason, the data used consisted of figures provided by the Wirtschaftsvereinigung Stahl steel-industry association. Since the secondary fuels are used solely as substitute reducing agents, in place of coke, the CO_2 emissions resulting from their use are also included in the CO_2 emissions determined via inputs of top gas and converter gas and do not have to be calculated separately.

Determination of CO_2 emissions from limestone inputs in pig iron production

CO_2 emissions from limestone use are determined in accordance with Tier 1 (UBA 2006, FKZ 20541217/02). The steel industry uses limestone ($CaCO_3$) only in aggregation of iron ores in sintering plants and in pig iron production in blast furnaces. In the oxygen steel and electric steel processes, already burnt lime for steel-mill applications (CaO) is used as a slag former; the CO_2 emissions released in producing that burnt lime are thus already reported under 2.A.2. Until 2004, limestone inputs in sinter and pig iron production were published as part of iron and steel statistics (*FEDERAL STATISTICAL OFFICE* Fachserie 4, Reihe 8.1). Since then, they have to be calculated from the production quantities of sinter and pig iron reported by the association, via specific input factors (kg of limestone per tonne of sinter or pig iron). Multiplying the activity data for limestone inputs by the stoichiometric emission factor for limestone produces the CO_2-emissions figures given in Table 129.

Table 129: Limestone inputs and resulting CO_2 emissions in sinter and pig iron production

	Limestone input [t/a]		CO_2 emissions [t/a]		
Year	**Pig iron**	**Sinter**	**Pig iron**	**Sinter**	**Total**
1990	755,737	4,680,775	332,524	2,059,541	2,392,065
1991	757,000	4,532,000	333,080	1,994,080	2,327,160
1992	666,000	4,198,000	293,040	1,847,120	2,140,160
1993	627,000	3,891,000	275,880	1,712,040	1,987,920
1994	733,000	4,173,153	322,520	1,836,187	2,158,707
1995	751,000	4,600,000	330,440	2,024,000	2,354,440
1996	686,000	4,350,000	301,840	1,914,000	2,215,840
1997	629,000	4,471,000	276,760	1,967,240	2,244,000
1998	677,000	4,588,000	297,880	2,018,720	2,316,600
1999	817,000	4,144,000	359,480	1,823,360	2,182,840
2000	924,000	4,273,000	406,560	1,880,120	2,286,680
2001	866,000	4,136,000	381,040	1,819,840	2,200,880
2002	831,000	3,940,000	365,640	1,733,600	2,099,240
2003	832,525	4,046,711	366,311	1,780,553	2,146,864
2004	847,689	4,209,871	372,983	1,852,343	2,225,326
2005	787,724	4,306,067	346,599	1,894,669	2,241,268
2006	822,920	4,410,408	362,085	1,940,580	2,302,664
2007	840,868	4,608,067	369,982	2,027,549	2,397,531
2008	790,216	4,541,174	347,695	1,998,117	2,345,812
2009	547,680	3,496,405	240,979	1,538,418	1,779,397
2010	799,679	4,045,042	351,859	1,779,818	2,131,677
2011	782,420	3,457,153	344,265	1,521,147	1,865,412

Source: until 2004: Calculations from the "limestone balance" project ("Kalksteinbilanz"; UBA 2006, FKZ 20541217/02); as of 2005: calculations via the product-specific factors determined in the aforementioned project

Determination of CO_2 emissions from limestone inputs in pig iron production

In electric steel production, CO_2 emissions occur directly via consumption of graphite electrodes. These emissions must also be allocated to process-related CO_2 emissions for steel production. They are calculated from the quantity of produced electric steel, via an emission factor that was newly determined in 2009 (7.4 kg/t) and that is based on the specific electrode consumption per tonne of electric steel (2.06 kg/t), its carbon content (98%) and the relevant stoichiometric factor (3.667 t CO_2/t C). The contribution from electrode combustion in electric steel production, at about 0.2% of total CO_2 emissions in iron and steel production, is insignificant.

Determination of the total CO_2 emissions from iron and steel production to be reported under 2.C.1

The total process-related emissions to be reported under 2.C.1 consist of the following:

1. The CO_2 emissions resulting from use of reducing agents in primary steel production, where the relevant top gas and converter gas is not used in other source categories and thus reported under other categories as CO_2 emissions
1. The CO_2 emissions from limestone inputs in pig iron production, and
2. The CO_2 emissions from electrode consumption in electrical steel production

The relevant so-determined emissions quantities are shown in Table 131.

Table 130: Total process-related emissions to be reported under 2.C.1

Year	CO_2 emissions from use of reducing agents, where not reported in other source categories [t/a]	CO_2 emissions from limestone inputs [t/a]	CO_2 emissions from electrode consumption [t/a]	2.C.1 total [t/a]
1990	20,244,570	2,392,065	75,242	22,711,877
1991	19,566,299	2,327,160	68,464	21,961,923
1992	18,233,163	2,140,160	64,358	20,437,681
1993	17,368,898	1,987,920	59,840	19,416,658
1994	18,244,329	2,158,707	65,783	20,468,820
1995	15,999,678	2,354,440	74,794	18,428,912
1996	15,407,293	2,215,840	76,291	17,699,424
1997	17,159,145	2,244,000	87,552	19,490,696
1998	15,330,371	2,316,600	89,196	17,736,167
1999	14,081,926	2,182,840	90,457	16,355,223
2000	17,878,539	2,286,680	98,251	20,263,471
2001	15,130,790	2,200,880	96,961	17,428,630
2002	12,856,088	2,099,240	97,381	15,052,709
2003	17,432,279	2,146,864	99,048	19,678,190
2004	20,045,595	2,225,326	104,984	22,375,905
2005	18,587,293	2,241,268	100,780	20,929,341
2006	18,952,642	2,302,664	108,206	21,363,512
2007	16,749,314	2,397,531	110,721	19,257,566
2008	16,638,663	2,345,812	107,948	19,092,423
2009	11,600,674	1,779,397	83,590	13,463,660
2010	15,075,367	2,131,677	97,446	18,208,004
2011	14,379,883	1,865,412	104,744	16,350,039

4.4.1.3 Uncertainties and time-series consistency (2.C.1)

The time series is consistent, since the activity data have been determined for all plants and since the same method has been used to determine the emissions for all years concerned.

A discontinuity in methods is seen in the case of CO_2 emissions from limestone inputs, from 2004 to 2005; it results from the absence of the data source used until 2004. The time-series trend seems plausible in spite of this discontinuity. In keeping with the required calculation, the uncertainty for the activity data here is ± 10%.

The uncertainty for the emission factor for electrode consumption is ± 3 %, while the uncertainty for the other data is ± 5 %, since it is based solely on inaccuracies in measurement and analysis.

4.4.1.4 Source-specific quality assurance / control and verification (2.C.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Determining emissions in source categories 1.A.2.a and 2.C.1 is a complex task, since the Energy Balance, emissions reporting, emissions trading and association statistics differ widely in terms of their underlying methods. In the interest of data quality assurance, regular experts' discussions are carried out for the purpose of comparing and evaluating data. As a result of the methodological differences, plausibility checks of the determined emissions quantities, using data of the German emissions trading authority, are possible only at a highly aggregated level. A research project that is currently in progress, and that is expected to be concluded in 2012, is studying ways of preparing emissions-trading data specifically for plausibility checking of reported emissions.

4.4.1.5 Source-specific recalculations (2.C.1)

Minor recalculations were carried out for 2009 and 2010 to take account of updated statistical data.

4.4.1.6 Planned improvements (source-specific) (2.C.1)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

4.4.2 *Metal production: Ferroalloys production (2.C.2)*

4.4.2.1 Source category description (2.C.2)

CRF 2.C.2	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Ferroalloys	CO_2	-	-	429.0	(0.04%)	6.1	(0.00%)	-98.59%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	T2	IS	CS
NO_X, CO, NMVOC, SO_2			NE

The source category *Ferroalloys production* is not a key category. Ferroalloys are aggregates that are alloyed with steel. There are five ferroalloy producers in Germany; ferrochromium, ferrosilicon and silicon metal are each produced by only one company, and other ferroalloys are produced only in small quantities. According to data of the U.S. Geological Survey, in 2010, 55,000 t of ferroalloys were produced in Germany in 2007. The only process in use since 1995 is the electric arc process, a process that releases only small amounts of process-related CO_2, with such releases occurring in electrode consumption.

Until 1995, the blast-furnace process, which produces relatively higher CO_2 emissions, was used to some extent.

4.4.2.2 Methodological issues (2.C.2)

The **emission factors** for the aforementioned two processes (blast-furnace and electric-arc processes) were determined in the research project "NEW CO_2" ("NEU-CO_2") (FKZ 203 41 253/02).

For the period since 1994, the **activity data** are determined via data of the U.S. Geological Survey (USGS). The currently available data are from 2010. The activity data have been carried forward for 2011.

4.4.2.3 Uncertainties and time-series consistency (2.C.2)

The activity data provided by the U.S. Geological Survey (USGS) are based partly on estimates and thus are subject to relatively large uncertainties.

For the period 2001 – 2006, data of the Federal Statistical Office (DESTATIS) on sales of ferroalloys are available. Those data are lower, by a factor of 0.7, than the production data of the USGS, however. In the interest of the consistency of the time series, the USGS data have thus also been used for those years.

The considerable decrease in the CO_2 emission factor that took place from 1994 to 1995 does not represent any inconsistency; it is the result of the change in the production process.

4.4.2.4 Source-specific quality assurance / control and verification (2.C.2)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The activity data used, which come from the USGS, have been verified with the help of the DESTATIS figures (see above). The emissions figures were not compared with corresponding figures from other other data sources for Germany, because no other data sources for emissions in category 2.C.2 are known.

4.4.2.5 Source-specific recalculations (2.C.2)

The USGS's provision of activity data solely at two-year intervals necessitated a minimal recalculation for the previous year, 2010.

4.4.2.6 Planned improvements (source-specific) (2.C.2)

No improvements are planned at present.

4.4.3 Metal production: Primary aluminium production (2.C.3)

4.4.3.1 Source category description (2.C.3)

CRF 2.C.3	Gas	Key category		1995/1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
All fuels	**PFC**	**-**	**T**	**1,551.7**	**(0.13%)**	**81.5**	**(0.01%)**	**-94.75%**
All fuels	CO_2	-	-	1,011.9	(0.08%)	591.2	(0.06%)	-41.57%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 3	AS	CS
CH_4	-	-	NE
PFC	Tier 3	AS	CS
NO_X	-	-	NE
CO, SO_2		AS	CS

The source category *Primary aluminium production* is a key category for PFC emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-91.32 %), and thus an extremely low emissions level has been attained, the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

In Germany, aluminium is produced at four foundries, in electrolytic furnaces with pre-burnt anodes. The principal emission sources are the waste gases from the electrolytic furnaces and fugitive emissions via the plant roofs. CO, CO_2, SO_2, CF_4 and C_2F_6 are among the most important climate-relevant substances and air pollutants that are emitted.

Production of primary aluminium continues to be the largest source of PFC emissions in Germany, in spite of the considerable reductions that have been achieved since 1990. Thanks to extensive modernisation measures in German aluminium foundries, and to decommissioning of production capacities, absolute emissions from this sector have fallen by more than 90 % since 1995. As to the future development of PFC emissions, stagnation at a low level can be expected.

4.4.3.2 Methodological issues (2.C.3)

The production figures for the year 2011 were taken from the monitoring report by the aluminium industry for the year 2011 (GDA, 2011). The average anode consumption is 430 kg of petrol coke per tonne of aluminium. Table 131 shows the process-related emission factors.

The total quantity of waste gas incurred per tonne of aluminium during the production of primary aluminium was multiplied by an average concentration value formed from several individual figures, from various different plants, with appropriate weighting. The emission factors also make allowance for fugitive emission sources, such as emissions via plant roofs. The emission figures used for CO are the results of emission measurements within the context of investment projects.

The emission factors for SO_2 and CO_2 were calculated from the specific anode consumption. The anodes consist of petrol coke; this material has specific sulphur concentrations of about 1.2 %, from which an SO_2 emission factor of 10.4 kg/t Al can be calculated. The CO_2-emission factor is calculated on the basis of the specific carbon content of petrol coke, 857 kg per t. (cf. Chapter 18.7.2). By multiplying the average anode consumption by the mean carbon content and carrying out stoichiometric conversion to CO_2, one obtains a CO_2-emission factor of 1367 kg/t aluminium. Theoretically, the CO_2-emission factor must be reduced by the proportion resulting from a CO fraction of 180 kg/t Al, since CO can also form only via consumption of anodes. The CO_2 factor listed below does not take this into account.

The emission factors shown in Table 131 were compared with the emission data in Best Available Techniques Reference Documents (BREF)[45] and other sources (such as VDI Guideline 2286 sheet 1).

Table 131: Activity data and process-related emission factors for primary aluminium production in 2010

	AD		Emission factors				
	Number of smelters	Production [t]	CO_2 [kg/t]	NO_X [kg/t]	SO_2 [kg/t]	C total [kg/t]	CO [kg/t]
Primary aluminium	4	432,500	1367	N. e.	10.4	N. e.	180

Emissions data are available for PFC emissions from primary aluminium smelters, thanks to a voluntary commitment on the part of the aluminium industry. Since 1997, the aluminium industry has reported annually on the development of PFC emissions from this sector. The measurement data are not published, but they are made available to the Federal Environment Agency.

[45] cf. http://www.bvt.umweltbundesamt.de/kurzue.htm

The measurements conducted in all German smelters in the years 1996 and 2001 form the basis for calculation of CF_4 emissions. In this context, specific CF_4 emission figures per anode effect[46] were calculated, in keeping with the technologies used. The number of anode effects is recorded and documented in the foundries. The total CF_4 emissions were calculated by multiplying the total anode effects for the year by the specific CF_4 emissions per anode effect determined in 2001. The total emission factor for CF_4 is obtained by adding the CF_4 emissions of the smelters and then dividing the sum by the total aluminium production of the smelters. C_2F_6 and CF_4 occur in a constant ratio of about 1:10. The above-described method was applied to the entire time series, and the emissions for the years 1990 to 1996 were filled in via recalculations.

4.4.3.3 Uncertainties and time-series consistency (2.C.3)

The figures for PFC, CO, CO_2 and SO_2 emissions are in keeping with the Tier 3b approach and thus are considered very accurate. The time series for CO, CO_2 and SO_2 are consistent.

On the other hand, in the framework of voluntary commitments no survey of the plant-specific number of anode effects in 1991, 1992, 1993 and 1995 was conducted, and no calculation was carried out for those years (cf. 4.4.3.6).

In addition, the years 1991 through 1994 were years of deep crisis for the German aluminium industry, due to sharp drops in the world-market prices for primary aluminium. For this reason, a number of plants were decommissioned. While all smelter types were affected, smelters that had recently been modernised, with point-feeder technology, were most strongly affected. Their capacity decreased by 43%, with regard to the relevant levels in 1990. This also explains the sudden increase and stagnation in the implied emission factor for CF_4 in these years. In absolute terms, the primary smelters emitted only 26 tonnes of CF_4 in 2007, while they emitted 45 tonnes in 2005. This drop was due to a decrease in production. With regard to 2006, production increased slightly, however, because partial shutdowns of furnaces in the Stade plant were more than offset by production increases at the Hamburg production site. In 2009, drastic reductions of production took place at the Rheinwerk Neuss site. As a result of the difficult economic situation at other German smelters, process instabilities repeatedly occurred that were caused by frequent start-up and shutdown processes. Those instabilities led to higher numbers of anode effects and, thus, to higher PFC emissions. The economic situation restabilised in 2010. That made it possible to run continuous, stable processes. As a result, the numbers of anode effects decreased to such a degree that absolute PFC emissions decreased, by comparison to their level in 2009, in spite of the production increases. Production increased slightly in 2011, by comparison to production in 2010, even though the overall economic situation remained difficult.

4.4.3.4 Source-specific quality assurance / control and verification (2.C.3)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

46 “...Organic fluorides occur only under certain conditions, and such conditions occur in the furnace repeatedly, at intervals of hours to severals days. These conditions are referred to as the "anode effect". ... The gas at the anode changes in composition from CO_2 to CO and 5 to 20 % CF_4...." (ÖKO-RECHERCHE 1996)

The industry conducts annual surveys of activity data and reports such data to (inter alia) the Federal Statistical Office and the Federal Office of Economics and Export Control. The relevant time series seems plausible and shows no inconsistencies. It is assumed that such data collection conforms to quality assurance criteria.

Specific PFC emissions during anode effects were determined via industry measurements carried out in 1996 and 2001 at all plants in Germany that produce primary aluminium. In each case, the amount of PFCs produced depends on the duration and frequency of the relevant anode effects. In recent years, the duration and frequency of anode effects have been considerably reduced via computer-aided process control. In 2010, the German emission factor for CF_4, resulting from anode effects, was 0.044 kg/t aluminium. That factor is thus of the same magnitude as the average international factor, as reported by the International Aluminium Institute (IAI), of 0.034 kg/t for point-feeder systems. Therefore, the emission factor has been verified.

4.4.3.5 Source-specific recalculations (2.C.3)

No recalculations are required.

4.4.3.6 Planned improvements (source-specific) (2.C.3)

No improvements are planned at present.

4.4.4 Metal production: SF_6 used in aluminium and magnesium foundries (2.C.4)

4.4.4.1 Source category description (2.C.4)

CRF 2.C.4c	Gas	Key category		1995 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
SF_6 used in aluminium and magnesium foundries	SF_6	-	-	197.1	(0.02%)	57.6	(0.01%)	-70.80%

Gas	Method used	Source for the activity data	Emission factors used
SF_6	D/CS	PS/NS	D/CS

The source category *SF_6 used in aluminium and magnesium foundries* is not a key category.

Aluminium production:

Generally speaking, inert gases without additives are sufficient for rinsing secondary molten aluminium. A purification system of inert gases, with added SF_6 at a concentration of 1 or 2.5 %, has been used in the past, however, in a few – usually smaller – aluminium foundries and in laboratories. Such purification systems were last used in 1999 (no sales have taken place in Germany since 2000). From 1990 to 1999, SF_6 consumption remained relatively constant, at 0.5 t/a.

Since 1999, pure SF_6 has been used again as a purification gas, in isolated cases.

Magnesium production:

In magnesium casting, since the mid-1970s, SF_6 has been used as a protective gas over molten magnesium to prevent the magnesium's oxidation and ignition. The amount of SF_6 used per tonne of magnesium (specific SF_6 coefficient) has decreased sharply since 1995, since HFC-134a is increasingly being used as a substitute. SF_6 is used in both a) the sand-casting process, for production of prototypes, individual parts and small series, and b) the pressure-casting process, in which it serves as a protective gas.

4.4.4.2 Methodological issues (2.C.4)

Use of SF_6 as a purification and protective gas in magnesium production is an open use, i.e. all of the SF_6 used in the process is emitted into the atmosphere. The practice of assuming the equivalence between consumption (AD) and emissions conforms to the method in the IPCC Guidelines (IPCC, 1996a: page 2.34).

For aluminium foundries, the relevant emission factor has been established more reliably, via plant-specific measurements carried out in 2010. As a result, the relevant emissions figures have been established more reliably as well.

Reports and archived survey records from 1996 have been used as a basis for the reporting years 1990 through 1994.

Emission factors

Until now, an emission factor of 100% has been assumed for aluminium foundries, because information relative to the extent to which SF_6 breaks down was lacking.

On the basis of confidential measurement records certified by the pertinent permit authority, the emission factor for the period 1999 through 2008 has been reduced to 3 %. Via structural conversions, the emission factor has been further reduced, to 1.5%, as of 2009.

For magnesium foundries, EF_{use} = 100% is assumed, due to a continuing lack of more precise decomposition-level data that would support a more precise estimate.

Activity data for aluminium production

SF_6-consumption data are obtained via surveys of gas sellers. At the same time, the survey for the 2000 reporting year revealed that there have been no sales of this gas mixture since 2000.

Data on the SF_6 used in pure form since 1999 have been obtained via direct surveys of users and have been compared with relevant data of gas sellers.

Since the 2007 reporting year, the data have been obtained by the *Federal Statistical Office* via surveys of gas sellers with regard to SF_6-sales figures.

Activity data for magnesium production

In 1996, a survey was carried out, under commission to the Federal Environment Agency, of all domestic magnesium foundries that use SF_6. That survey determined the amounts consumed in the years 1990 to 1995.

Until the 2007 reporting year, data on the amounts used were obtained directly from users. Since the 2006 reporting year, the data have been obtained via surveys of gas sellers with regard to SF_6-sales figures. In the 2006 reporting year, the two methods were compared.

Since the 2007 reporting year, data of the *Federal Statistical Office* have been used.

4.4.4.3 Uncertainties and time-series consistency (2.C.4)

As studies have shown, part of the SF_6 used in aluminium and magnesium production is broken down during such use. For this reason, the assumption that amounts used in magnesium production are emitted to a degree of 100 % probably overstates the emissions considerably. Without more precise measurements, for magnesium production, that would make it possible to determine an average degree of decomposition in the process, the uncertainties for the emission factors cannot be quantified.

For the aluminium industry, the emission factor has been applied to the highest measured emissions level, and an uncertainty of 50% has been assumed for lower levels, since measurements have shown that emissions are frequently considerably lower than the maximum levels.

4.4.4.4 Source-specific quality assurance / control and verification (2.C.4)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality assurance / control for amounts consumed in Mg foundries was carried out via a one-time comparison of findings from foundry surveys with producers' total SF_6 sales figures – and with data of gas sellers. For reported year 2007, additional findings resulting from a technical discussion held in December 2007 have been taken into account.

As to amounts consumed by Al foundries, for the 2002 reporting year, sales figures were compared for the first time with amounts used by industry, and this comparison revealed a discrepancy. That discrepancy has since been corrected. Sales figures and industrial usage quantities were compared for reporting year 2004 and showed good agreement.

4.4.4.5 Source-specific recalculations (2.C.4)

No recalculations are required.

4.4.4.6 Planned improvements (source-specific) (2.C.4)

No improvements are planned at present.

4.4.5 *Metal production: Other (2.C.5)*

CRF 2.C.5	Gas	Key category		1995 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
	HFC 134a	-	-	0.0	(0.00%)	34.7	(0.00%)	-

Gas	Method used	Source for the activity data	Emission factors used
HFC	D	PS/NS	D

The source category Metal production: Other is not a key category for HFC-134a emissions from uses in magnesium foundries.

4.4.5.1 Source category description (2.C.5)

Since 2003, HFC-134a has increasingly been used, instead of SF_6, as a protective gas over molten baths.

4.4.5.2 Methodological issues (2.C.5)

For use of HFC-134a, the calculation method, emission factor used and figures for activity data in magnesium production are identical with the comparable figures for use of SF_6 in magnesium production (2.C.4). For this reason, they are described in Chapter 4.4.4.2.

4.4.5.3 Uncertainties and time-series consistency (2.C.5)

The relevant uncertainties have been quantified.

4.4.5.4 Source-specific recalculations (2.C.5)

No recalculations are required.

4.4.5.5 Source-specific planned improvements (2.C.5)

No improvements are planned at present.

4.4.5.6 Source-specific quality assurance / control and verification (2.C.5)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.5 Other production (2.D)

In the CSE, process-related emissions from production of particle board and from pulp production are reported under 2.D.1 Pulp and paper.

Process-related emissions from production of alcoholic beverages, and from production of bread and other foods, are listed under 2.D.2 Food and drink.

4.5.1 *Other production: Pulp and paper (2.D.1)*

4.5.1.1 Source category description (2.D.1)

CRF 2.D.1	Gas	Key category	1990 Total emissions (Gg) & percentage (%)	2011 Total emissions (Gg) & percentage (%)	Trend

Gas	Method used	Source for the activity data	Emission factors used
NO_X, CO			CS
NMVOC, SO_2			D

The source category *Other production – pulp and paper* is not a source of greenhouse-gas emissions and is thus not a key category.

All emissions of climate-relevant gases from the pulp and paper industry, and from particle-board production, in Germany result from combustion of fuels; for this reason, they are reported in Chapter 3.2 as energy-related emissions. The pulp and paper industry does not produce any process-related emissions of climate-relevant gases within the meaning of the *IPCC Good Practice Guidance* (2000).

Two of the six pulping plants in Germany carry out sulphate-process **pulp production** via caustification. For these plants, fuel-related CO_2 emissions in lime ovens are already taken into account, as energy-related emissions, via the pertinent fuel statistics. The remaining four plants use the sulphite process.

No attempt was made to take account of country-specific CO emission factors in energy-related emissions from pulp production, since that would have required conversion of product-based emission factors into fuel-based emission factors. Such conversion is an extremely involved process. Compared to the relevant CO emissions from paper mills, the CO emissions from the six pulping plants are of insignificant quantities.

The sulphate and sulphite pulp-production processes can both be a source of SO_2 emissions. In sulphate pulp production, NO_X, CO and NMVOC emissions are also released from recovery boilers, lime ovens, bark boilers and auxiliary boilers.

A detailed description of the relevant processes – in the present example, fibre production (including wood-pulp production) and paper and carton production – and supplementary information about auxiliary boilers are provided in Annex 3, Chapter 19.2.4.1.

Particle board is produced from wood chips, with added binders, in a process that applies heat and pressure. The main source of NMVOC emissions in such production are the wood chips used, which release NMVOC during drying via heating. NMVOC can also be emitted from wood and binders during the pressing process.

Particle board is produced in a total of 16 plants in Germany. Some 6,000 employees work in particle-board plants nation-wide. The particle-board industry tends to be dominated by larger companies.

4.5.1.2 Methodological issues (2.D.1)

The **pulp and paper industry** produces no process-related emissions of climate-relevant gases within the meaning of the *IPCC Good Practice Guidance* (IPCC, 2000). For indirect greenhouse gases, the IPCC-Guidelines emission factors listed in Table 132 were used until the reported year 2004.

Table 132: IPCC default emission factors for SO_2, NO_x, CO and NMVOC from pulp production

	NO_X	CO	NMVOC	SO_2
		[kg / t ADt*]		
Sulphate pulp	1.5	5.6	3.7	7
Sulphite pulp				30

* ADt = Air-dried tonne

As of reported year 2005, plant operators have provided updated emission factors.

Table 133: Real emission factors, for German plants, from pulp production. (German contribution to revision of the BAT reference (BREF) document for the pulp and paper industry, 2007)

	NO_X	CO	NMVOC	SO_2
		[kg / t ADt*]		
Sulphate pulp	1.75	0.16	3.7	0.05
Sulphite pulp	2.8			2

In 2010 the following quantities were produced, in a total of 138 plants:

Table 134: Pulp and paper production, produced quantities

Product	Quantities produced in 2011	
Production of paper, cardboard and carton (PCC):	22.60	million t
Raw-material production:		
Paper pulp	1,563,211	t
of this, sulphite pulp	*597,541*	*t*
of this, sulphate pulp	*965,670*	*t*
Wood pulp	1,163,000	t
Recycled paper	13,414,000	t
Quantity of recycled paper used for this purpose	(16,045,753	t)

Source: Verband Deutscher Papierfabriken, Leistungsbericht 2010 (VDP, various years)

These figures can be traced back to the base year, 1990.

Particle board

Emission factors

The emission factors have been determined on the basis of experts' assessments.

Activity data

The activity data were obtained from national statistics (FEDERAL STATISTICAL OFFICE: Fachserie 4, Reihe 3.1).

Table 135: Updated activity data for the particle-board industry (2.D.3)

Year	2006	2007	2008	2009	2010	2011
Activity data for the particle-board industry [in t]	6,502,000	6,460,000	5,300,000	4,575,000	4,561,000	4,488,000

Source: Federal Statistical Office, Fachserie 4, Reihe 3.1.4

4.5.1.3 Uncertainties and time-series consistency (2.D.1)

Pulp and paper

Until reported year 2004, the IPCC default values (IPCC, 1996b) were used for emissions calculation. As of reported year 2005, updated, Germany-specific emission factors were entered into the CSE emissions database, following consultation with German plant operators. Such updating was required because German sulphate pulp plants had undertaken considerable modernisation measures, in the previous five years, that had led to sharp emissions reductions. The updating was completed as of 2005. In sulphite pulp plants, continual improvements led to considerable SO_2-emissions reductions with respect to corresponding emissions levels in 1990.

The uncertainties in the activity data are estimated to amount to 5-10 %. The uncertainties in the emission factors are estimated to amount to 20 %.

Particle board

The uncertainties in the activity data for the particle-board industry ±5 % (expert assessment).

4.5.1.4 Source-specific quality assurance / control and verification (2.D.1)

Due to resources limitations, and to the area's minimal relevance, no QC/QA is carried out for reporting relative to precursors.

4.5.1.5 Source-specific recalculations (2.D.1)

The available data relative to **production of particle board** have been improved via use of the activity data since 2004. As of 2004, data that have been carried forward from previous years will be replaced with data of the Federal Statistical Office (Fachserie 4 Reihe 3.1).

4.5.1.6 Source-specific planned improvements (2.D.1)

Since plant operators have confirmed the emission factors from the international guidelines, no further inventory improvements for this source category are planned at present.

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

4.5.2 Other production: Food and drink (2.D.2)

4.5.2.1 Source category description (2.D.2)

CRF 2.D.2	Gas	Key category	1990 Total emissions (Gg) & percentage (%)	2010 Total emissions (Gg) & percentage (%)	Trend
		- -			

Gas	Method used	Source for the activity data	Emission factors used
CO_2	IE	IE	IE
NMVOC	CS	NS	CS/D

The source category *Other production – food and drink* is not a source of greenhouse-gas emissions and is thus not a key category.

The food and beverage industry's emissions of direct climate gases in Germany result from fuel combustion; for this reason, they are reported under CRF 1.A.2. The food and beverage industry's important process-related emissions include non-methane volatile organic compounds (NMVOC) (IPCC 1996c: p. 2.41). Carbon dioxide emissions from food inputs that occur during certain production processes are not reported in CRF 2.D.2., since they result from use of biological carbon and do not contribute to net CO_2 emissions. Solvent emissions related to production of margarine and vegetable oils are reported in source category 3.D. Animal fats are thus included in the source category "Margarine and solid and hardened fats". CO_2 used in sugar production, which is obtained from burning of limestone, is bound during the production process. Therefore, that process is not emissions-relevant (cf. UFOPLAN research project FKZ 205 41 217/02).

Emissions of the food and drink industry are reported, in summary form, in the inventory in "Table2(I)s2" of the sectoral report for industrial processes. In the table "Background data of the sectoral report for industrial processes" ("Hintergrunddaten des sektoralen Reports für Industrielle Prozesse"), "Table2(I).A-G", the IEF is listed as NE, since the pertinent CO_2 emissions are reported under CRF 1.A.2.

With revenue of EUR 163.3 billion in 2011, the food industry is one of Germany's most important economic sectors. In that same year, 550,000 people were employed in a total of 5,960 food-industry companies (BVE 2012, p. 4). The German food industry includes an especially large number of small and medium-sized enterprises (SMEs); nearly 80 percent of its companies have fewer than 100 employees, and only 3 percent have more than 500 employees (BpB 2002: p.51).

Pursuant to the IPCC, emissions reporting for the food and drink source category covers the following products:

Alcoholic beverages

- Wine
- Beer
- Spirits

Bread and other foods

- Meat, fish and poultry
- Sugar
- Margarine and solid and hardened fats
- Cake, cookies and breakfast cereals
- Bread
- Animal feedstuffs
- Coffee roasting

Default emission factors for NMVOC emissions relative to these products are listed (IPCC, 1996c: p. 2.41f).

4.5.2.2 Methodological issues (2.D.2)

For emissions calculations, national emission factors were used where available. Otherwise, the emission factors recommended by IPCC and CORINAIR were used. The basis for selection of emission factors consists of the research report "Emissions from the food industry" ("Emissionen aus der Nahrungsmittelindustrie") (FKZ 206 42 101/01; IER, 2008).

The Central System of Emissions (CSE) lists activity data (produced amounts) and emission factors for NMVOC emissions for the relevant sectors. The activity data for the various products / product groups, with the exception of that for feedstuffs, were obtained from the *FEDERAL STATISTICAL OFFICE* (Fachserie 4, Reihe 3.1 and Fachserie 3, Reihe 3.2.2). The activity data for feedstuffs were obtained from the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) (Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten). Because of its greater precision, the distilled-spirit tax (Branntweinsteuerstatistik) of the *Federal Statistical Office* was used to determine the activity data for spirits production.

Table 136 shows the activity data determined, emission factors used and the relevant NMVOC emissions calculated for the year 2011.

Table 136: NMVOC emissions from the food industry (2.D.2) in 2011

Product	Activity data		Emission factors		Emissions [t]
Bread					
- Industrial bakeries	3, 726,421	t	0.3	kg/t	1118.0
- Craft bakeries	915,818	t	3.0	kg/t	2747.5
Cakes, cookies and breakfast cereals	1,587,154	t	0.1	kg/t	158.7
Sugar	4,152,766t		0.9	kg/t	3967.0
Meat, poultry, fish	1,549,301	t	0.03	kg/t	46.5
- Meat/fish, smoked	2,319,108	t	0.0023	kg/t	5.3
Animal fats	344,959	t	1	kg/t	345.0
Coffee roasting	539,890	t	0.069	kg/t	37.2
Feedstuffs	20,505,717	t	0.1	kg/t	2050.6
Beer	89,447,120	hl	0.002	kg/hl	178.9
Wine					
- Red wine	3,500,761	hl	0.08	kg/hl	280.1
- White wine	5,022,430	hl	0.035	kg/hl	175.8
- Other wines	1,353,377	hl	0.058	kg/hl	78.5
Spirits	1,198,949	hl	2.93	kg/hl	3512.9

* With reduction measures taken into account

A total of 14.7 Gg of NMVOC emissions result for source category 2.D.2.

4.5.2.3 Uncertainties and time-series consistency (2.D.2)

The uncertainties in the activity data are estimated to amount to 5-20 %. A research project was carried out (IER, 2008), in the UFOPLAN framework for 2006-2008, with the aim of improving the database and facilitating maximally realistic estimation of emissions from the *food industry*. That research project was able to determine national emission factors for a number of source areas (sugar production, spirits production, coffee roasting, smoking of meat and fish), to obtain more-detailed information with regard to the nature and scope of emissions-reduction measures in the various sectors and to improve the database for determination of activity data. Where no national emission factors were available, emission factors from the *IPCC Workbook* (1996a, 2.41f) and the *Emission Inventory Guidebook* (EMEP, 2009) were used. For determination of emissions from production of other wines (fruit wines), the average of the emission factors for red-wine and white-wine production was used.

4.5.2.4 Source-specific quality assurance / control and verification (2.D.2)

Due to resources limitations, and to the area's minimal relevance, no QC/QA is carried out for reporting relative to precursors.

Other countries' reports contain very little information about 2.D.2, and thus no comparisons are possible at present. No comparison with ETS data is possible, since no emissions subject to emissions trading occur in 2.D.2.

4.5.2.5 Source-specific recalculations (2.D.2)

No recalculations are required.

4.5.2.6 Source-specific planned improvements (2.D.2)

No improvements are planned at present.

4.6 Production of halocarbons and SF_6 (2.E)

CRF 2.E	Gas	Key category		1995 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
	HFC	**L**	**T**	**4,218.5**	**(0.35%)**	**41.4**	**(0.00%)**	**-99.02%**
	SF_6	-	-	167.3	(0.01%)	101.8	(0.01%)	-39.14%
	PFC	-	-	C	C	C	C	C

Gas	Method used	Source for the activity data	Emission factors used
HFC	Tier 3	PS	PS
SF_6	Tier 3	PS	PS

The source category *Production of halocarbons* is a key category for HFC emissions in terms of emissions level and trend. It is subdivided into 2.E.1 By-product emissions and 2.E.2 Fugitive emissions.

4.6.1 By-product emissions (2.E.1)

4.6.1.1 Source category description (2.E.1)

For process-related reasons, production of HCFC-22 produces up to 3 % HFC-23 as a by-product. For technical reasons, even when the HFC-23 is subjected to further processing (for example, to produce refrigerants) or is collected and then broken down into other substances, some HFC-23 is always released into the atmosphere.

Germany formerly had two production plants for HCFC-22. Those two plants, which were operated by a single company, were located in Frankfurt and Bad Wimpfen. In 1995, a CFC-cracking plant went into operation in Frankfurt that cracked, at high temperature, excess HFC-23 produced during production of HCFC-22 and that recovered hydrofluoric acid; i.e. no significant emissions were produced. HFC-23 produced at the second German production facility was captured in large amounts at the production system itself; the substance was then sold as a refrigerant or – following further distillative purification – as an etching gas for the semiconductor industry. Beginning in 1999, the excess amount that could not be sold was delivered to the cracking facility in Frankfurt. That measure substantially reduced emissions. HCFC-22 production was terminated in mid-2010, at both locations. HFC-23 emissions stopped occurring as of 2011.

4.6.1.2 Methodological issues (2.E.1)

In keeping with manufacturer information from 1996, HFC-23 emissions are assumed to have remained constant in the years 1990 to 1994.

Beginning in 1995, the producer calculated emissions, via a mass-balance procedure, on the basis of HCFC-22 production, HFC-23 concentrations in exhaust gas (as measured annually), sales of HFC-23 and quantities of HFC-23 delivered to the cracking plant. For the reported year 1995, emissions-reduction measures (the cracking plant) for the first production plant were assumed to have been in place since mid-year.

Emission factors

Since produced quantities of HCFC were not reported, it was not possible to determine an emission factor and compare it with the IPCC standard emission factor.

Activity data

The relevant HFC-23 emissions were reported by the producer.

Since there are fewer than three producers in Germany, the pertinent emissions data are confidential. Data for SF_6 are reported in aggregation with other confidential data in 2.G. Data for the other F-gases are reported in 2.E as an "unspecified mix" that is an aggregate of 2.E.1 and 2.E.2.

4.6.1.3 Uncertainties and time-series consistency (2.E.1)

The production figures used as a basis for emissions calculation may be considered highly accurate, since they come directly from the producer's internal records.

4.6.1.4 Source-specific quality assurance / control and verification (2.E.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.6.1.5 Source-specific recalculations (2.E.1)

No recalculations are required.

4.6.1.6 Source-specific planned improvements (2.E.1)

No improvements are planned at present.

4.6.2 Production-related emissions (2.E.2)

4.6.2.1 Source category description (2.E.2)

In Germany, one company produces these gases; its HFC und SF_6 production takes place at two locations. Emissions trends are tied to trends in amounts produced. While SF_6 and HFC-134a are produced in Germany, until 2008 no complete synthesis of HFC-227ea was carried out in Germany. Part of the HFC-227ea produced in Tarragona, Spain, undergoes subsequent distillation, in Germany, to pharmaceutical purity (use in dosing aerosols). That process produces emissions as a result of minor gas losses.

HFC-134a has been produced since 1994, while HFC-227ea has been produced since 1996.

4.6.2.2 Methodological issues (2.E.2)

Emission factors

It is possible to calculate an emission factor from the emissions and production quantities reported by the producer. The resulting factor is not published, however, because the underlying data are confidential.

Activity data

Because the HFC producer in Germany is the country's sole producer, that company's data are confidential. Emissions and production quantities are reported to the Federal Environment Agency, but only in a form aggregated with emissions from CRF source category 2.E.1.

4.6.2.3 Uncertainties and time-series consistency (2.E.2)

The production figures used as a basis for emissions calculation may be considered highly accurate, since they come directly from the producer's internal records.

4.6.2.4 Source-specific quality assurance / control and verification (2.E.2)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.6.2.5 Source-specific recalculations (2.E.2)

Entry errors in the last submission made it necessary to recalculate the activity data, emission factor and emissions for SF_6. For reasons of confidentiality, the pertinent details cannot be provided here.

4.6.2.6 Source-specific planned improvements (2.E.2)

No improvements are planned at present.

4.6.3 Other (2.E.3)

No other sources of relevant greenhouse-gas emissions are known.

4.7 Consumption of halocarbons and SF_6 (2.F)

CRF 2.F	Gas	Key category		1995 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Consumption of halocarbons and SF_6	**SF_6**	**L**	**T**	**C**	**C**	**C**	**C**	**C**
Consumption of halocarbons and SF_6	**HFC**	**L-**	**T**	**C**	**C**	**C**	**C**	**C**
Consumption of halocarbons and SF_6	PFC			C	C	C	C	C

Gas	Method used	Source for the activity data	Emission factors used
HFC, PFC, SF_6		cf. Table 137	

The source category *Consumption of halocarbons and SF_6* is a key category for SF_6 and HFC emissions in terms of emissions level and trend.

Source category 2.F includes Refrigeration and air conditioning systems (2.F.1), Foam production (2.F.2), Fire extinguishing agents (2.F.3), Aerosols (2.F.4), Solvents (2.F.5), Other applications that use ODS substitutes (2.F.6), Semiconductor production (2.F.7), Electrical operating equipment (2.F.8) and Other applications (2.F.9). In the interest of more precise data collection, these sub- source categories are broken down further, as described in the following sub-chapters.

Use of relevant substances as refrigerants in stationary and mobile refrigeration applications, which accounts for over three-fourths of relevant emissions, is the largest source of HFC emissions in source category 2.F from use of fluorinated greenhouse gases. The remaining emissions are distributed among the sources "foams" and "aerosols" and, in small amounts, "fire extinguishers", "solvents" and "semiconductor production".

Some two-thirds of PFC emissions come from the semiconductor industry (which includes circuit boards; due to its insignificance in this context, that category is not reported separately), and one-third come from air-conditioning and refrigeration systems. Small quantities are emitted from shoes and from production of photovoltaic modules (PV modules).

About half of the SF_6 emissions come from soundproof windows, with emissions in that area occurring primarily in disposal of soundproof windows. About one-fourth of the emissions originate from electrical equipments. As to the remaining emissions, production of PV modules is the predominant source, followed by production of optical glass fibres. Small amounts originate in the semiconductor industry, from automobile tyres and from trace gases. No information can be provided regarding quantities for the emissions sources "shoes", "AWACS" and "welding", since the relevant data are confidential.

Table 137: Overview of methods and emission factors used for the current reporting year, in source category 2.F - *Consumption of HFCs, PFCs and SF_6*.

		Method	Gas			Emission factor (dimensionsless)		
			HFC	PFC	SF_6	Production	Application	Waste management
1st Air-conditioning and refrigeration systems	**2.F.1**							
Household refrigeration	2.F.1a					NO	0.003 (D)	0.3 (D)
Commercial refrigeration	2.F.1b							
- Plug-in appliances						0.005 (D)	0.01 - 0.015 (D)	0.522 – 0.72 (CS)
- Condensing units						0.01 (D)	0.068 - 0.1 (D)	0.323 – 0.595 (CS)
- Central systems				PFC		0.01 (D)	0.049 - 0.2 (D)	0.216 - 0.7 (D)
Refrigeration for transports (vehicles and containers)	2.F.1c			PFC		5 g / unit (CS, D)	0.1 - 0.3 (D)	0.3 (D)
Industrial refrigeration	2.F.1d			PFC		0.005 - 0.01 (D)	0.063 - 0.09 (D)	0.21 – 0.68 (CS)
Stationary air conditioning systems	2.F.1e							
- Large air conditioning systems		Tier 2a	HFC			0.005 (D)	0.0388 - 0.06 (D)	0.221 - 0.45 (CS)
- Heat pumps						0.005 (D)	0.02 - 0.025 (D)	0.364 – 0.563 (CS)
- Heat-pump dryers						0.005 (CS)	0.003 (CS)	NO
- Room air conditioners						0.01 - 0.1 (D, CS)	0.025 – 0.1 (D, CS)	0.3325 – 0.7 (CS)
Mobile air conditioning systems	2.F.1f							
- Trucks						5 g/system (CS)	0.15 (D)	0.21 (CS)
- Automobiles						3 g/system (CS)	0.1 (D)	
- Buses						50 g/system (CS)	0.15 (D)	
- Ships						0.01 (CS)	0.1 – 0.3 (CS)	NO
- Railway vehicles						0.002 (CS)	0.06 (CS)	
- Agricultural machines						5 g/system (CS)	0.15 - 0.25 (CS)	0.3 (CS)
2. Foam production	**2.F.2**							
Hard foam with 134a	2.F.2a	Tier 2a	HFC			0.1 (D)	0.005 (D)	NO
Hard foam with 365mfc/245fa/227ea						0.15 (CS)	0.01 (CS)	
Integral foam						1 (CS)	NO	
PUR foam (134a)						0.5 g/can (CS)	1 (CS)	
PUR foam (152a)						0.5 g/can (CS)	1 (CS)	
XPS foam (134a)						C	0.0066 (CS)	
XPS foam (152a)						1 (CS)	NO	
3. Fire extinguishers	**2.F.3**	CS	HFC			0.001 (CS)	0.01 – 0.08 (CS) 0.04 (D)	1.0 (D)
4. Aerosols	**2.F.4**							
Metered dose inhalers	2.F.4a	CS	HFC			0.01 (CS)	1 (CS)	NO
Other aerosols / novelties	2.F.4b/c	Tier 2				0.015 (CS)	1 (D)	
5. Solvents	**2.F.5**	Tier 2				NO	1 (D)	
6. Other applications that use ODS substitutes	**2.F.6**					NO	NO	
7. Semiconductor production	**2.F.7**	Tier 2a	HFC	PFC	SF_6	C (CS)	NO	

		Method	Gas			Emission factor (dimensionsless)		
			HFC	PFC	SF_6	Production	Application	Waste management
8. Electrical equipments	**2.F.8**							
Switchgear and controlgear	2.F.8a	Tier 3a			SF_6	0.02 (CS)	0.001 – 0.01 (CS)	0.015 (CS)
Other	2.F.8b	CS				0.15 – 1 (CS)	0.006 – 0.003 (CS)	NO
9. Other	**2.F.9**							
Insulated glass windows	2.F.9a	Equ. 3.24 ff			SF_6	0.33 (D)	0.01 (D)	1 (D)
Car tyres	2.F.9b	Equ. 3.23				NO	NO	1 (D)
Sports shoes	2.F.9c	Equ. 3.23		PFC		NO	NO	1 (D)
Trace gas	2.F.9d	Equ. 3.22				NO	1 (D)	NO
AWACS maintenance	2.F.9e	CS				NO	C	NO
Welding	2.F.9f	CS				NO	1 (CS)	NO
Optical glass fibre	2.F.9g	CS				0.7 (CS)	NO	NO
Photovoltaics	2.F.9h	CS		PFC		0.058 (CS)	NO	NO

Equ. = Equation from the IPCC GPG (2000)

Halocarbons and SF_6 are used in a number of different applications. Whereas in some, so-called "open" applications, consumed quantities are emitted completely, in the same year in question, in other applications large quantities are stored (stocks). The substances then are emitted, either partially or completely, from such "stocks" throughout the entire usage phase and in relevant waste management. It is thus neither possible nor useful to provide a mean emission factor. Most of the EF used are country-specific (CS), although some are also IPCC default (D).

The "current emissions (A)", as listed in Table 2(II)s2 of the inventory tables, consist of the quantities of HFCs, PFCs and SF_6 that, during a reporting year, slowly escape from "stocks" and are emitted in production and waste management.

On the other hand, the potential emissions of gases listed in Table 2 (II) s2 correspond to the production quantities in the relevant country, with import quantities added and export quantities deducted. The pertinent quantities are determined via evaluation of statistical surveys and experts' assessments (for example, for fill quantities).

In general, the emissions data collected for the various product groups comprise emissions from production, use and waste disposal. Except where indicated otherwise in connection with the pertinent methods, these emissions are calculated as follows:

1. Production emissions are determined via new domestic consumption, as activity data:

Equation 1:

$$EM_{production} = EF_{production} * \text{new domestic consumption}$$

2. Application emissions are based on the average annual stock of relevant pollutants (the activity data), and they are calculated via the following formula:

Equation 2:

$$EM_{application} = EF_{application} * \text{average stocks}$$

These average stocks are obtained as half of the sum of the final stocks of the previous year (n-1) and of the current year (n); summation is carried out from the first year of application on. The result consists of the accumulated average pollutant stocks for year n.

The final stocks for the current year are calculated by summing annual new additions, from the first reporting year to the current one. The new additions for a given year consist of the new domestic consumption for that year, minus production emissions and losses from removals. The calculation thus requires consideration of foreign trade.

3. Disposal emissions refer to new additions for the year that is x years (depends on product lifetime) prior to the current reporting year n:

Equation 3:

$$EM_{disposal} = EF_{disposal} * \text{new additions (n-x)}$$

In this chapter, the sections *Uncertainties and time-series consistency, Source-specific quality assurance / control and verification, Source-specific recalculations and Planned improvements* vary in their reference – some refer to the entire relevant source category, some to the sub - source category in question and some to only a part of a sub - source category. In each case, the reference involved is apparent from the CRF number in the section heading.

4.7.1 Refrigeration and air conditioning systems (2.F.1)

4.7.1.1 Source category description (2.F.1)

This category is divided into the sub-categories of household refrigeration, commercial refrigeration, transport refrigeration, industrial refrigeration, stationary air conditioning systems and room air conditioners, and mobile air conditioning systems (cf. Table 137).

In Germany, the leading pure-HFC refrigerants, far and away, are HFC-134a and the mixtures R404A, R407C, R410A and R507A.

For calculation of HFC emissions from the sub-categories of refrigeration and stationary air conditioning systems, individual data are collected, or refrigerant models are used. Any refrigerant models used are described in connection with the relevant method.

The emission factors used are the result of surveys of experts. Disposal emissions in this source category first occurred in 2000, in sub- source category 2.F.1.b (commercial refrigeration).

4.7.1.2 Methodological issues (2.F.1)

4.7.1.2.1 Household refrigeration (2.F.1.a)

In 1994, domestic producers of household refrigerators and freezers made a changeover from CFC-12 to HFC-134a. A short time later, they then switched to isobutane. Small numbers of devices containing HFC-134a, representing a small share of all relevant appliances, have been imported since 1993.

Equation 2 is used to calculate annual HFC emissions on the basis of average stocks. To that end, annual HFC additions since 1993 are determined and aggregated.

Production losses and new consumption for domestic purposes do not have to be determined, since filling takes place only abroad.

Emission factors

Current HFC emissions from household refrigerators and freezers are estimated at 0.3 %, which is within the value range given by IPCC–GPG (2000) in Table 3.22, 0.1 to 0.5 %

The emission factor for disposal, at a value of 30 %, is in keeping with the value given by IPCC–GPG (2000) in Table 3.22.

Activity data

The annual additions figure of 1 % of new appliances is an estimate of leading refrigerator manufacturers.

The appliances in question are considered to have an average lifetime of 15 years. That value lies within the upper section of the value range given by IPCC–GPG (2000) in Table 3.22, 12 to 15 years.

4.7.1.2.2 Commercial refrigeration (2.F.1.b)

Commercial refrigeration is the largest and most diverse area of HFC application. It is subdivided into the areas of plug-in devices, condensing units and central systems. The great diversity seen in the area of central systems, with regard to model, size, type of refrigerant and emissions-tightness, results from the fact that most relevant systems are customised systems. Less diversity is found in the areas of plug-in devices and condensing units. In light of the extremely large number of companies specialising in refrigeration, detailed statistical surveys of refrigerant stocks are not practicable. Therefore, a different calculation method is used.

Use of HFCs as refrigerants grew only gradually. For example, HFC-134a was not used on any significant scale until mid-1993. Use of the refrigerant mixture R404A also did not begin until 1993. The refrigerant mixture R407C has been used since 1996, and the various R422 mixtures, which are used as "drop-in" refrigerants in conversions of HCFC-22 systems, have been used only since 2009.

Today, the mixture R404A is the most important HFC refrigerant for stationary refrigeration systems, ranking ahead of even HFC-134a in this category. The mixtures R407C and R422 are also of some significance.

For calculation of emissions from *central systems* for commercial refrigeration, in the food retail sector, the following refrigeration model is used (cf. SCHWARZ et al., n.y.):

- Foreign trade with locally installed refrigeration systems plays a negligible role, and thus annual HFC consumption for new systems is the same as new HFC additions in new systems.
- Except in the case of discount stores, calculations begin not with the numbers of pertinent operations but with the sales floor areas of the food retail businesses involved. The pertinent sales floor areas, and numbers of discount stores, are recorded on an annual basis.
- The coefficient "kilograms per square meter of sales floor area" is derived on the basis of a typical medium-sized supermarket. It has the value 0.23 kg/m^2. For discount stores, the coefficient "kilograms per discount store" is determined. It has the value 80 kg / store. Those coefficients are used to calculate the annual refrigerant stocks for the six store formats self-service department store (SB-Warenhaus), large retail store, small retail store, supermarket, cash & carry and discount store.

- The refrigerant stocks for the various store formats, subdivided by refrigerant types, are determined with the help of applicable component percentages for refrigerant combinations. The refrigerant combinations are derived with the help of statistical calculation models based on experts' assessments. In the process, a basic distinction is made between large stores (cash and carry stores, large retail stores and self-service department stores and small stores (supermarkets, small retail store and discount stores).
- Division of refrigerant stocks by the systems' average lifetime (14 years) yields the HFC additions via new systems.
- The production emissions and emissions from stocks are calculated with Equation 1 and Equation 2. Production normally takes place at the relevant sites.
- Replacement of CFCs and HCFCs in old systems is considered separately.
- Disposal emissions occurred in connection with central systems for the first time in 2000. Removals of refrigerants are calculated with the help of the average lifetime, which is 14 years for central systems. In each case, the nominal quantity for disposal is equivalent to the added new quantity a system had when it was commissioned. In practice, however, the quantities of refrigerants that systems contain when they are disposed of are smaller than the corresponding nominal fill quantities, since systems are normally not refilled before they are decommissioned. For this reason, the actual fill level upon disposal, the "effective" quantity for disposal, is determined with the help of applicable percentage values for residual fill levels. The most important factor that enters into the determination of residual fill levels is the refrigerant-loss level at which a system has to be refilled in order to maintain its proper function. The effective fill level at the end of a device's / system's service lifetime is larger, by half of the difference between that minimum "technical" fill level and the nominal fill level, than the minimum "technical" fill level. For central systems, it amounts to 87.5 % of the nominal fill level.
- The disposal emissions are calculated by multiplying the so-determined "effective" quantity for disposal by the inverse of the recovery factor, using Equation 4:

Equation 4:

$$EM_{disposal} = \text{new additions (n-x)} * \text{residual fill level} * (1 - \text{recovery factor})$$

Also in the case of *condensing units* for commercial refrigeration, the refrigerant stocks are the central point of reference for the refrigerant model for emissions calculation:

- The starting point for such calculations consists of the number of operation sites in the numerous sectors in which condensing units are used; the relevant sector selection derives from a study of the German Engineering Federation (VDMA) (2011). Such sectors include cash-and-carry beverage stores, service station shops, nurseries (garden centers), flower shops, flower wholesalers, cafeterias, caterers, hospitals, nursing homes, restaurants and hotels, butcher shops and franchise outlets for meat products, bakeries and franchise bakery outlets, discount stores, small food retailers and specialty food retailers. The number of sites involved is updated annually, from publicly accessible statistics.

- The refrigerant stocks for the various individual sectors are calculated as the product of the relevant number of operational sites, the sector-specific fill quantities (as determined from the literature and via surveys of experts) and the refrigerant combinations involved (with percentage shares for the pertinent components). The refrigerant combinations are derived via a static calculation model (cf. SCHWARZ et al., n.y.).
- Division of total refrigerant stocks by the average lifetime of condensing units (12 years) yields the HFC additions via new systems.
- The production emissions and emissions from stocks are calculated with Equation 1 and Equation 2.
- The disposal emissions are calculated via Equation 4. The nominal quantity for disposal is identical, in terms of both quantity (amount) and refrigerant combinations, with the corresponding initial-fill quantity from 12 years earlier. For condensing units, the effective fill level at the end of units' service lifetime amounts to 85 % of the nominal fill level.

The application sectors for hermetically sealed *plug-in appliances* are largely the same as those for condensing units. Emissions for such appliances are calculated in keeping with the refrigerant-model approach described for condensing units. Such appliances have an average lifetime of 10 years, and their residual fill level upon disposal amounts to 90 % of the nominal fill level.

Emission factors

The emission factors used are the result of surveys of experts and literature evaluations.

As a rule, filling of refrigeration systems produces only small quantities of emissions. For "initial emission", in Table 3.22 IPCC-GPG gives a figure of 0.5 to 3 percent of the initial filling quantity. The country-specific $EF_{production}$, at 0.5 % for plug-in appliances, and at 1 % for central systems and condensing units, falls within that range.

Ongoing (H)FC emissions from stationary refrigeration systems in the *commercial refrigeration* category vary widely in keeping with the type of system concerned. The refrigerant loss ranges from 1 to 1.5 % for individual devices to 20 % for converted, old central systems. The emission factors for application have decreased continuously since 1993 for all devices and systems in the area of commercial refrigeration (cf. Table 137), in keeping with the increasing degree of care taken in handling refrigerants. All of the values used lie within the lower value ranges given in Table 3.22 of IPCC-GPG (2000), 1 to 10 % for individual appliances and 10 to 30 % for commercial refrigeration systems.

The emission factors for disposal have also been decreasing continuously. In 2011, the emission factors for disposal were 52.2 % for plug-in appliances and 32.3 % for condensing units, values which were still above the range given in Table 3.22 of IPCC-GPG (2000) for commercial refrigeration systems, 10 to 30 percent. The refrigerants in such devices are often not disposed of properly, since proper disposal is extremely expensive. This applies all the more for smaller devices. At 20 % in 2011, the value for central systems lies within the range given, however. For such large systems, the losses are nearly identical with the residual quantity that cannot be practicably siphoned off. For converted CFC-12 systems only, a higher emission factor is assumed, in keeping with the smaller relative quantities of refrigerant that can be recovered from old systems at the time of disposal.

Activity data

The sales floor areas of grocery stores are surveyed annually, by two market-research institutes[47]. The EHI Retail Institute also monitors the numbers of discount stores. In addition, the applicable numbers of commercial sites are updated annually from various publicly available statistics (cf. SCHWARZ et al., n.y.).

The quantities and types of refrigeration and freezer systems typically used by businesses are determined from the literature and via estimation by experts. The coefficients "kilograms per square meter of sales floor area" and "kilograms per discount store" have been determined semiempirically by experts, with the help of the relevant technical literature. The fill quantities for condensing units and plug-in appliances have been determined via techical discussions with German manufacturers of refrigeration / freezer systems and via study of the relevant literature.

4.7.1.2.3 Transport refrigeration (refrigerated vehicles and containers) (2.F.1.c)

HFCs have been used as refrigerants in *refrigerated vehicles* since 1993. Today, the refrigerants most commonly used in refrigerated vehicles are HFC-134a and the refrigerant mixtures R404A and R410A. The sizes and refrigerant fill quantities of refrigeration systems vary in keeping with the load volumes of the refrigerated vehicles in question.

Refrigerated containers are used primarily for transports of perishable goods by ocean-going ships. Since their emissions take place primarily in international waters, their refrigerant emissions are divided, in each case, in keeping with the relevant country's share of world trade. Germany is assigned 10% of global emissions from refrigerated containers. Since 1993, the most commonly used refrigerant has been HFC-134a. Since 1997, R404A has also been used.

The following refrigeration model is applied to *refrigerated vehicles*:

- The entire sub-category of *transport refrigeration* is divided into four size classes of refrigerated vehicles: 2-5 t, 5-9 t, 9-22 t and > 22 t of gross vehicle weight.
- Refrigerant types, and specific refrigerant fill amounts, are assigned to the various size classes. Each refrigerant is also assigned a percentage share of each size class. In some cases, the refrigerant breakdown used may have to be modified. Since the 2006 reporting year, the refrigerant R404A has been used in half of the small systems of up to 5 t gross vehicle weight. Until 2005, only HFC-134a was used. Since 1993, relevant filling has consisted of 50 % HFC-134a and 50% R404A in the size class 5-9 t gross vehicle weight, while HFC-134a, R404A and R410A have been used in the size classes 9-22 t and > 22 t.
- The number of newly licensed refrigerated vehicles, and the number of refrigerated vehicles filled within the country (broken down by refrigerants), are determined for each year. The annual new additions of refrigerants result from the numbers of newly licensed refrigerated vehicles and the above assumptions.
- When one knows the final stocks from the previous year, one can calculate the average yearly stocks and the year-end stocks.

[47] EHI – EHI Retail Institute, Cologne; The Nielsen Company GmbH, Frankfurt am Main.

- In conformance with the Ordinance on CFC-halon prohibition (FCKW-Halon-Verbotsordnung), HFCs were substituted for CFC-12 in a certain number of old systems. These amounts have to be included in the annual new additions.
- Production emissions are calculated with Equation 1, since they must be seen in connection with new consumption. No use is made of the possibility of calculating emissions on the basis of numbers of newly filled vehicle refrigeration systems, and of the filling loss per system. Emissions from stocks are calculated with Equation 2.
- The service lifetime used for old systems, 7 years, lies within the value range recommended by the IPCC. The service lifetime used for new systems, at 10 years, is somewhat higher than the range given by the IPCC-GPG in Table 3.22, 6 to 9 years. Disposal emissions occurred in connection with refrigerated vehicles for the first time in 2003. They are calculated by means of Equation 3.

The "bottom-up" approach described in IPCC-GPG (2000) refers only to refrigerated vehicles on roads.

For *refrigerated containers*, the following refrigerant model is used:

- The number of refrigerated containers produced worldwide is determined for each year.
- The worldwide HFC additions for refrigerated containers are determined on the basis of annual unit figures from global production, in combination with the relevant fill quantities and fill percentages for the various relevant refrigerants.
- Germany's HFC additions are determined from worldwide additions, in keeping with Germany's share of global trade, which amounts to 10 %.
- When one knows the final stocks from the previous year, one can calculate the average yearly stocks and the year-end stocks.
- Emissions from stocks are calculated with Equation 2.
- Since refrigerated containers are produced only outside of Germany, no emissions from filling occur in Germany.
- Refrigerated containers have an average lifetime of 14 years, and disposal emissions from such containers occurred for the first time in 2007. They are calculated by means of Equation 3.

Emission factors

The emission factors on which the emissions data are based are listed in Table 137. The emission factors used lie within the ranges recommended in the IPCC-GPG (2000); they are thus *default values*. The only exception is the emission factor for emissions from stocks in refrigeration units of refrigerated containers; at 10 %, it lies below the range given in Table 3.22 of the IPCC-GPG (2000), 15 to 50 %.

Ongoing HFC emissions from new refrigeration units of refrigerated vehicles in the range 5-22 t gross vehicle weight are estimated to amount to 15 %. For units in vehicles up to 5 t gross vehicle weight, the emission factor is 30 %.

For old units in refrigerated vehicles, the emission factor for emissions from stocks is estimated to average 25 %, for all unit size classes. "Old systems" are understood to be converted CFC-12 systems. The emission factors for refrigerated vehicles thus lie at the lower end of the range given in IPCC-GPG (2000), 15 to 50 %. Filling losses are small by comparison to ongoing emissions from stocks. Filling losses of refrigerant, in filling of refrigerated vehicles, are placed at 5 grams per system, regardless of system size. That is a standard value for hose losses during on-site filling. When emissions from filling are calculatorily considered in relation to new consumption, emission factors between 0.06 und 0.25 % result. The great majority of the resulting values lie below the range given by the IPCC-GPG in Table 3.22, 0.2 to 1 percent.

No emissions from filling of refrigerated containers occur in Germany.

The emission factor for disposal of refrigerated transport systems, at 30 %, lies at the upper boundary of the range given in IPCC-GPG (2000), 20 to 30 percent.

Activity data

Until 2008, the registration figures for refrigerated vehicles, broken down by weight classes, were taken from statistical reports of the Federal Motor Transport Authority (KBA). Since in 2009 the Federal Motor Transport Authority stopped carrying out separate surveys of refrigerated vehicles, the numbers of new refrigerated vehicles since 2009 are determined via extrapolation from the registration figures for utility vehicles as determined by the KBA. Fill quantities in refrigeration systems, information on refrigerants used, and details on CFC-12 replacement were provided by experts of the leading providers of vehicle refrigeration units.

New additions of refrigerants in the area of refrigerated containers are determined via a refrigerant model based on the numbers of refrigerated containers produced worldwide, with the numbers provided by the "World Cargo News" information service for the industry. A 10 % share is allocated to Germany.

4.7.1.2.4 Industrial refrigeration (2.F.1.d)

The industrial refrigeration included in this sector refers to refrigeration for production of products – mostly food and drink – that are refrigerated or frozen.

Refrigeration systems in this category, as in the category of *commercial refrigeration*, are usually not purchased directly from series production. They tend to be customised systems, and thus emissions for this category have to be calculated with the help of a refrigeration model. Use of fluorine-based refrigerants has not yet become standard practice in industry, especially the food industry. In addition, natural refrigerants – primarily ammonia – are used much more frequently in this sector than they are in other sectors.

The leading refrigerants for industrial refrigeration are R404A, HFC-134a, R407C, R507 and R422D. The last of these serves as a substitute refrigerant for converted HCFC-22 systems. HFC-23 und PFC-116 are also used, in low-temperature systems, while HFC-227ea, a high-temperature refrigerant, is used in air-conditioning systems for cranes.

Use of fluorine-based refrigerants began in Germany in 1993. Disposal emissions began occurring in 2002, from converted CFC-12 and HCFC-22 systems.

The following refrigerant model is used for *industrial refrigeration*:

- The refrigerant stocks serve as the central point of reference for the model. The model is divided into the twelve sectors beer breweries, wine production, meat production, dairies, cold-storage facilities, chocolate production, production of frozen foods and of juices, skating rinks, milk refrigeration in the agricultural sector, other industry (80 % chemical industry) and hermetically sealed appliances in manufacturing. The basis for calculation of the refrigerant stocks consists of the quantities of produced goods. They are updated annually via publicly accessible merchandise statistics. In the three smaller sectors of industrial refrigeration, air-conditioning for cranes and low-temperature refrigeration with HFC-23 and R508A/B, the annual new additions are used as the starting value for calculating stocks and all emissions.
- On the basis of the relevant production quantities, a conversion is made to the installed cooling capacity required for cooling goods and products in the twelve major sectors. The key factors required for that conversion, "installed cooling capacity per units of annual goods production", have been determined empirically, on the basis of the technical literature.
- The refrigerant quantities required for the resulting cooling capacity are estimated on the basis of refrigerant-use rates for plus and minus refrigeration and for direct and indirect refrigeration. The refrigerant-use rates were also determined via study of the literature, including CLODIC et al 2011 & 2012. They range from 2 kg/kW for indirect plus refrigeration to 8.8 kg/kW for direct minus refrigeration. The typical fill quantities per installed unit of cooling capacity are calculated, for the twelve sectors, by combining these values with the applicable sector-specific weightings for the four basic forms of refrigeration.
- Foreign trade with locally installed refrigeration systems plays a negligible role, and thus annual HFC consumption for new systems is the same as new HFC additions in new systems.
- The refrigerant stocks also provide the basis for calculating the quantity for disposal. For each sector, that quantity is calculated by dividing the stocks by devices' service lifetimes. For most sectors, the applicable service lifetime is 30 years. For dairy farms and skating rinks, it is 20 years, and for plug-in appliances, air conditioners for cranes and low-temperature applications, it is 10 years.
- The refrigerant combinations, which vary over time for stocks, new additions and quantities for disposal, are derived for each sector via a static calculation model (cf. SCHWARZ et al., n.y.).
- Replacement of CFCs and HCFCs in old systems is considered separately.
- The production emissions and emissions from stocks are calculated with Equation 1 and Equation 2.

The disposal emissions are calculated via Equation 4. The nominal quantity for disposal is identical with the initial-fill quantity. The effective fill level at the end of devices' service lifetimes is 85 % of the nominal fill level, for all sectors except plug-in appliances, for which it is higher – 90 %.

Emission factors

The emission factors on which the emissions data are based are listed in Table 137.

The emission factors used are the result of surveys of experts and literature evaluations.

As a rule, filling of industrial refrigeration systems produces only small quantities of emissions. In Table 3.22, IPCC-GPG (2000) gives for "initial emission" values of 0.5 to 3 percent of the initial fill quantity. The country-specific $EF_{production}$ for the major application sectors is 1 %, while it is 0.5% for plug-in appliances. The EF thus lie within the lower part of the range given by IPCC-GPG.

In all sectors except hermetically sealed appliances, ongoing HFC emissions from industrial refrigeration systems have been decreasing continually, changing from 9 % in 1991 to 6.3 % in 2011. The reason for this trend is that refrigeration systems' capacity for retaining their refrigerants has improved as a consequence of national and international legislation. Such emissions now lie within the lower part of the range, or even completely below the range, given by IPCC–GPG (2000) in Table 3.22 – 7 % to 25 %. For plug-in appliances, the decrease has been comparable to that seen in commercial refrigeration, from 1.5 % to 1 %.

The emission factor for disposal of industrial refrigeration systems has also decreased continually, from 68 % to a level of 21 %. The relevant values are slightly, or even markedly, higher than the range given by IPCC-GPG (2000), 10 % to 20 %.

Activity data

The statistics of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) contain numerous time series for food-production quantities. In addition, data are available from industrial associations such as the German association of cold-storage facilities and cold-chain logistics companies (VDKL) and the Association of the German Confectionary Industry (BDSI), as well as from specialised institutes, such as the German Wine Institute.

The unit-number figures for plug-in appliances have been taken from a study of the German Engineering Federation (VDMA) (2011) and provided by industry experts.

The "installed cooling capacity per units of annual goods production" indices, and the refrigerant-use rates for plus and minus cooling and for direct and indirect cooling, were determined on the basis of information provided in the relevant technical literature.

4.7.1.2.5 Stationary air conditioning systems (2.F.1.e)

The area of *stationary air conditioning systems* includes room air conditioners, chillers for air conditioning of buildings and industrial refrigeration of liquids, heat-pump systems and heat-pump laundry dryers.

4.7.1.2.5.1 Room air conditioners

Room air conditioners are used to cool the interiors of individual rooms or even of entire floors. Their performance levels tend to be lower than those of large air conditioning systems. The refrigerants used include the HFC mixture R407C (since 1998) and the mixture R410A (since 2001).

There is no domestic production of room air conditioners. Room air conditioners are normally already filled when imported. Installation of factory-manufactured single-split, multi-split and VRF-multi-split units involves installation of refrigerant pipes, and these have to be filled on site, however. Such filling of pipes is not required in connection with mobile, plug-in room air conditioners.

The following refrigeration model is used for room air conditioners:

- *Room air conditioners* are divided into four categories. The applicable numbers of new systems produced each year in each category are determined via surveys of manufacturers and via the data published in pertinent international publications. The categories are: small mobile units, single-split units, multi-split units with constant-volume refrigerant flow and VRF-multi-split systems with variable-volume refrigerant flow.
- For each category, the fill quantities and refrigerant combinations are determined in keeping with the numbers of new systems sold each year. The annual new consumption, which is identical to annual new additions of refrigerants, is obtained from sales statistics and the above assumptions. The stocks at the end of the year can be calculated from the old stocks.
- No production emissions occur. Filling losses do occur, however, in installation of stationary single-split units, multi-split units and VRF multi-split systems. According to surveys of experts, such installation losses amount to 10 % for single-split units and 1 % for multi-split units and VRF multi-split systems.
- Emissions from stocks are calculated with Equation 2.
- Disposal emissions occurred for the first time in 2008. The average lifetime of mobile units and single-split units is 10 years, while the average lifetime of multi-split units and VRF multi-split systems is 13 years. Disposal emissions are calculated with Equation 4. The estimated lifetime of such systems lies within the range proposed by IPCC-GPG (2000), 10 to 15 years. The residual fill level upon disposal is 75 % for mobile units and 87.5 % for all other types of units.

Emission factors

The emission factors used are the result of surveys of experts and evaluations of the literature.

The country-specific $EF_{production}$ = 1 % for multi-split units and VRF multi-split units lies within the value range proposed by IPCC-GPG (2000), 0.2 to 1 %. For single-split units, the emission factor is 10 %, which translates into a loss of 5 g of refrigerant for an initial fill quantity of 50 g.

The emission factors for use decrease continually, for all devices, within the time series as of 1998, the first year of use (cf. Table 137). For mobile room air conditioners, they range from 3.5 to 2.5 %; for single-split units, they range from 6.9 to 5 %; for multi-split units, they range from 7.9 to 6 %; and for VRF multi-split units, they range from 8.9 to 7 %.

The emission factors for use thus lie within, or slightly above, the range proposed in Table 3.22 of IPCC-GPG (2000), 1 to 5 %.

The emission factors for disposal, $EF_{disposal}$, have also been decreasing continually since 1998. For mobile room air conditioners, they range from 55.1 to 63.4 %; for single-split units, they range from 50.8 to 63.6 %; and for multi-split units and VRF multi-split units, they range from 33.25 to 46.1 %. As a result, the factors used in Germany thus lie above, overall, than the value range proposed by IPCC-GPG (2000), 20 to 30 %.

Activity data

The numbers of units sold in Germany, of the various types of units and systems involved, are determined on an annual basis via technical publications[48] and surveys of sellers.

4.7.1.2.5.2 Chillers

Chillers for air-conditioning of buildings and industrial refrigeration of liquids are divided into three categories: chillers with a cooling capacity of less than 100 kW, chillers with a cooling capacity of more than 100 kW and turbo-compressor systems (with cooling capacities above 1500 kW[49]). Chillers, which are grouped into performance classes, use piston, scroll or screw compressors.

In turbocompressor systems, only HFC-134a has been used since 1993. In the years 1995 through 1999, HFC-134a was also used for conversions of CFC-12 turbocompressor systems. The most important refrigerants used in chillers include HFC-134a (used as of 1993), R407C (as of 1998) and R410A (as of 2004).

The following refrigeration model is applied:

- Chillers are divided into three categories. The number of new systems in each of the following categories is determined each year via surveys of experts and international sales statistics: chillers ‹100 kW, chillers ›100 kW cooling capacity, and turbo-compressor systems in the performance range above 1500 kW[50].
- An average fill amount and specific refrigerant composition are determined for each category. The fill quantities are 10 kg for chillers ‹100 kW, 95 kg for chillers ›100 kW and 630 kg for turbo-compressor systems.
- Data on annual HFC additions to domestic stocks are obtained from the numbers of new systems, in connection with the above assumptions. Consumption for CFC replacements in old systems has to be taken into account.
- The year-end refrigerant stocks can be calculated from the previous-year stocks, the new additions and the removals.
- Production emissions are calculated by multiplying the quantities consumed in filling by the $EF_{production}$, pursuant to Equation 1.
- Emissions from stocks are calculated with Equation 2.
- Disposal emissions occurred for the first time in 2003. They are calculated with Equation 4.

IPCC-GPG (2000), Table 3.22, gives a service lifetime of 10 to 30 years for liquid chiller systems. The values used in the present case lie within that range: 15 years for chillers with cooling capacities either less or more than 100 kW, and 25 years for turbo-compressor systems.

[48] The trade journal JARN – Japan Air Conditioning, Heating & Refrigeration News, Tokyo 107-0052, Special Edition "World Air Conditioner Market".

[49] Turbo-compressor systems are also produced with cooling capacities of less than 1500 kW. Pursuant to EUROVENT, only one such system was installed in Germany in 2008, however.

[50] The statistics for chillers in the performance range above 100 kW give sales figures for systems in the range above 900 kW. Throughout the entire time series, turbo-compressor systems have accounted for a constant one-third of units in the performance range above 900 kW. This was determined via evaluation of complete annual data sets.

Emission factors

The emission factors used are the result of surveys of experts.

The filling loss, at 0.5 %, lies within the value range given by IPCC-GPG (2000), 0.2 to 1 %. To take account of the fact that large numbers of chillers are imported as pre-filled units, $EF_{production\,=}$ 1 %, the actual $EF_{production}$, is not used.

The ongoing HFC emissions through 2000 are estimated at 6 % for all cooling-capacity classes / compressor models, age classes and refrigerant types. Thereafter, the EF_{use} decreases continuously, to 3.9 % (2011). All of the values used thus lie within the lower part of the range proposed by IPCC-GPG (2000), 2 to 15 %.

The country-specific emission factors used for disposal also decrease continuously, as a result of technical progress and the increasing care taken in handling refrigerants. The $EF_{disposal}$ lies between 22.1 and 45 %, and thus exceeds the value range proposed in IPCC-GPG (2000), 5 to 20 %.

Activity data

The numbers of new systems are determined annually via surveys of experts and consultation of international sales statistics. The statistics are prepared by two market-research institutes[51], and they are made available for purchase.

The average fill quantities and refrigerant combinations are determined via expert consultation with industry representatives.

4.7.1.2.5.3 Heat-pump systems

Via a refrigeration cycle, heat pumps draw heat from the air, ground or groundwater and make it available for heating or cooling indoor areas or for heating water. Devices that directly use heat from the outdoor environment to warm indoor air fall within the category of room air conditioners. Since 1995, HFC-134a and the HFC mixtures R404A and R407C have been used as refrigerants in heat pumps; since 2001, R410A has been used as well.

A refrigerant model developed with the help of experts differentiates three categories of heat pumps for heating: air-water, ground (groundwater) - water, ground (brine) - water. A fourth category of heat pumps is used for pumping hot process water.

Methodologically, the refrigerant model is structured like the model for room air conditioners. The starting and reference point for calculations consists of the annual unit-number figures for newly installed heat pumps in all four categories. These data are published annually by the German heat-pump association (BWP). The unit-number figures are also used as production quantities. On the basis of the data for new additions, the various heat-pump types are assigned average HFC fill quantities and percentage shares of the various types of HFCs. The model also includes service-life and emissions-rate figures.

Production emissions are calculated by multiplying the quantities consumed in filling by the $EF_{production}$, pursuant to Equation 1, while emissions from stocks are calculated with Equation 2 and disposal emissions are calculated with Equation 4.

[51] BSRIA, the UK, and the European industry association EUROVENT, Brussels. Both companies break down the market for chillers by compressor types and cooling-capacity classes.

Heat pumps with HFCs have been produced and sold since 1995. Since the units have an average service life of 15 years, disposal-related emissions began occurring in 2010.

Emission factors

The emission factors used are the result of surveys of experts.

The filling loss is 0.5 %. Consequently, the $EF_{production}$ lies within the range given in Table 3.22 of IPCC-GPG (2000), 0.2 to 1 %.

The current HFC emissions for heating-system heat pumps are estimated at 2.5 %, while the emissions for water-heating heat pumps are placed at 2 %. The EF_{use} used thus lie within the range proposed by IPCC-GPG (2000), 1 to 5 %.

The country-specific emission factors $EF_{disposal}$ used for disposal also decrease continuously, as a result of technical progress and the increasing care taken in handling refrigerants. The $EF_{disposal}$ lies between 36.4 % (2011) and 56.3 %, and thus exceeds the value range proposed in IPCC-GPG (2000), 20 to 30 %.

Activity data

Each year, the Bundesverband Wärmepumpe (BWP) national heat-pump association publishes the numbers of new domestic installations of heat pumps. Those figures serve as the basis for the relevant emissions calculation.

4.7.1.2.5.4 Heat-pump dryers

This new category of household appliances has been on the market in Germany since 2008. As of the Submission 2013, it is being reported in source category 2.F.1.e.

Heat-pump dryers are produced in Germany by a number of different companies. As to refrigerants, most manufacturers use HFC-134a; only a few use R407C. The fill quantities in hermetically sealed units range from 300 g to 570 g; the average is 475 g.

The relevant refrigerant model is structured similarly to the models for room air conditioners:

- The most important starting values are the unit-number figures for domestic sales and domestic production and for the two refrigerants used (the figures for refrigerants follow those for domestic sales). The total numbers of devices are calculated from the sums of new additions.
- Production emissions are calculated by multiplying the quantities consumed in filling by the $EF_{production}$, pursuant to Equation 1, while emissions from stocks are calculated with Equation 2.
- Heat-pump dryers with HFCs have been produced and sold since 2008. Since the units have an average service life of 15 years, disposal-related emissions will begin occurring in 2023.

Emission factors

The emission factors used are based on information from experts.

The filling loss is 0.5 %. The $EF_{production}$ is country-specific, since the IPCC Guidelines do not cover this application.

The ongoing HFC emissions of these hermetically sealed units are estimated at 0.3 %. In this area as well, the IPCC Guidelines provide no specifications.

Activity data

Heat-pump dryers are a relatively new product for which little statistical data and technical information are available. The pertinent refrigerant model is thus based almost exclusively on information provided by manufacturers (cf. SCHWARZ et al., n.y.).

4.7.1.2.6 Mobile air-conditioning systems (2.F.1.f)

"Mobile air conditioning systems" comprises vehicle air conditioning systems in passenger cars, trucks and utility vehicles, buses, agricultural machinery, rail vehicles and ships. Hydrofluorocarbons (HFCs) have been used in mobile air conditioning systems since 1993. In German-produced automobiles, they have been used since 1991. HFC-134a is the only HFC-based refrigerant used in such systems. Since the 2002 reporting year, less-significant sources (such as agricultural machinery) have been included for the first time.

The time series show a significant emissions increase since 1995. This increase, which has occurred in spite of decreases in fill amounts, is a direct result of increased use of mobile air conditioning systems in vehicles.

For automobiles, the following refrigeration model is applied:

- The production figures for German automobile production are available, on an annual basis, from the publicly accessible statistics of the German Association of the Automotive Industry (VDA). Those figures provide the database for calculating consumption data relative to filling.
- The annual percentages of automobiles equipped with air-conditioning systems are obtained via extensive surveys of manufacturers, since they are not provided by any official or publicly available statistics. This also applies to the average refrigerant (fill) quantities, which are determined from the technical data for the various automobile models and from information provided by industry experts.
- The quantities consumed in filling such air conditioners are calculated by multiplying the numbers of automobiles produced by the annual percentages of automobiles equipped with air-conditioning systems and by the average per-unit refrigerant (fill) quantities.
- Production emissions are computed with Equation 1.
- The annual numbers of new vehicle registrations as recorded by the Federal Motor Transport Authority (KBA) are not used in determining annual new additions and the refrigerant stocks in automobile air conditioning systems, since it is not possible to quantitatively estimate early departures of vehicles (i.e. prior to vehicles' reaching the end of their average lifetimes) from the registration cohorts that form the basic fleet.
- Instead, the refrigerant stocks are determined on the basis of the numbers of registered vehicles on the road, divided according to age since the initial registration. Relevant official data are available from the statistical communications (Statistische Mitteilung) of the KBA[52], for all required years, i.e. as of 1991. They make it possible to determine, on a continuous, chronological basis, the numbers of vehicles in the total fleet, divided by registration cohorts.

[52] KBA "Fahrzeugzulassungen Bestand an Kraftfahrzeugen und Kraftfahrzeuganhängern nach Fahrzeugalter 1. Januar 2011".

- The annual percentages of automobiles equipped with air conditioning systems, for newly registered vehicles, are also obtained via extensive surveys of manufacturers. Those numbers are not identical with the corresponding percentages of automobiles produced in Germany and equipped with air conditioning systems, since foreign cars also have to be taken into account. The necessary percentages are thus also obtained via surveys of foreign companies. This also applies to strategies for determining the average per-unit refrigerant (fill) quantities in newly registered vehicles.
- The refrigerant stocks in each registration cohort are calculated by multiplying the specific fill quantities for the year in question by the numbers of automobiles equipped with air conditioners. The total stocks are equivalent to the sum of the refrigerant stocks for all registration cohorts since 1991.
- Emissions from stocks are calculated with Equation 2.
- Replacement of CFCs in old systems, and air-conditioner retrofits, are considered separately.
- In determination of quantities for disposal, only the old vehicles are taken into account that are handled each year by German dismantling facilities. Those numbers are obtained from the official data on old vehicles (cf. UBA/BMU, 2011). The refrigerant model does not take account of exports of used cars and old cars, since the relevant disposal emissions occur in the pertinent destination countries and double-counting has to be avoided.
- An average lifetime of 15 years is assumed for dismantled vehicles. The total quantity of refrigerants that are disposed of can be determined by multiplying the number of dismantled vehicles by the applicable percentage of vehicles equipped with air conditioning systems and the average per-unit refrigerant (fill) quantity for the relevant new-registration cohort of 15 years earlier.
- Disposal emissions occurred for the first time in 2002. They are calculated with Equation 4.

The refrigerant models for *utility vehicles and buses* are structured similarly to the model for automobiles. A detailed description of those models has been provided by Öko-Recherche (cf. SCHWARZ et al., n.y.).

The refrigerant model used for *agricultural machinery*, *ships and railway vehicles* is as follows:

- For ships and railway vehicles, refrigerant emissions are determined on the basis of annual new installations of air conditioning systems in ships (outset data: newly built ships for the German fleet) and in railway vehicles (outset data: new procurements by German Railways (DB)), as well as the relevant fill quantities.
- The refrigerant model for air conditioning systems in agricultural machinery is based on the number of new vehicle registrations for each year, the average percentage of vehicles equipped with air conditioning systems and the average fill quantities.
- The annual new additions of HFC-134a, as well as the final stocks and average annual stocks, are determined, for each area, from the relevant previous set of data.
- Emissions from stocks are obtained by multiplying the "average yearly stocks", for each area, by the relevant EF_{use}.
- Domestic consumption of HFC-134a, for production of mobile air conditioning systems, is determined on the basis of unit-number figures for production.

- Disposal emissions from agricultural machinery occurred for the first time in 2004. These are calculated via Equation 3. Due to the long lifetimes involved, no air conditioning systems in ships and railway vehicles have been disposed of yet.

Emission factors

The emission factors used have been obtained via evaluation of the relevant literature (e.g. ÖKO-RECHERCHE / ECOFYS 2003; SIEGL et. al., 2002; CLODIC et. al., 2011 und 2012; Öko-Recherche 2012, SCHWARZ et al., n.y.), measurements (automobiles), evaluations of service-center records, extensive surveys of experts and surveys of automobile service centers and dismantling facilities. In addition to regular emissions during operation, emissions also arise as a result of accidents and other external influences.

The EF for filling of systems in automobiles, utility vehicles, buses and railway vehicles (cf. Table 137) lie below the value given in IPCC-GPG (2000: p. 3.110), 0.5 %. The Guidelines provide no values for agricultural machinery and ships.

Current HFC emissions are estimated at 10 % for automobiles; at 15 % for utility vehicles and buses; at 6 % for railway vehicles; at 15 - 25 % for agricultural machinery; and at 10 - 30 % for ships. The EF_{use} used thus lie largely within the range proposed in IPCC-GPG (2000), 10 to 20 % for air-conditioning systems in automobiles, utility vehicles, buses and railway vehicles. No proposals have been provided for agricultural machinery and ships.

For automobiles, utility vehicles and buses, the emission factor for HFC disposal from mobile air-conditioning systems is 21 %; for agricultural machinery, it is 30 %. The $EF_{disposal}$ used are thus lower than the standard value in IPCC-GPG (2000: p. 3.110), 40 %.

Activity data

The Federal Motor Transport Authority (KBA) reports numbers of registered automobiles, utility vehicles and buses, and new registrations of agricultural tractors. The sources for production figures include the German Association of the Automotive Industry (VDA), the German Engineering Federation (VDMA), other statistics and surveys of manufacturers.

Fill amounts for automobile air conditioners are determined via direct surveys of automobile companies. In addition, they are obtained by combining official statistics, information from surveys of automakers and experts' assessments.

4.7.1.3 Uncertainties and time-series consistency (2.F.1 all)

The emission factors are subject to considerable uncertainties. The broad range of emission factors found in the literature (see the refrigeration models) for identical applications is only partly a consequence of technical modifications, of how well systems are sealed or of national differences. To a large extent, it also results from real uncertainties, since too little solid empirical study of such factors has been carried out (ÖKO-RECHERCHE, 2007).

As a result of the aforementioned uncertainty with regard to emission factors, and to the large number of individual applications (systems) involved, the emissions data are considered to be too imprecise. In order to improve the reliability of data provided, the data were compared with manufacturers' (substance-oriented) sales data.

Until the 2001 reporting year, Germany reported only aggregated emissions, covering all sub- source categories. Within the context of emissions surveys for the years 1999 to 2001, and the emissions survey for the 2002 reporting year, the emissions for the reported years 1995 to 1998 were reviewed and updated on the basis of new findings on input quantities and emission factors. All data are thus being improved on an ongoing basis. A comprehensive review of the currentness of the refrigerant models, outset data and emission factors used was carried out in 2012.

The quality of the data on emissions from mobile air conditioning systems is good. The reason for this is that annual HFC consumption can be precisely determined via statistics on registered vehicles and new registrations, and on production, imports and exports of automobiles, which account for the largest part of this sector, as well as via annual model-specific figures on air-conditioner-installation rates and the pertinent fill quantities. Only in the area of commercial vehicles are the data subject to major uncertainties.

The emission factors have been updated on the basis of the results of a study of the Federal Environment Agency (UBA) (ÖKO-RECHERCHE, 2012; SCHWARZ et al., n.y.). In many application areas, the factors show a continuous development throughout the time series. Overall, the EF are considered to be accurate.

The uncertainties for the entire sub- source category of refrigeration and air conditioning systems have been quantified for the 2013 report.

4.7.1.4 Source-specific recalculations (2.F.1 all)

Numerous recalculations were carried out to take account of the use of new refrigerant models with different calculation steps and new basic data, as well as of the first-time inclusion of data for heat-pump dryers. Recalculations were carried out in the areas of commercial refrigeration (sub- source category 2.F.1.b), industrial refrigeration (sub- source category 2.F.1.d), stationary air-conditioning systems (sub- source category 2.F.1.e) and mobile air-conditioning systems of buses, utility vehicles and automobiles (sub- source category 2.F.1.f). The recalculations led to the changes, listed in Table 138 through Table 141, in activity data (AR), emissions (EM) and emission factors for production, use and disposal. The impacts of the model changes are described in detail in a study prepared under commission to the Federal Environment Agency (SCHWARZ et al., n.y.).

Table 138: Overview of the changes, resulting from recalculations, in activity data (AR), emissions (EM) and EF for production, use and disposal, relative to C_2F_6, C_3F_8, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-23 and HFC-32 in commercial refrigeration (sub- source category 2.F.1.b).

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013	C_2F_6	AR_Prod	t	-	-	-	0.54	1.08	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.03	0.06	0.04	0.10
2012	C_2F_6	AR_Prod	t	-	-	-	0.54	1.08	1.08	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	0.27	0.27	0.27	0.27
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-0.98**	**-1.79**	**-1.79**	**-1.79**	**-1.79**	**-1.79**	**-1.79**	**-1.79**	**-1.79**	**-0.24**	**-0.21**	**-0.23**	**-0.17**
2013	C_3F_8	AR_Prod	t	1.00	2.90	7.60	12.39	14.29	14.00	10.00	6.00	4.00	1.00	0.90	0.80	0.70	0.50	0.30	0.30	0.20	0.10
2012	C_3F_8	AR_Prod	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Diff.	**t**	**1.00**	**2.90**	**7.60**	**12.39**	**14.29**	**14.00**	**10.00**	**6.00**	**4.00**	**1.00**	**0.90**	**0.80**	**0.70**	**0.50**	**0.30**	**0.30**	**0.20**	**0.10**
2013	HFC-125	AR_Prod	t	8.39	64.27	117.80	215.05	222.15	227.52	179.66	139.61	151.65	151.47	151.58	154.10	154.89	157.43	158.59	160.52	233.41	222.16
2012	HFC-125	AR_Prod	t	2.95	29.54	97.49	194.97	251.85	297.16	299.16	301.66	303.91	306.41	307.76	307.76	307.76	307.76	307.76	307.76	307.76	307.76
		Diff.	**t**	**5.44**	**34.72**	**20.31**	**20.07**	**-29.70**	**-69.65**	**-119.50**	**-162.05**	**-152.26**	**-154.94**	**-156.19**	**-153.66**	**-152.87**	**-150.34**	**-149.18**	**-147.24**	**-74.35**	**-85.61**
2013	HFC-134a	AR_Prod	t	16.64	47.06	102.49	332.69	344.73	376.92	379.60	280.02	304.47	302.84	305.29	308.85	309.37	311.79	313.29	315.45	346.98	341.61
2012	HFC-134a	AR_Prod	t	21.14	77.21	157.91	241.30	322.48	328.59	332.75	337.95	342.63	347.83	350.64	350.64	350.64	350.64	350.64	350.64	350.64	350.64
		Diff.	**t**	**-4.49**	**-30.15**	**-55.42**	**91.39**	**22.25**	**48.33**	**46.85**	**-57.93**	**-38.16**	**-44.99**	**-45.35**	**-41.79**	**-41.27**	**-38.85**	**-37.35**	**-35.19**	**-3.66**	**-9.03**
2013	HFC-143a	AR_Prod	t	2.40	10.47	34.69	135.22	142.42	163.20	168.98	136.69	154.35	154.19	155.20	157.82	158.65	161.27	162.48	164.50	184.68	183.73
2012	HFC-143a	AR_Prod	t	3.49	34.91	115.21	230.42	296.76	349.12	349.12	349.12	349.12	349.12	349.12	349.12	349.12	349.12	349.12	349.12	349.12	349.12
		Diff.	**t**	**-1.09**	**-24.44**	**-80.52**	**-95.21**	**-154.33**	**-185.93**	**-180.15**	**-212.44**	**-194.78**	**-194.93**	**-193.92**	**-191.30**	**-190.47**	**-187.86**	**-186.64**	**-184.62**	**-164.44**	**-165.40**
2013	HFC-152a	AR_Prod	t	-	-	6.50	13.00	39.00	-	-	-	-	-	-	-	-	-	-	-	-	-
2012	HFC-152a	AR_Prod	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Diff.	**t**	**-**	**-**	**6.50**	**13.00**	**39.00**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
2013	HFC-23	AR_Prod	t	0.50	1.00	1.00	2.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.00	2.00
2012	HFC-23	AR_Prod	t	1.00	1.00	1.00	2.46	2.92	3.92	15.98	15.98	15.98	15.98	15.98	15.98	15.98	15.98	9.73	9.73	9.73	9.73
		Diff.	**t**	**-0.50**	**-**	**-**	**-0.46**	**1.08**	**0.08**	**-11.98**	**-11.98**	**-11.98**	**-11.98**	**-11.98**	**-11.98**	**-11.98**	**-11.98**	**-5.73**	**-5.73**	**-6.73**	**-7.73**
2013	HFC-32	AR_Prod	t	0.33	1.29	4.09	15.30	16.23	18.79	19.95	16.61	18.54	18.49	18.63	18.92	18.99	19.29	19.41	19.62	21.83	21.71
2012	HFC-32	AR_Prod	t	-	-	-	-	0.69	1.61	3.45	5.75	7.82	10.12	11.36	11.36	11.36	11.36	11.36	11.36	11.36	11.36
		Diff.	**t**	**0.33**	**1.29**	**4.09**	**15.30**	**15.54**	**17.18**	**16.50**	**10.86**	**10.72**	**8.37**	**7.27**	**7.55**	**7.63**	**7.93**	**8.05**	**8.26**	**10.47**	**10.35**
2013	C_2F_6	EM_Prod	t	-	-	-	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	C_2F_6	EM_Prod	t	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Diff.	**t**	**-**	**-**	**-**	**0.00**	**0.01**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**0.00**	**-0.00**	**0.00**
2013	C_3F_8	EM_Prod	t	0.01	0.03	0.08	0.12	0.14	0.14	0.10	0.06	0.04	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
2012	C_3F_8	EM_Prod		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Diff.	**t**	**0.01**	**0.03**	**0.08**	**0.12**	**0.14**	**0.14**	**0.10**	**0.06**	**0.04**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**
2013	HFC-125	EM_Prod	t	0.08	0.63	1.15	2.12	2.19	2.25	1.77	1.37	1.49	1.49	1.49	1.51	1.52	1.54	1.56	1.58	2.30	2.19
2012	HFC-125	EM_Prod	t	0.01	0.06	0.19	0.39	0.50	0.59	0.60	0.60	0.61	0.61	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
		Diff.	**t**	**0.07**	**0.57**	**0.95**	**1.73**	**1.69**	**1.65**	**1.17**	**0.76**	**0.88**	**0.87**	**0.87**	**0.90**	**0.90**	**0.93**	**0.94**	**0.96**	**1.69**	**1.58**
2013	HFC-134a	EM_Prod	t	0.11	0.36	0.80	3.09	3.22	3.54	3.56	2.57	2.81	2.80	2.82	2.85	2.86	2.88	2.89	2.91	3.23	3.18
2012	HFC-134a	EM_Prod	t	0.04	0.15	0.32	0.48	0.64	0.66	0.67	0.68	0.69	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
		Diff.	**t**	**0.07**	**0.21**	**0.48**	**2.61**	**2.58**	**2.88**	**2.89**	**1.89**	**2.12**	**2.10**	**2.12**	**2.15**	**2.16**	**2.18**	**2.19**	**2.21**	**2.53**	**2.48**

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013	HFC-143a	EM_Prod	t	0.02	0.09	0.32	1.32	1.40	1.60	1.66	1.34	1.52	1.51	1.52	1.55	1.56	1.58	1.60	1.62	1.82	1.81
2012	HFC-143a	EM_Prod	t	0.01	0.07	0.23	0.46	0.59	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
		Diff.	**t**	**0.01**	**0.02**	**0.09**	**0.86**	**0.80**	**0.90**	**0.96**	**0.64**	**0.82**	**0.82**	**0.82**	**0.85**	**0.86**	**0.88**	**0.90**	**0.92**	**1.12**	**1.11**
2013	HFC-152a	EM_Prod	t	-	-	0.07	0.13	0.39	-	-	-	-	-	-	-	-	-	-	-	-	-
2012	HFC-152a	EM_Prod		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Diff.	**t**	**-**	**-**	**0.07**	**0.13**	**0.39**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
2013	HFC-23	EM_Prod	t	0.01	0.01	0.01	0.02	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.02
2012	HFC-23	EM_Prod	t	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02
		Diff.	**t**	**0.00**	**0.01**	**0.01**	**0.02**	**0.03**	**0.03**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.02**	**0.01**	**0.00**
2013	HFC-32	EM_Prod	t	0.00	0.01	0.04	0.15	0.16	0.18	0.20	0.16	0.18	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.21	0.21
2012	HFC-32	EM_Prod	t	-	-	-	-	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
		Diff.	**t**	**0.00**	**0.01**	**0.04**	**0.15**	**0.16**	**0.18**	**0.19**	**0.15**	**0.17**	**0.16**	**0.16**	**0.16**	**0.16**	**0.17**	**0.17**	**0.17**	**0.19**	**0.19**
2013		EF_Prod	[1]	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01	0.005-0.01
2012		EF_Prod	[1]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Diff.	**%**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**	**+60 to +80**
2013	C_2F_6	AR_Use	t	-	-	-	0.54	1.62	1.72	1.82	1.92	2.02	2.12	2.22	2.32	2.42	1.98	0.93	0.90	0.83	0.84
2012	C_2F_6	AR_Use	t	-	-	-	0.27	1.08	2.16	3.64	5.53	7.42	9.31	11.20	13.09	14.98	16.60	16.87	16.06	14.85	13.23
		Diff.	**t**	**-**	**-**	**-**	**0.27**	**0.54**	**-0.44**	**-1.82**	**-3.61**	**-5.40**	**-7.19**	**-8.98**	**-10.77**	**-12.56**	**-14.62**	**-15.94**	**-15.16**	**-14.01**	**-12.39**
2013	C_3F_8	AR_Use	t	1.00	3.90	11.50	23.89	38.18	52.18	62.18	68.18	72.18	73.18	73.08	70.98	64.08	52.19	38.20	24.50	14.70	8.80
2012	C_3F_8	AR_Use	t	0.50	2.45	7.70	17.70	31.04	47.73	61.17	67.46	72.25	76.19	77.23	75.28	70.03	60.04	46.70	30.01	16.57	10.28
		Diff.	**t**	**0.50**	**1.45**	**3.80**	**6.20**	**7.15**	**4.46**	**1.02**	**0.73**	**-0.06**	**-3.01**	**-4.15**	**-4.30**	**-5.95**	**-7.85**	**-8.50**	**-5.51**	**-1.87**	**-1.48**
2013	HFC-125	AR_Use	t	8.45	73.37	193.69	468.48	780.47	1,088.49	1,329.81	1,392.33	1,462.50	1,533.39	1,605.00	1,644.44	1,637.95	1,653.95	1,694.60	1,769.61	1,989.30	2,194.21
2012	HFC-125	AR_Use	t	4.48	50.72	185.44	422.27	742.88	1,109.29	1,468.40	1,791.61	2,097.80	2,403.86	2,704.73	2,959.64	3,121.69	3,183.82	3,173.17	3,125.53	3,085.18	3,074.13
		Diff.	**t**	**3.97**	**22.65**	**8.25**	**46.21**	**37.59**	**-20.80**	**-138.59**	**-399.28**	**-635.31**	**-870.47**	**-1,099.73**	**-1,315.20**	**-1,483.74**	**-1,529.87**	**-1,478.57**	**-1,355.93**	**-1,095.88**	**-879.92**
2013	HFC-134a	AR_Use	t	16.50	62.17	158.00	649.21	1,206.57	1,775.31	2,299.04	2,391.10	2,500.00	2,607.06	2,732.89	2,869.68	2,954.40	3,071.79	3,257.85	3,472.31	3,713.01	3,901.77
2012	HFC-134a	AR_Use	t	10.57	59.74	207.50	507.70	960.79	1,487.72	1,969.39	2,355.14	2,695.43	3,040.66	3,349.13	3,549.99	3,611.87	3,561.51	3,479.26	3,453.96	3,473.93	3,489.22
		Diff.	**t**	**5.93**	**2.43**	**-49.50**	**141.51**	**245.79**	**287.59**	**329.64**	**35.96**	**-195.43**	**-433.61**	**-616.24**	**-680.31**	**-657.47**	**-489.72**	**-221.41**	**18.35**	**239.08**	**412.56**
2013	HFC-143a	AR_Use	t	2.56	14.79	56.44	247.95	483.35	729.85	962.66	1,019.63	1,089.72	1,160.65	1,239.19	1,334.40	1,413.33	1,515.37	1,643.14	1,791.07	1,935.67	2,064.95
2012	HFC-143a	AR_Use	t	1.75	20.95	98.61	279.23	558.41	899.56	1,261.68	1,616.00	1,965.13	2,314.25	2,659.03	2,981.15	3,239.62	3,397.73	3,470.26	3,491.25	3,491.25	3,491.25
		Diff.	**t**	**0.82**	**-6.16**	**-42.17**	**-31.27**	**-75.06**	**-169.71**	**-299.02**	**-596.37**	**-875.41**	**-1,153.60**	**-1,419.85**	**-1,646.75**	**-1,826.29**	**-1,882.35**	**-1,827.12**	**-1,700.18**	**-1,555.58**	**-1,426.29**
2013	HFC-152a	AR_Use	t	-	-	6.50	19.50	58.50	58.50	58.50	58.50	58.50	58.50	58.50	58.50	52.00	39.00	-	-	-	-
2012	HFC-152a	AR_Use	t	-	-	3.25	13.00	39.00	71.50	91.00	100.00	102.50	102.50	99.25	89.50	63.50	31.00	11.50	2.50	-	-
		Diff.	**t**	**-**	**-**	**3.25**	**6.50**	**19.50**	**-13.00**	**-32.50**	**-41.50**	**-44.00**	**-44.00**	**-40.75**	**-31.00**	**-11.50**	**8.00**	**-11.50**	**-2.50**	**-**	**-**
2013	HFC-23	AR_Use	t	0.50	1.50	2.50	4.50	8.50	12.50	16.50	20.50	24.50	28.50	32.00	35.00	38.00	40.00	40.00	40.00	39.00	37.00
2012	HFC-23	AR_Use	t	0.50	1.50	2.50	4.23	6.92	10.34	20.29	36.27	52.26	68.24	83.73	98.71	113.70	127.95	138.12	144.43	144.21	137.96
		Diff.	**t**	**-**	**-**	**-**	**0.27**	**1.58**	**2.16**	**-3.79**	**-15.77**	**-27.76**	**-39.74**	**-51.73**	**-63.71**	**-75.70**	**-87.95**	**-98.12**	**-104.43**	**-105.21**	**-100.96**
2013	HFC-32	AR_Use	t	0.26	0.79	1.78	28.22	54.72	82.73	109.71	117.46	126.61	135.80	146.06	157.90	167.77	180.33	195.55	212.88	229.55	244.43
2012	HFC-32	AR_Use	t	-	-	-	-	0.35	1.50	4.03	8.63	15.41	24.38	35.12	46.48	57.85	69.21	80.22	90.44	99.27	106.03
		Diff.	**t**	**0.26**	**0.79**	**1.78**	**28.22**	**54.37**	**81.24**	**105.68**	**108.83**	**111.20**	**111.42**	**110.94**	**111.42**	**109.92**	**111.13**	**115.33**	**122.44**	**130.28**	**138.40**

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013	C_2F_6	EM_Use	t	-	-	-	0.10	0.30	0.31	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.32	0.15	0.14	0.13	0.13
2012	C_2F_6	EM_Use	t	-	-	-	0.03	0.11	0.22	0.36	0.55	0.74	0.93	1.12	1.31	1.50	1.66	1.69	1.61	1.48	1.32
		Diff.	**t**	**-**	**-**	**-**	**0.07**	**0.19**	**0.10**	**-0.04**	**-0.21**	**-0.39**	**-0.57**	**-0.75**	**-0.92**	**-1.10**	**-1.34**	**-1.54**	**-1.47**	**-1.36**	**-1.20**
2013	C_3F_8	EM_Use	t	0.19	0.75	2.18	4.46	7.03	9.47	11.13	12.02	12.54	12.52	12.31	11.77	10.46	8.38	6.03	3.80	2.24	1.32
2012	C_3F_8	EM_Use	t	0.08	0.37	1.16	2.65	4.66	7.16	9.17	10.12	10.84	11.43	11.58	11.29	10.50	9.01	7.00	4.50	2.48	1.54
		Diff.	**t**	**0.12**	**0.38**	**1.02**	**1.81**	**2.38**	**2.32**	**1.95**	**1.90**	**1.70**	**1.09**	**0.72**	**0.48**	**-0.05**	**-0.63**	**-0.97**	**-0.70**	**-0.24**	**-0.22**
2013	HFC-125	EM_Use	t	1.36	13.20	34.53	82.41	134.09	181.48	213.44	214.50	216.34	217.98	218.65	213.63	201.65	192.11	190.85	194.55	214.91	229.08
2012	HFC-125	EM_Use	t	0.59	6.61	23.24	50.53	86.04	125.55	162.65	194.24	223.16	251.95	279.94	301.84	312.47	312.77	306.50	297.55	291.02	288.99
		Diff.	**t**	**0.77**	**6.59**	**11.29**	**31.88**	**48.04**	**55.92**	**50.80**	**20.26**	**-6.82**	**-33.97**	**-61.29**	**-88.21**	**-110.82**	**-120.66**	**-115.65**	**-103.00**	**-76.11**	**-59.92**
2013	HFC-134a	EM_Use	t	1.09	5.51	15.04	93.76	178.99	259.00	324.77	317.26	312.29	307.32	303.64	304.21	300.42	299.59	316.58	336.80	356.09	362.75
2012	HFC-134a	EM_Use	t	0.90	5.10	19.60	51.70	101.50	159.50	210.50	246.80	276.10	305.90	330.70	341.80	336.40	319.50	303.20	298.10	300.10	301.60
		Diff.	**t**	**0.19**	**0.41**	**-4.56**	**42.06**	**77.49**	**99.50**	**114.27**	**70.46**	**36.19**	**1.42**	**-27.06**	**-37.59**	**-35.98**	**-19.91**	**13.38**	**38.70**	**55.99**	**61.15**
2013	HFC-143a	EM_Use	t	0.21	1.95	8.50	41.16	79.22	116.09	147.33	148.30	151.03	153.56	156.29	161.34	163.98	168.68	181.51	196.61	208.37	214.30
2012	HFC-143a	EM_Use	t	0.16	1.96	9.38	26.74	53.78	86.76	121.42	154.91	187.61	220.32	252.48	282.21	305.55	319.34	325.40	327.07	327.07	327.07
		Diff.	**t**	**0.05**	**-0.01**	**-0.88**	**14.42**	**25.44**	**29.33**	**25.91**	**-6.61**	**-36.59**	**-66.76**	**-96.19**	**-120.87**	**-141.57**	**-150.65**	**-143.89**	**-130.46**	**-118.70**	**-112.78**
2013	HFC-152a	EM_Use	t	-	-	1.23	3.64	10.78	10.62	10.47	10.31	10.16	10.01	9.85	9.70	8.48	6.26	-	-	-	-
2012	HFC-152a	EM_Use	t	-	-	0.49	1.95	5.85	10.73	13.65	15.00	15.38	15.38	14.89	13.43	9.53	4.65	1.73	0.38	-	-
		Diff.	**t**	**-**	**-**	**0.74**	**1.69**	**4.93**	**-0.10**	**-3.18**	**-4.69**	**-5.21**	**-5.37**	**-5.03**	**-3.73**	**-1.04**	**1.61**	**-1.73**	**-0.38**	**-**	**-**
2013	HFC-23	EM_Use	t	0.05	0.14	0.22	0.39	0.72	1.02	1.30	1.56	1.81	2.03	2.19	2.30	2.40	2.42	2.32	2.21	2.05	1.85
2012	HFC-23	EM_Use	t	0.03	0.08	0.13	0.22	0.39	0.61	1.17	2.05	2.93	3.81	4.66	5.49	6.32	7.10	7.62	7.91	7.84	7.46
		Diff.	**t**	**0.02**	**0.06**	**0.10**	**0.17**	**0.32**	**0.41**	**0.13**	**-0.48**	**-1.12**	**-1.78**	**-2.47**	**-3.19**	**-3.92**	**-4.68**	**-5.31**	**-5.70**	**-5.79**	**-5.61**
2013	HFC-32	EM_Use	t	0.01	0.02	0.05	4.58	8.81	12.94	16.49	16.70	17.10	17.47	17.87	18.52	18.88	19.48	20.97	22.69	24.02	24.69
2012	HFC-32	EM_Use	t	-	-	-	-	0.03	0.15	0.40	0.86	1.54	2.44	3.51	4.65	5.78	6.92	8.02	9.04	9.93	10.60
		Diff.	**t**	**0.01**	**0.02**	**0.05**	**4.58**	**8.78**	**12.79**	**16.08**	**15.84**	**15.56**	**15.03**	**14.36**	**13.87**	**13.10**	**12.56**	**12.95**	**13.65**	**14.09**	**14.09**
2013		EF_Use plug-in	[1]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2012		EF_Use plug-in	[1]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
		Diff.	**%**	**-3.85**	**-5.88**	**-8.00**	**-10.20**	**-12.50**	**-14.89**	**-17.39**	**-20.00**	**-22.73**	**-25.58**	**-28.57**	**-31.71**	**-35.00**	**-38.46**	**-42.11**	**-45.95**	**-50.00**	**-50.00**
2013		EF_Use cond. units	[1]	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07
2012		EF_Use cond. units	[1]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Diff.	**%**	**48.37**	**47.51**	**46.63**	**45.71**	**44.77**	**43.79**	**42.77**	**41.72**	**40.62**	**39.49**	**38.31**	**37.09**	**35.81**	**34.48**	**33.33**	**31.90**	**30.40**	**28.57**
2013		EF_Use cent. sys.	[1]	0.095-0.195	0.092-0.192	0.089-0.190	0.087-0.187	0.084-0.184	0.082-0.182	0.079-0.179	0.076-0.176	0.074-0.174	0.071-0.171	0.068-0.168	0.066-0.166	0.063-0.163	0.061-0.161	0.058-0.158	0.055-0.155	0.053-0.153	0.05-0.15
2012		EF_Use cent. sys.	[1]	0.1-0.18	0.1-0.19	0.1-0.20	0.1-0.21	0.1-0.22	0.1-0.23	0.1-0.24	0.1-0.25	0.1-0.26	0.1-0.27	0.1-0.28	0.1-0.29	0.1-0.30	0.1-0.31	0.1-0.32	0.1-0.33	0.1-0.34	0.1-0.35
		Diff.	**%**	**-58 to +49**	**-63 to +48**	**-68 to +47**	**-73 to +47**	**-78 to +46**	**-84 to +45**	**-90 to +44**	**-97 to +43**	**-104 to +42**	**-111 to +42**	**-119 to +41**	**-128 to +40**	**-138 to +39**	**-148 to +38**	**-159 to +37**	**-171 to +36**	**-185 to +34**	**-200 to +33**

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013	C_2F_6	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	-	-	-	0.47	0.94	0.09	0.09	0.09
2012	C_2F_6	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	-	-	-	0.54	1.08	1.08	1.89	1.89
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-0.07**	**-0.13**	**-0.99**	**-1.80**	**-1.80**
2013	C_3F_8	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	0.88	2.54	6.65	10.84	12.50	12.25	8.75	5.25
2012	C_3F_8	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	1.00	2.90	7.60	12.39	14.29	19.09	7.79	4.79
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-0.13**	**-0.36**	**-0.95**	**-1.55**	**-1.79**	**-6.84**	**0.96**	**0.46**
2013	HFC-125	AR_Disp.	t	-	-	-	-	-	-	-	29.96	29.96	29.96	36.47	79.77	108.88	106.58	96.31	82.74	48.17	63.08
2012	HFC-125	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	13.35	92.34	199.09	292.17	344.65	366.16	330.06	307.56
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**29.96**	**29.96**	**29.96**	**23.12**	**-12.57**	**-90.21**	**-185.59**	**-248.34**	**-283.43**	**-281.90**	**-244.48**
2013	HFC-134a	AR_Disp.	t	-	-	-	-	-	-	-	71.10	71.10	71.10	81.29	91.78	112.87	107.84	85.91	87.76	102.55	154.52
2012	HFC-134a	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	81.54	218.01	359.51	442.50	423.28	328.59	332.75	337.95
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**71.10**	**71.10**	**71.10**	**-0.25**	**-126.23**	**-246.64**	**-334.66**	**-337.37**	**-240.83**	**-230.20**	**-183.43**
2013	HFC-143a	AR_Disp.	t	-	-	-	-	-	-	-	31.00	31.00	31.00	32.26	33.55	36.39	33.99	23.35	22.79	35.79	59.21
2012	HFC-143a	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	8.69	45.31	136.01	246.02	307.16	349.12	349.12	349.12
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**31.00**	**31.00**	**31.00**	**23.56**	**-11.76**	**-99.62**	**-212.03**	**-283.80**	**-326.33**	**-313.33**	**-289.91**
2013	HFC-152a	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	-	-	5.69	11.38	34.13	-	-	-
2012	HFC-152a	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	6.50	13.00	39.00	26.00	13.00	5.00	-	-
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-6.50**	**-13.00**	**-33.31**	**-14.63**	**21.13**	**-5.00**	**-**	**-**
2013	HFC-23	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	0.44	0.88	0.88	1.75	3.50	3.50	3.50	3.50
2012	HFC-23	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	1.00	1.00	1.00	2.46	2.92	3.92	15.98	15.98
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-0.56**	**-0.13**	**-0.13**	**-0.71**	**0.58**	**-0.42**	**-12.48**	**-12.48**
2013	HFC-32	AR_Disp.	t	-	-	-	-	-	-	-	3.43	3.43	3.43	3.61	3.80	4.22	3.97	2.81	2.83	4.38	7.19
2012	HFC-32	AR_Disp.	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.69	1.61	3.45	5.75
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3.43**	**3.43**	**3.43**	**3.61**	**3.80**	**4.22**	**3.97**	**2.12**	**1.22**	**0.93**	**1.44**
2013	C_2F_6	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	-	-	-	0.27	0.52	0.05	0.05	0.04
2012	C_2F_6	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16	0.32	0.32	0.57	0.57
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.10**	**0.19**	**-0.28**	**-0.52**	**-0.52**
2013	C_3F_8	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	0.53	1.51	3.85	6.11	6.84	6.51	4.51	2.63
2012	C_3F_8	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	0.50	1.45	3.80	6.20	7.15	9.55	3.90	2.40
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.03**	**0.06**	**0.05**	**-0.09**	**-0.30**	**-3.03**	**0.62**	**0.23**
2013	HFC-125	EM_Disp.	t	-	-	-	-	-	-	-	17.12	16.26	15.41	18.61	43.50	58.89	55.95	50.02	41.42	19.65	20.73
2012	HFC-125	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	6.09	40.26	80.05	107.09	121.96	123.65	105.20	93.45
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**17.12**	**16.26**	**15.41**	**12.52**	**3.24**	**-21.16**	**-51.14**	**-71.93**	**-82.23**	**-85.55**	**-72.72**
2013	HFC-134a	EM_Disp.	t	-	-	-	-	-	-	-	40.63	38.60	36.57	41.40	46.22	57.65	53.41	42.61	42.05	45.36	57.06
2012	HFC-134a	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	36.50	93.60	148.20	173.00	147.10	98.60	99.80	101.40
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**40.63**	**38.60**	**36.57**	**4.90**	**-47.38**	**-90.55**	**-119.59**	**-104.49**	**-56.55**	**-54.44**	**-44.34**
2013	HFC-143a	EM_Disp.	t	-	-	-	-	-	-	-	17.71	16.83	15.94	15.90	15.86	16.76	14.92	9.98	9.45	13.08	18.44
2012	HFC-143a	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	3.65	15.67	44.96	76.93	94.23	104.74	104.74	104.74
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**17.71**	**16.83**	**15.94**	**12.26**	**0.19**	**-28.20**	**-62.01**	**-84.25**	**-95.29**	**-91.66**	**-86.29**
2013	HFC-152a	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	-	-	3.29	6.41	18.68	-	-	-
2012	HFC-152a	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	3.25	6.50	19.50	13.00	6.50	2.50	-	-
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-3.25**	**-6.50**	**-16.21**	**-6.59**	**12.18**	**-2.50**	**-**	**-**
2013	HFC-23	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	0.20	0.37	0.35	0.64	1.18	1.08	0.98	0.88

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2012	HFC-23	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	0.30	0.30	0.30	0.74	0.88	1.18	4.80	4.80
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-0.10**	**0.07**	**0.05**	**-0.10**	**0.30**	**-0.10**	**-3.82**	**-3.92**
2013	HFC-32	EM_Disp.	t	-	-	-	-	-	-	-	1.96	1.86	1.76	1.79	1.82	1.98	1.78	1.24	1.22	1.67	2.33
2012	HFC-32	EM_Disp.	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21	0.48	1.04	1.73
		Diff.	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1.96**	**1.86**	**1.76**	**1.79**	**1.82**	**1.98**	**1.78**	**1.03**	**0.74**	**0.63**	**0.61**
2013		EF_Disposal plug-in units	[1]	-	-	-	-	-	-	-	0.63	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54
2013		EF_Disposal condensing units	[1]	-	-	-	-	-	-	-	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.41	0.40	0.34
2013		EF_Disposal central systems	[1]	-	-	-	-	-	-	-	0.50	0.48	0.45	0.43	0.40	0.38	0.35	0.32	0.28	0.25	0.22
2012		EF_Disposal	[1]	-	-	-	-	-	-	-	0.3-0.5	0.3-0.5	0.3-0.5	0.3-0.5	0.3-0.5	0.3-0.5	0.3-0.5	0.3-0.5	0.3-0.5	0.3-0.5	0.3-0.5
		Diff.	**%**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0 to +53**	**-5 to +52**	**-11 to +51**	**-18 to +51**	**-25 to +50**	**-33 to +49**	**-43 to +48**	**-58 to +47**	**-76 to +46**	**-99 to +45**	**-129 to +44**

Table 139: Overview of the changes, resulting from recalculations, in activity data (AR), emissions (EM) and EF for production, use and disposal, relative to C_2F_6, HFC-125, HFC-134a, HFC-143a, HFC-227ea, HFC-23 and HFC-32 in industrial refrigeration (sub- source category 2.F.1.d).

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013	C_2F_6	AR_Prod	t	-	-	-	-	-	-	-	0.10	0.10	0.10	0.10	0.10	0.10	0.10	-	-	-	-
2012	C_2F_6	AR_Prod	t	-	-	-	0.50	0.60	0.70	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50
		Difference	**t**	**-**	**-**	**-**	**-0.50**	**-0.60**	**-0.70**	**-0.80**	**-0.90**	**-0.90**	**-0.90**	**-0.90**	**-0.90**	**-0.90**	**-0.90**	**-0.50**	**-0.50**	**-0.50**	**-0.50**
2013	HFC-125	AR_Prod	t	1.51	6.24	24.45	128.21	258.83	397.47	551.76	720.59	855.69	924.92	982.06	1,043.46	1,097.75	1,146.35	1,197.48	1,329.16	1,499.74	1,777.69
2012	HFC-125	AR_Prod	t	2.95	5.65	28.90	55.30	90.14	135.39	142.34	142.34	142.34	142.34	142.34	142.23	142.34	142.34	142.34	142.34	142.34	142.34
		Difference	**t**	**-1.44**	**0.59**	**-4.45**	**72.91**	**168.68**	**262.08**	**409.43**	**578.25**	**713.35**	**782.58**	**839.73**	**901.24**	**955.41**	**1,004.01**	**1,055.14**	**1,186.82**	**1,357.41**	**1,635.35**
2013	HFC-134a	AR_Prod	t	8.54	46.50	116.29	388.82	667.41	948.74	1,235.48	1,527.07	1,748.83	1,819.79	1,886.72	1,950.15	1,997.24	2,013.64	2,030.98	2,085.23	2,157.22	2,276.99
2012	HFC-134a	AR_Prod	t	9.76	28.00	57.60	125.00	197.65	238.74	175.76	175.76	175.76	175.76	175.76	175.75	175.76	175.75	175.75	175.75	175.75	175.76
		Difference	**t**	**-1.22**	**18.50**	**58.69**	**263.82**	**469.75**	**710.00**	**1,059.72**	**1,351.31**	**1,573.07**	**1,644.03**	**1,710.96**	**1,774.40**	**1,821.49**	**1,837.89**	**1,855.23**	**1,909.48**	**1,981.47**	**2,101.23**
2013	HFC-143a	AR_Prod	t	1.56	6.46	25.30	132.67	267.84	411.31	570.98	745.68	885.49	957.13	1,016.26	1,079.80	1,135.98	1,186.27	1,239.18	1,306.84	1,382.14	1,488.09
2012	HFC-143a	AR_Prod	t	2.60	5.20	31.20	62.40	102.10	154.10	159.35	159.35	159.35	159.35	159.35	159.22	159.35	159.35	159.35	159.35	159.35	159.35
		Difference	**t**	**-1.04**	**1.26**	**-5.90**	**70.27**	**165.74**	**257.21**	**411.63**	**586.33**	**726.14**	**797.78**	**856.91**	**920.58**	**976.63**	**1,026.92**	**1,079.83**	**1,147.48**	**1,222.79**	**1,328.74**
2013	HFC-227ea	AR_Prod	t	0.13	0.38	2.13	7.38	13.63	19.63	24.63	28.63	31.63	34.63	37.50	40.25	41.50	39.25	34.10	29.50	26.60	23.35
2012	HFC-227ea	AR_Prod	t	0.25	0.25	3.25	5.25	6.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	2.00	2.00	2.00	2.00
		Difference	**t**	**-0.13**	**0.13**	**-1.13**	**2.13**	**7.38**	**12.38**	**17.38**	**21.38**	**24.38**	**27.38**	**30.25**	**33.00**	**34.25**	**32.00**	**32.10**	**27.50**	**24.60**	**21.35**
2013	HFC-23	AR_Prod	t	1.50	5.00	9.50	15.50	21.50	26.50	31.00	35.50	40.00	44.50	47.50	48.50	48.50	47.00	45.50	45.00	45.00	45.00
2012	HFC-23	AR_Prod	t	3.00	4.00	5.00	6.00	7.00	9.00	9.50	9.50	9.50	9.50	9.50	9.50	9.50	9.50	6.00	6.00	6.00	6.00
		Difference	**t**	**-1.50**	**1.00**	**4.50**	**9.50**	**14.50**	**17.50**	**21.50**	**26.00**	**30.50**	**35.00**	**38.00**	**39.00**	**39.00**	**37.50**	**39.50**	**39.00**	**39.00**	**39.00**
2013	HFC-32	AR_Prod	t	0.17	0.71	2.80	14.67	29.62	45.48	63.14	82.46	97.92	105.84	112.38	119.40	125.61	131.17	137.03	144.51	152.83	164.55
2012	HFC-32	AR_Prod	t	0.69	1.15	2.30	2.30	3.45	4.60	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90
		Difference	**t**	**-0.52**	**-0.44**	**0.50**	**12.37**	**26.17**	**40.88**	**56.24**	**75.56**	**91.02**	**98.94**	**105.48**	**112.50**	**118.71**	**124.27**	**130.13**	**137.61**	**145.93**	**157.65**
2013	C_2F_6	EM_Prod	t	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-
2012	C_2F_6	EM_Prod	t	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Difference	**t**	**-**	**-**	**-**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**	**-0.00**
2013	HFC-125	EM_Prod	t	0.02	0.05	0.18	0.73	0.75	0.84	0.98	1.14	0.96	0.66	0.66	0.67	0.67	0.67	0.68	1.46	1.84	2.69
2012	HFC-125	EM_Prod	t	0.00	0.01	0.04	0.08	0.14	0.20	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
		Difference	**t**	**0.01**	**0.04**	**0.14**	**0.65**	**0.62**	**0.64**	**0.77**	**0.93**	**0.75**	**0.45**	**0.45**	**0.46**	**0.46**	**0.46**	**0.46**	**1.25**	**1.63**	**2.47**
2013	HFC-134a	EM_Prod	t	0.05	0.20	0.38	1.43	1.41	1.44	1.48	1.52	1.17	0.64	0.64	0.64	0.64	0.64	0.64	1.00	1.18	1.56
2012	HFC-134a	EM_Prod	t	0.01	0.04	0.09	0.19	0.30	0.36	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
		Difference	**t**	**0.04**	**0.16**	**0.29**	**1.24**	**1.11**	**1.08**	**1.22**	**1.26**	**0.91**	**0.38**	**0.38**	**0.38**	**0.38**	**0.38**	**0.38**	**0.74**	**0.92**	**1.30**
2013	HFC-143a	EM_Prod	t	0.02	0.05	0.19	0.76	0.78	0.87	1.01	1.18	0.99	0.68	0.69	0.69	0.69	0.69	0.70	0.84	0.91	1.07
2012	HFC-143a	EM_Prod	t	0.00	0.01	0.05	0.09	0.15	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
		Difference	**t**	**0.01**	**0.04**	**0.14**	**0.66**	**0.63**	**0.64**	**0.78**	**0.94**	**0.75**	**0.45**	**0.45**	**0.45**	**0.45**	**0.45**	**0.46**	**0.60**	**0.67**	**0.83**
2013	HFC-227ea	EM_Prod	t	0.00	0.00	0.02	0.05	0.06	0.06	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.01	0.02	0.01
2012	HFC-227ea	EM_Prod	t	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
		Difference	**t**	**0.00**	**0.00**	**0.01**	**0.04**	**0.05**	**0.05**	**0.04**	**0.03**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	**0.01**	**0.02**	**0.00**

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013	HFC-23	EM_Prod	t	0.02	0.04	0.05	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
2012	HFC-23	EM_Prod	t	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		Difference	**t**	**0.01**	**0.03**	**0.04**	**0.05**	**0.05**	**0.04**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.04**	**0.04**	**0.04**	**0.04**
2013	HFC-32	EM_Prod	t	0.00	0.01	0.02	0.08	0.09	0.10	0.11	0.13	0.11	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.10	0.12
2012	HFC-32	EM_Prod	t	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		Difference	**t**	**0.00**	**0.00**	**0.02**	**0.08**	**0.08**	**0.09**	**0.10**	**0.12**	**0.10**	**0.07**	**0.07**	**0.07**	**0.07**	**0.07**	**0.07**	**0.08**	**0.09**	**0.11**
2013		EF_Prod systems	[1]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2013		EF_Prod plug-in units	[1]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2012		EF_Prod old	[1]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Difference	**%**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**	**+70 to +85**
2013	C_2F_6	AR_Use	t	-	-	-	0.50	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	1.50	0.90	0.80	0.70	0.60
2012	C_2F_6	AR_Use	t	-	-	-	0.25	0.80	1.45	2.20	3.10	4.10	5.10	6.10	7.10	8.10	8.85	9.05	8.90	8.65	8.25
		Difference	**t**	**-**	**-**	**-**	**0.25**	**0.30**	**-0.25**	**-0.90**	**-1.70**	**-2.60**	**-3.50**	**-4.40**	**-5.30**	**-6.20**	**-7.35**	**-8.15**	**-8.10**	**-7.95**	**-7.65**
2013	HFC-125	AR_Use	t	1.51	6.24	24.45	128.21	258.83	397.47	551.76	720.59	855.69	924.92	982.06	1,043.46	1,097.75	1,146.35	1,197.48	1,329.16	1,499.74	1,777.69
2012	HFC-125	AR_Use	t	1.48	5.78	23.05	65.15	137.87	250.64	389.51	531.85	674.18	816.52	957.38	1,095.37	1,220.37	1,320.61	1,390.23	1,419.80	1,423.27	1,423.27
		Difference	**t**	**0.03**	**0.46**	**1.40**	**63.06**	**120.96**	**146.83**	**162.26**	**188.74**	**181.51**	**108.40**	**24.68**	**-51.90**	**-122.62**	**-174.26**	**-192.75**	**-90.63**	**76.47**	**354.42**
2013	HFC-134a	AR_Use	t	8.54	46.50	116.29	388.82	667.41	948.74	1,235.48	1,527.07	1,748.83	1,819.79	1,886.72	1,950.15	1,997.24	2,013.64	2,030.98	2,085.23	2,157.22	2,276.99
2012	HFC-134a	AR_Use	t	4.88	23.76	66.56	157.86	319.19	537.38	744.63	920.39	1,096.16	1,271.92	1,442.80	1,599.68	1,732.63	1,817.09	1,831.51	1,789.07	1,757.58	1,757.58
		Difference	**t**	**3.66**	**22.74**	**49.73**	**230.96**	**348.22**	**411.36**	**490.85**	**606.68**	**652.67**	**547.88**	**443.92**	**350.47**	**264.61**	**196.55**	**199.47**	**296.16**	**399.65**	**519.42**
2013	HFC-143a	AR_Use	t	1.56	6.46	25.30	132.67	267.84	411.31	570.98	745.68	885.49	957.13	1,016.26	1,079.80	1,135.98	1,186.27	1,239.18	1,306.84	1,382.14	1,488.09
2012	HFC-143a	AR_Use	t	1.30	5.20	23.40	70.20	152.45	280.55	437.28	596.64	755.99	915.34	1,073.40	1,228.78	1,369.87	1,482.43	1,559.53	1,590.78	1,593.41	1,593.41
		Difference	**t**	**0.26**	**1.26**	**1.90**	**62.47**	**115.39**	**130.76**	**133.70**	**149.05**	**129.50**	**41.79**	**-57.13**	**-148.98**	**-233.89**	**-296.15**	**-320.35**	**-283.95**	**-211.27**	**-105.31**
2013	HFC-227ea	AR_Use	t	0.13	0.38	2.13	7.38	13.63	19.63	24.63	28.63	31.63	34.63	37.50	40.25	41.50	39.25	34.10	29.50	26.60	23.35
2012	HFC-227ea	AR_Use	t	0.13	0.38	2.13	6.38	12.13	18.88	26.13	33.38	40.63	47.88	55.00	62.00	67.50	70.50	69.38	64.63	59.38	54.13
		Difference	**t**	**-**	**-**	**-**	**1.00**	**1.50**	**0.75**	**-1.50**	**-4.75**	**-9.00**	**-13.25**	**-17.50**	**-21.75**	**-26.00**	**-31.25**	**-35.28**	**-35.13**	**-32.78**	**-30.78**
2013	HFC-23	AR_Use	t	1.50	5.00	9.50	15.50	21.50	26.50	31.00	35.50	40.00	44.50	47.50	48.50	48.50	47.00	45.50	45.00	45.00	45.00
2012	HFC-23	AR_Use	t	1.50	5.00	9.50	15.00	21.50	29.50	38.75	48.25	57.75	67.25	75.25	81.25	86.25	90.25	91.50	89.50	86.25	82.75
		Difference	**t**	**-**	**-**	**-**	**0.50**	**-**	**-3.00**	**-7.75**	**-12.75**	**-17.75**	**-22.75**	**-27.75**	**-32.75**	**-37.75**	**-43.25**	**-46.00**	**-44.50**	**-41.25**	**-37.75**
2013	HFC-32	AR_Use	t	0.17	0.71	2.80	14.67	29.62	45.48	63.14	82.46	97.92	105.84	112.38	119.40	125.61	131.17	137.03	144.51	152.83	164.55
2012	HFC-32	AR_Use	t	0.35	1.27	2.99	5.29	8.17	12.19	17.94	24.84	31.74	38.64	45.20	51.18	56.35	60.95	64.98	67.85	69.00	69.00
		Difference	**t**	**-0.17**	**-0.55**	**-0.19**	**9.38**	**21.45**	**33.29**	**45.20**	**57.62**	**66.18**	**67.20**	**67.18**	**68.23**	**69.26**	**70.22**	**72.05**	**76.66**	**83.83**	**95.55**
2013	C_2F_6	EM_Use	t	-	-	-	0.04	0.09	0.10	0.11	0.11	0.12	0.13	0.13	0.14	0.15	0.11	0.07	0.06	0.05	0.04
2012	C_2F_6	EM_Use	t	-	-	-	0.02	0.06	0.10	0.15	0.22	0.29	0.36	0.43	0.50	0.57	0.62	0.63	0.62	0.61	0.58
		Difference	**t**	**-**	**-**	**-**	**0.03**	**0.04**	**-0.00**	**-0.05**	**-0.10**	**-0.17**	**-0.23**	**-0.29**	**-0.36**	**-0.42**	**-0.51**	**-0.57**	**-0.57**	**-0.56**	**-0.54**
2013	HFC-125	EM_Use	t	0.13	0.54	2.11	10.94	21.85	33.18	45.54	58.80	69.03	73.75	77.39	81.25	84.45	87.12	87.72	93.71	101.61	115.55
2012	HFC-125	EM_Use	t	0.10	0.40	1.61	4.56	9.65	17.54	27.27	37.23	47.19	57.16	67.02	76.68	85.43	92.44	97.32	99.39	99.63	99.63
		Difference	**t**	**0.03**	**0.14**	**0.50**	**6.38**	**12.19**	**15.63**	**18.27**	**21.57**	**21.83**	**16.59**	**10.37**	**4.58**	**-0.97**	**-5.32**	**-9.60**	**-5.68**	**1.98**	**15.92**

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013	HFC-134a	EM_Use	t	0.75	3.71	8.31	28.07	47.89	67.48	87.06	106.56	119.94	120.95	121.57	122.17	122.39	122.08	118.99	118.40	118.72	121.88
2012	HFC-134a	EM_Use	t	0.34	1.66	4.66	11.05	22.34	37.62	52.12	64.43	76.73	89.03	101.00	111.98	121.28	127.20	128.21	125.24	123.03	123.03
		Difference	**t**	**0.41**	**2.04**	**3.65**	**17.02**	**25.55**	**29.87**	**34.93**	**42.13**	**43.21**	**31.91**	**20.57**	**10.19**	**1.11**	**-5.11**	**-9.22**	**-6.83**	**-4.31**	**-1.15**
2013	HFC-143a	EM_Use	t	0.14	0.56	2.18	11.32	22.61	34.33	47.12	60.85	71.43	76.32	80.08	84.08	87.39	90.16	90.77	92.13	93.64	96.73
2012	HFC-143a	EM_Use	t	0.09	0.36	1.64	4.91	10.67	19.64	30.61	41.76	52.92	64.07	75.14	86.01	95.89	103.77	109.17	111.35	111.54	111.54
		Difference	**t**	**0.05**	**0.20**	**0.54**	**6.41**	**11.93**	**14.69**	**16.52**	**19.08**	**18.51**	**12.24**	**4.94**	**-1.93**	**-8.50**	**-13.61**	**-18.40**	**-19.22**	**-17.90**	**-14.81**
2013	HFC-227ea	EM_Use	t	0.01	0.03	0.18	0.63	1.15	1.64	2.03	2.34	2.55	2.76	2.96	3.13	3.19	2.98	2.50	2.08	1.80	1.52
2012	HFC-227ea	EM_Use	t	0.01	0.03	0.15	0.45	0.85	1.32	1.83	2.34	2.84	3.35	3.85	4.34	4.73	4.94	4.86	4.52	4.16	3.79
		Difference	**t**	**0.00**	**0.01**	**0.03**	**0.18**	**0.30**	**0.32**	**0.20**	**-0.00**	**-0.29**	**-0.59**	**-0.90**	**-1.21**	**-1.53**	**-1.95**	**-2.36**	**-2.44**	**-2.35**	**-2.27**
2013	HFC-23	EM_Use	t	0.13	0.44	0.82	1.32	1.81	2.21	2.56	2.90	3.23	3.55	3.74	3.78	3.73	3.57	3.33	3.17	3.05	2.93
2012	HFC-23	EM_Use	t	0.11	0.35	0.67	1.05	1.51	2.07	2.71	3.38	4.04	4.71	5.27	5.69	6.04	6.32	6.41	6.27	6.04	5.79
		Difference	**t**	**0.03**	**0.09**	**0.15**	**0.27**	**0.31**	**0.15**	**-0.15**	**-0.48**	**-0.82**	**-1.16**	**-1.52**	**-1.91**	**-2.31**	**-2.75**	**-3.07**	**-3.09**	**-2.99**	**-2.87**
2013	HFC-32	EM_Use	t	0.02	0.06	0.24	1.25	2.50	3.80	5.21	6.73	7.90	8.44	8.86	9.30	9.66	9.97	10.04	10.19	10.35	10.70
2012	HFC-32	EM_Use	t	0.02	0.09	0.21	0.37	0.57	0.85	1.26	1.74	2.22	2.70	3.16	3.58	3.94	4.27	4.55	4.75	4.83	4.83
		Difference	**t**	**-0.01**	**-0.03**	**0.03**	**0.88**	**1.93**	**2.94**	**3.96**	**4.99**	**5.68**	**5.73**	**5.69**	**5.72**	**5.72**	**5.70**	**5.49**	**5.44**	**5.52**	**5.87**
2013		EF_Use	[1]	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
2012		EF_Use	[1]	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
		Difference	**%**	**20.57**	**19.72**	**18.86**	**17.97**	**17.06**	**16.13**	**15.19**	**14.22**	**13.22**	**12.21**	**11.17**	**10.10**	**9.01**	**7.89**	**4.44**	**0.71**	**-3.32**	**-7.69**
2013	C_2F_6	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	0.43	0.51	0.09	0.09	0.09
2012	C_2F_6	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	0.60	0.70	0.80	1.00
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-0.08**	**-0.09**	**-0.62**	**-0.72**	**-0.92**
2013	HFC-125	AR_Disposal	t	-	-	-	-	-	-	-	-	-	6.42	6.42	6.42	6.42	13.29	13.29	13.29	13.29	13.29
2012	HFC-125	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	2.95	5.65	28.90	55.30	90.14	135.39	142.34	142.34
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**6.42**	**3.47**	**0.77**	**-22.48**	**-42.01**	**-76.85**	**-122.10**	**-129.05**	**-129.05**
2013	HFC-134a	AR_Disposal	t	-	-	-	-	-	-	-	-	-	18.14	18.14	22.41	35.24	63.21	63.21	63.21	63.21	63.21
2012	HFC-134a	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	9.76	28.00	57.60	125.00	197.65	238.74	175.76	175.76
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**18.14**	**8.38**	**-5.59**	**-22.36**	**-61.79**	**-134.44**	**-175.52**	**-112.55**	**-112.55**
2013	HFC-143a	AR_Disposal	t	-	-	-	-	-	-	-	-	-	6.64	6.64	6.64	6.64	13.76	13.76	13.76	13.76	13.76
2012	HFC-143a	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	2.60	5.20	31.20	62.40	102.10	154.10	159.35	159.35
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**6.64**	**4.04**	**1.44**	**-24.56**	**-48.64**	**-88.35**	**-140.35**	**-145.60**	**-145.60**
2013	HFC-227ea	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	0.11	0.21	1.49	4.46	5.31	5.10	4.25	3.40
2012	HFC-227ea	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	0.25	0.25	3.25	5.25	6.25	7.25	7.25	7.25
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-0.14**	**-0.04**	**-1.76**	**-0.79**	**-0.94**	**-2.15**	**-3.00**	**-3.85**
2013	HFC-23	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	1.28	2.98	3.83	5.10	5.10	4.25	3.83	3.83
2012	HFC-23	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	3.00	4.00	5.00	6.00	7.00	9.00	9.50	9.50
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-1.73**	**-1.03**	**-1.18**	**-0.90**	**-1.90**	**-4.75**	**-5.68**	**-5.68**
2013	HFC-32	AR_Disposal	t	-	-	-	-	-	-	-	-	-	0.73	0.73	0.73	0.73	1.52	1.52	1.52	1.52	1.52
2012	HFC-32	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	0.69	1.15	2.30	2.30	3.45	4.60	6.90	6.90
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.73**	**0.04**	**-0.42**	**-1.57**	**-0.78**	**-1.93**	**-3.08**	**-5.38**	**-5.38**
2013	C_2F_6	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	0.19	0.22	0.03	0.03	0.02
2012	C_2F_6	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15	0.18	0.21	0.24	0.30
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.04**	**0.04**	**-0.18**	**-0.21**	**-0.28**
2013	HFC-125	EM_Disposal	t	-	-	-	-	-	-	-	-	-	3.53	3.37	3.21	3.05	5.98	5.65	5.32	3.99	3.32

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2012	HFC-125	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	0.89	1.70	8.67	16.59	27.04	40.62	42.70	42.70
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3.53**	**2.48**	**1.51**	**-5.62**	**-10.61**	**-21.39**	**-35.30**	**-38.71**	**-39.38**
2013	HFC-134a	EM_Disposal	t	-	-	-	-	-	-	-	-	-	9.98	9.52	11.90	19.78	36.66	35.59	34.63	32.13	30.77
2012	HFC-134a	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	2.93	8.40	17.28	37.50	59.30	71.62	52.73	52.73
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**9.98**	**6.59**	**3.50**	**2.50**	**-0.84**	**-23.71**	**-37.00**	**-20.60**	**-21.96**
2013	HFC-143a	EM_Disposal	t	-	-	-	-	-	-	-	-	-	3.65	3.49	3.32	3.16	6.19	5.85	5.50	4.13	3.44
2012	HFC-143a	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	0.78	1.56	9.36	18.72	30.63	46.23	47.81	47.81
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3.65**	**2.71**	**1.76**	**-6.20**	**-12.53**	**-24.78**	**-40.73**	**-43.68**	**-44.37**
2013	HFC-227ea	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	0.06	0.11	0.71	2.01	2.26	2.04	1.28	0.85
2012	HFC-227ea	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	0.08	0.08	0.98	1.58	1.88	2.18	2.18	2.18
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-0.02**	**0.03**	**-0.27**	**0.43**	**0.38**	**-0.14**	**-0.90**	**-1.33**
2013	HFC-23	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	0.67	1.49	1.82	2.30	2.17	1.70	1.15	0.96
2012	HFC-23	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	0.90	1.20	1.50	1.80	2.10	2.70	2.85	2.85
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-0.23**	**0.29**	**0.32**	**0.50**	**0.07**	**-1.00**	**-1.70**	**-1.89**
2013	HFC-32	EM_Disposal	t	-	-	-	-	-	-	-	-	-	0.40	0.39	0.37	0.35	0.68	0.65	0.61	0.46	0.38
2012	HFC-32	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	0.21	0.35	0.69	0.69	1.04	1.38	2.07	2.07
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.40**	**0.18**	**0.02**	**-0.34**	**-0.01**	**-0.39**	**-0.77**	**-1.61**	**-1.69**
2013		EF_Disposal	[1]	-	-	-	-	-	-	-	-	-	0.47	0.45	0.43	0.40	0.38	0.36	0.34	0.26	0.21
2012		EF_Disposal	[1]	-	-	-	-	-	-	-	-	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Difference	**%**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**35.83**	**32.77**	**29.41**	**25.70**	**21.57**	**16.96**	**11.76**	**-17.65**	**-41.18**

Table 140: Overview of the changes, resulting from recalculations, in activity data (AR), emissions (EM) and EF for production, use and disposal, relative to HFC-125, HFC-134a, HFC-143a and HFC-32 in stationary air conditioning systems (sub- source category 2.F.1.e).

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013	HFC-125	AR_Prod	t	-	-	0.50	0.98	1.56	6.00	19.96	41.95	54.51	53.53	61.08	72.35	105.74	144.30	167.45	235.89	215.48	233.73
2012	HFC-125	AR_Prod	t	-	-	0.77	0.84	1.30	5.09	9.02	13.32	16.68	16.79	18.47	20.47	29.26	51.60	57.40	75.22	66.87	70.18
		Difference	**t**	**-**	**-**	**-0.27**	**0.14**	**0.27**	**0.91**	**10.94**	**28.63**	**37.84**	**36.73**	**42.61**	**51.88**	**76.48**	**92.70**	**110.05**	**160.67**	**148.61**	**163.55**
2013	HFC-134a	AR_Prod	t	9.17	34.11	115.15	145.77	167.30	210.97	262.10	245.68	251.22	222.04	214.06	220.18	246.56	269.29	305.39	337.41	316.46	339.30
2012	HFC-134a	AR_Prod	t	21.94	61.87	184.63	260.69	277.78	282.20	159.64	181.19	162.61	162.73	165.13	165.95	149.25	193.47	191.90	224.25	161.02	186.85
		Difference	**t**	**-12.76**	**-27.76**	**-69.48**	**-114.92**	**-110.48**	**-71.24**	**102.45**	**64.49**	**88.61**	**59.32**	**48.94**	**54.23**	**97.31**	**75.82**	**113.49**	**113.16**	**155.44**	**152.45**
2013	HFC-143a	AR_Prod	t	-	-	0.35	0.58	0.90	0.99	1.14	1.44	2.03	1.97	2.59	2.90	4.52	11.44	11.87	15.73	11.80	11.02
2012	HFC-143a	AR_Prod	t	-	-	0.51	0.53	0.73	0.74	0.86	1.09	1.67	1.64	2.36	2.75	4.37	11.92	13.91	26.21	23.09	24.80
		Difference	**t**	**-**	**-**	**-0.16**	**0.06**	**0.16**	**0.24**	**0.28**	**0.36**	**0.37**	**0.33**	**0.23**	**0.15**	**0.15**	**-0.48**	**-2.04**	**-10.48**	**-11.29**	**-13.78**
2013	HFC-32	AR_Prod	t	-	-	0.18	0.45	0.74	4.75	17.48	37.47	48.66	47.85	54.77	65.64	97.24	129.30	151.48	215.70	198.67	217.56
2012	HFC-32	AR_Prod	t	-	-	0.31	0.36	0.62	4.15	7.68	11.48	14.18	14.31	15.33	16.96	24.31	39.60	43.71	51.01	45.69	47.63
		Difference	**t**	**-**	**-**	**-0.12**	**0.08**	**0.12**	**0.60**	**9.80**	**26.00**	**34.48**	**33.54**	**39.44**	**48.68**	**72.93**	**89.70**	**107.77**	**164.69**	**152.98**	**169.94**
2013	HFC-125	EM_Prod	t	-	-	0.00	0.00	0.01	0.03	0.11	0.24	0.31	0.32	0.43	0.52	0.71	0.95	1.14	1.50	1.36	1.50
2012	HFC-125	EM_Prod	t	-	-	0.00	0.00	0.00	0.03	0.08	0.12	0.14	0.14	0.16	0.18	0.24	0.31	0.42	0.47	0.42	0.47
		Difference	**t**	**-**	**-**	**0.00**	**0.00**	**0.01**	**-0.00**	**0.04**	**0.12**	**0.16**	**0.18**	**0.26**	**0.34**	**0.47**	**0.63**	**0.72**	**1.03**	**0.94**	**1.03**
2013	HFC-134a	EM_Prod	t	0.05	0.20	0.60	0.70	0.80	1.00	1.40	1.30	1.30	1.30	1.30	1.30	1.50	1.60	1.90	1.96	1.82	1.83
2012	HFC-134a	EM_Prod	t	-	0.10	0.30	0.40	0.50	0.50	0.40	0.50	0.50	0.40	0.50	0.40	0.50	0.50	0.50	0.60	0.40	0.30
		Difference	**t**	**0.05**	**0.10**	**0.30**	**0.30**	**0.30**	**0.50**	**1.00**	**0.80**	**0.80**	**0.90**	**0.80**	**0.90**	**1.00**	**1.10**	**1.40**	**1.36**	**1.42**	**1.53**
2013	HFC-143a	EM_Prod	t	-	-	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.06	0.06	0.08	0.06	0.06
2012	HFC-143a	EM_Prod	t	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02
		Difference	**t**	**-**	**-**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.05**	**0.05**	**0.06**	**0.04**	**0.04**
2013	HFC-32	EM_Prod	t	-	-	0.00	0.00	0.00	0.03	0.10	0.22	0.28	0.29	0.39	0.48	0.66	0.86	1.04	1.39	1.27	1.41
2012	HFC-32	EM_Prod	t	-	-	0.00	0.00	0.00	0.03	0.07	0.11	0.13	0.13	0.15	0.17	0.23	0.30	0.40	0.45	0.40	0.45
		Difference	**t**	**-**	**-**	**0.00**	**0.00**	**0.00**	**-0.00**	**0.03**	**0.10**	**0.14**	**0.16**	**0.24**	**0.31**	**0.43**	**0.57**	**0.65**	**0.94**	**0.87**	**0.96**
2013		EF_Prod split	[1]	-	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
2013		EF_Prod multi-split, VRF	[1]	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2012		EF_Prod	[1]	-	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
		Difference	**%**	**-**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**	**+75 to -150**
2013		EF_Prod large systems	[1]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2012		EF_Prod large systems	[1]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		Difference	**%**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**	**-100.00**

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013		EF_Prod heat pumps	[1]	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2012		EF_Prod heat pumps	[1]	-	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25	0.07-0.25
		Difference	**%**	**-**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**	**-1300 to -4900**
2013	HFC-125	AR_Use new	t	-	-	0.50	1.48	3.04	10.53	35.91	90.35	160.05	239.54	354.84	497.69	685.83	934.42	1,231.77	1,594.01	1,903.43	2,243.41
2012	HFC-125	AR_Use old	t	-	-	0.38	1.19	2.45	14.30	50.96	120.85	218.94	326.36	443.79	583.77	756.63	984.50	1,279.31	1,620.90	1,947.36	2,245.57
		Difference	**t**	**-**	**-**	**0.12**	**0.29**	**0.60**	**-3.77**	**-15.04**	**-30.50**	**-58.89**	**-86.82**	**-88.95**	**-86.07**	**-70.80**	**-50.08**	**-47.54**	**-26.89**	**-43.93**	**-2.16**
2013	HFC-134a	AR_Use new	t	9.17	43.28	158.43	304.21	471.50	685.56	958.93	1,230.59	1,511.52	1,784.08	2,061.60	2,360.54	2,693.18	3,230.34	3,638.10	4,050.55	4,371.99	4,687.37
2012	HFC-134a	AR_Use old	t	9.14	44.06	147.05	333.19	558.66	811.38	1,059.71	1,324.26	1,623.28	1,913.99	2,206.61	2,495.28	2,751.02	2,962.88	3,143.36	3,311.43	3,460.82	3,571.56
		Difference	**t**	**0.03**	**-0.78**	**11.38**	**-28.99**	**-87.16**	**-125.82**	**-100.78**	**-93.67**	**-111.76**	**-129.91**	**-145.01**	**-134.74**	**-57.84**	**267.46**	**494.73**	**739.13**	**911.17**	**1,115.81**
2013	HFC-143a	AR_Use new	t	-	-	0.35	0.94	1.83	2.82	3.96	5.41	7.44	9.41	12.00	14.90	19.42	30.87	42.74	58.47	70.26	80.94
2012	HFC-143a	AR_Use old	t	-	-	0.25	0.77	1.41	2.14	2.95	3.92	5.29	6.95	8.95	11.51	15.07	23.22	36.13	56.20	80.84	104.53
		Difference	**t**	**-**	**-**	**0.10**	**0.16**	**0.43**	**0.68**	**1.02**	**1.49**	**2.15**	**2.46**	**3.05**	**3.40**	**4.35**	**7.65**	**6.61**	**2.27**	**-10.58**	**-23.60**
2013	HFC-32	AR_Use new	t	-	-	0.18	0.63	1.37	7.49	29.95	78.92	141.61	213.48	319.45	451.99	627.74	857.04	1,133.51	1,471.86	1,763.05	2,086.24
2012	HFC-32	AR_Use old	t	-	-	0.15	0.49	1.16	11.51	44.66	108.41	198.52	297.70	406.53	537.61	700.73	914.89	1,192.40	1,511.39	1,813.63	2,091.36
		Difference	**t**	**-**	**-**	**0.03**	**0.14**	**0.22**	**-4.01**	**-14.70**	**-29.49**	**-56.92**	**-84.22**	**-87.08**	**-85.61**	**-72.99**	**-57.85**	**-58.90**	**-39.52**	**-50.58**	**-5.11**
2013	HFC-125	EM_Use new	t	-	-	0.01	0.04	0.08	0.48	1.97	5.27	8.40	12.30	18.34	25.53	34.52	45.66	58.93	73.83	85.61	98.11
2012	HFC-125	EM_Use old	t	-	-	0.01	0.03	0.07	0.61	2.27	5.26	9.31	13.73	18.43	23.70	29.86	37.67	47.40	58.46	69.31	79.63
		Difference	**t**	**-**	**-**	**0.00**	**0.01**	**0.01**	**-0.13**	**-0.30**	**0.01**	**-0.91**	**-1.43**	**-0.09**	**1.83**	**4.66**	**7.98**	**11.53**	**15.38**	**16.30**	**18.48**
2013	HFC-134a	EM_Use new	t	0.60	2.60	9.40	18.00	27.80	40.60	56.70	73.00	76.00	87.90	100.10	112.60	125.90	146.80	161.60	174.37	181.22	186.74
2012	HFC-134a	EM_Use old	t	0.50	2.60	8.70	19.80	33.20	47.90	61.60	75.00	89.90	104.60	119.40	134.00	146.80	156.30	163.60	170.40	177.60	184.90
		Difference	**t**	**0.10**	**-**	**0.70**	**-1.80**	**-5.40**	**-7.30**	**-4.90**	**-2.00**	**-13.90**	**-16.70**	**-19.30**	**-21.40**	**-20.90**	**-9.50**	**-2.00**	**3.97**	**3.62**	**1.84**
2013	HFC-143a	EM_Use new	t	-	-	0.01	0.02	0.05	0.07	0.10	0.14	0.19	0.24	0.30	0.37	0.49	0.77	1.07	1.46	1.76	2.02
2012	HFC-143a	EM_Use old	t	-	-	0.01	0.02	0.04	0.05	0.07	0.10	0.13	0.17	0.22	0.29	0.38	0.58	0.90	1.40	2.02	2.61
		Difference	**t**	**-**	**-**	**0.00**	**0.00**	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.08**	**0.08**	**0.11**	**0.19**	**0.17**	**0.06**	**-0.26**	**-0.59**
2013	HFC-32	EM_Use new	t	-	-	0.00	0.02	0.03	0.38	1.74	4.74	7.59	11.16	16.78	23.54	32.04	42.55	55.13	69.32	80.60	92.69
2012	HFC-32	EM_Use old	t	-	-	0.00	0.01	0.04	0.52	2.03	4.77	8.49	12.57	16.91	21.82	27.59	34.94	44.13	54.53	64.71	74.46
		Difference	**t**	**-**	**-**	**0.00**	**0.00**	**-0.00**	**-0.14**	**-0.30**	**-0.03**	**-0.90**	**-1.41**	**-0.13**	**1.72**	**4.45**	**7.61**	**11.00**	**14.79**	**15.90**	**18.23**

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013		EF_Use mobile	[1]	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
2013		EF_Use split	[1]	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05
2013		EF_Use multi-split	[1]	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06
2013		EF_Use VRF	[1]	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
2012		EF_Use	[1]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
		Difference	**%**	**+35 to +74**	**+34 to +74**	**+32 to +73**	**+31 to +73**	**+29 to +72**	**+27 to +72**	**+26 to +71**	**+24 to +71**	**+22 to +70**	**+20 to +70**	**+18 to +69**	**+16 to +69**	**+14 to +68**	**+11 to +67**	**+9 to +67**	**+6 to +66**	**+3 to +65**	**0 to +64**
2013		EF_Use large systems	[1]	-	-	-	-	-	-	-	-	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04
2012		EF_Use large systems	[1]	-	-	-	-	-	-	-	-	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
		Difference	**%**	-	-	-	-	-	-	-	-	**-20.00**	**-22.73**	**-25.58**	**-28.57**	**-31.71**	**-35.00**	**-38.46**	**-42.11**	**-45.95**	**-50.00**
2013	HFC-125	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.94	3.01
2012	HFC-125	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.31	19.88	51.37
		Difference	**t**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-6.23**	**-18.94**	**-48.36**
2013	HFC-134a	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	13.50	13.50	13.50	18.00	18.00	23.27	32.65	36.84
2012	HFC-134a	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	50.00	100.00	111.34	124.46	52.69	112.44
		Difference	**t**	-	-	-	-	-	-	-	-	-	-	**13.50**	**13.50**	**-36.50**	**-82.00**	**-93.34**	**-101.19**	**-20.04**	**-75.60**
2013	HFC-143a	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.26
2012	HFC-143a	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.51
		Difference	**t**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-0.25**
2013	HFC-32	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	0.86	2.56
2012	HFC-32	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.80	18.29	47.15
		Difference	**t**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-5.73**	**-17.43**	**-44.59**
2013	HFC-125	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.61	1.88
2012	HFC-125	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.89	5.96	15.41
		Difference	**t**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-1.84**	**-5.35**	**-13.53**
2013	HFC-134a	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	4.12	4.01	3.91	5.07	4.93	6.30	9.24	11.71
2012	HFC-134a	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	15.00	30.00	33.40	37.34	15.81	33.73
		Difference	**t**	-	-	-	-	-	-	-	-	-	-	**4.12**	**4.01**	**-11.09**	**-24.93**	**-28.48**	**-31.04**	**-6.57**	**-22.03**
2013	HFC-143a	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13
2012	HFC-143a	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15
		Difference	**t**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-0.02**
2013	HFC-32	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.56	1.63
2012	HFC-32	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.74	5.49	14.30
		Difference	**t**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-1.70**	**-4.92**	**-12.67**

Submission	Substance	Value	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013		EF_Disposal mobile	[1]	-	-	-	-	-	-	-	-	-	-	0.60	0.60	0.59	0.59	0.58	0.57	0.57	0.56
2013		EF_Disposal split	[1]	-	-	-	-	-	-	-	-	-	-	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.53
2013		EF_Disposal multi-split, VRF	[1]	-	-	-	-	-	-	-	-	-	-	0.41	0.41	0.40	0.39	0.38	0.37	0.36	0.35
2012		EF_Disposal	[1]	-	-	-	-	-	-	-	-	-	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Difference	**%**											**+28 to +50**	**+26 to +50**	**+24 to +49**	**+22 to +49**	**+21 to +48**	**+19 to +48**	**+16 to +47**	**+14 to +47**
2013		EF_Disposal chillers		-	-	-	-	-	-	-	-	-	-	0.31	0.30	0.28	0.27	0.26	0.25	0.24	0.23
2013		EF_Disposal turbo		-	-	-	-	-	-	-	-	-	-	0.27	0.27	0.26	0.25	0.25	0.24	0.23	0.23
2012		EF_Disposal	[1]	-	-	-	-	-	-	-	-	-	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Difference	**%**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**+3 to -9**	**-1 to -12**	**-6 to -15**	**-10 to -18**	**-15 to -22**	**-21 to -25**	**-27 to -29**	**-33.00**
2013		EF_Disposal heat pumps	[1]	-	-	-	-	-	-	-	-	-	-	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.38
2012		EF_Disposal heat pumps	[1]	-	-	-	-	-	-	-	-	-	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Difference	**%**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**32.44**	**30.90**	**29.30**	**27.61**	**25.86**	**24.00**	**22.06**	**20.00**

Table 141: Overview of the changes, resulting from recalculations, in activity data (AR), emissions (EM) and EF for production, use and disposal, relative to HFC-134a in mobile air conditioning systems (sub- source category 2.F.1.f).

Submission	Substance	Value	Units	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2013	HFC-134a	AR_Prod	t	16.80	95.59	555.45	971.25	1,617.73	2,309.79	2,850.98	3,701.24	4,117.02	3,828.78	3,940.85	3,805.69	3,912.08	4,045.67	4,134.61	4,138.74	3,964.41	3,909.78	3,277.42	4,054.47
2012	HFC-134a	AR_Prod	t	33.63	95.59	555.26	930.77	1,581.31	2,230.16	2,761.94	3,612.53	4,058.32	3,798.78	3,925.43	3,790.13	3,898.75	4,020.52	4,128.70	4,228.95	4,404.66	4,340.39	3,642.47	4,034.41
		Difference	**t**	**-16.83**	**-0.00**	**0.19**	**40.48**	**36.42**	**79.63**	**89.03**	**88.71**	**58.70**	**30.00**	**15.41**	**15.56**	**13.34**	**25.16**	**5.91**	**-90.20**	**-440.25**	**-430.61**	**-365.05**	**20.07**
2013	HFC-134a	EM_Prod	t	0.04	0.28	1.80	3.30	5.41	7.68	10.05	13.43	15.07	15.46	16.43	16.10	16.55	17.19	17.76	18.16	18.59	18.34	15.51	18.16
2012	HFC-134a	EM_Prod	t	0.06	0.19	1.08	1.97	3.37	4.81	6.37	8.56	9.68	9.94	10.63	10.46	10.70	11.10	11.54	11.77	12.49	12.25	10.51	11.84
		Difference	**t**	**-0.01**	**0.09**	**0.72**	**1.33**	**2.04**	**2.88**	**3.67**	**4.87**	**5.39**	**5.52**	**5.80**	**5.64**	**5.85**	**6.09**	**6.23**	**6.38**	**6.10**	**6.09**	**5.00**	**6.32**
2013	HFC-134a	EF_Prod buses	g / unit	-	-	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
2012	HFC-134a	EF_Prod buses	g / unit	-	-	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
		Difference	**%**	**-**	**-**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**	**90.00**
2013	HFC-134a	EF_Prod utility vehicles	g / unit	-	-	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
2012	HFC-134a	EF_Prod utility vehicles	g / unit	-	-	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
		Difference	**%**	**-**	**-**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**	**60.00**
2013	HFC-134a	EF_Prod automobiles	g / unit	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
2012	HFC-134a	EF_Prod automobiles	g / unit	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
		Difference	**%**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**	**33.33**
2013	HFC-134a	AR_Use	t	20.57	84.62	410.29	1,009.93	1,866.72	3,133.94	4,749.46	6,807.52	8,971.29	11,151.46	13,119.52	14,899.97	16,621.60	18,298.64	20,021.76	21,702.45	21,021.22	21,958.49	23,193.54	24,121.53
2012	HFC-134a	AR_Use	t	8.40	49.77	246.15	716.60	1,444.91	2,540.84	4,084.92	6,022.49	8,269.73	10,569.71	12,812.48	14,994.57	17,080.67	19,127.95	21,082.17	22,903.03	24,438.73	25,506.90	26,265.05	26,554.66
		Difference	t	12.17	34.85	164.14	293.33	421.81	593.10	664.54	785.03	701.55	581.75	307.04	-94.60	-459.07	-829.31	-1,060.41	-1,200.58	-3,417.52	-3,548.41	-3,071.50	-2,433.14
2013	HFC-134a	EM_Use	t	2.10	8.40	53.00	165.85	361.32	889.22	1,497.24	2,130.83	2,716.91	3,037.35	3,304.93	3,548.81	3,792.43	4,037.19	4,263.99	4,525.10	4,596.84	4,876.04	5,182.11	5,415.53
2012	HFC-134a	EM_Use	t	0.80	4.90	25.30	74.45	150.34	263.66	422.77	622.00	852.97	1,089.79	1,320.67	1,545.39	1,760.67	1,971.71	2,172.54	2,359.76	2,518.82	2,631.86	2,710.91	2,740.27
		Difference	**t**	**1.30**	**3.50**	**27.71**	**91.40**	**210.98**	**625.56**	**1,074.47**	**1,508.83**	**1,863.94**	**1,947.56**	**1,984.26**	**2,003.42**	**2,031.76**	**2,065.48**	**2,091.45**	**2,165.34**	**2,078.02**	**2,244.18**	**2,471.20**	**2,675.26**
2013	HFC-134a	EF_Use utility vehicles	[1]	-	-	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Submission	Substance	Value	Units	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2012	HFC-134a	EF_Use utility vehicles < 1.5 t	[1]	-	-	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
2012	HFC-134a	EF_Use utility vehicles > 1.5 t	[1]	-	-	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
		Difference	**%**	**-**	**-**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**	**0 to +33**
2013	HFC-134a	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	1.60	3.32	15.11	16.15	18.68	21.04	31.86	100.51	53.38
2012	HFC-134a	AR_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	33.00	111.77	190.17	443.89	666.05	848.33	1,296.87	1,665.14	2,054.80
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-31.40**	**-108.45**	**-175.06**	**-427.74**	**-647.36**	**-827.28**	**-1,265.01**	**-1,564.63**	**-2,001.42**
2013	HFC-134a	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	1.00	2.10	5.78	5.76	6.36	7.19	12.77	55.00	25.37
2012	HFC-134a	EM_Disposal	t	-	-	-	-	-	-	-	-	-	-	-	9.90	33.53	57.03	133.17	199.84	254.47	389.04	499.51	616.46
		Difference	**t**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-8.90**	**-31.43**	**-51.25**	**-127.41**	**-193.48**	**-247.29**	**-376.27**	**-444.51**	**-591.09**
2013	HFC-134a	EF_Disposal	[1]	-	-	-	-	-	-	-	-	-	-	-	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
2012	HFC-134a	EF_Disposal	[1]	-	-	-	-	-	-	-	-	-	-	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Difference	**%**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-42.86**	**-42.86**	**-42.86**	**-42.86**	**-42.86**	**-42.86**	**-42.86**	**-42.86**	**-42.86**

4.7.1.5 Planned improvements (2.F.1)

No improvements are planned at present.

4.7.2 Foam blowing (2.F.2)

Since 1993, hydrofluorocarbons (HFCs) have also been used in foam blowing as substitutes for ozone-depleting, climate-damaging CFCs and HCFCs.

No HFC blowing agents are needed in soft-foam production, and thus soft foams are not taken into account in the report.

The four categories of hard foam for which HFCs are used as blowing agents include PUR hard foam, PUR integral foam, PUR foam sealant (one-component foam – OCF) and XPS insulation foam.

4.7.2.1 PUR foam products (2.F.2)

4.7.2.1.1 Source category description (2.F.2)

The group of PUR foam products includes hard-foam and integral-foam products. Hard foams are used in many different types of products, including household appliances, insulation boards, sandwich elements and insulating foams produced in small series. Integral foams are used in shoes for sports and recreation and in various automobile parts. From 1996 to 1997, HFCs were used only in integral foams. Since 1998, they have also been used as blowing agents in PUR hard-foam products. HFCs have been giving way to hydrocarbons such as pentane.

The time series, which does not begin until 1996, shows a small increase in emissions until 2001. A larger increase occurred from 2002 to 2004. These results agree with the historical development of HFC use in this application area, an area which arose only slowly, as a result of the long period of utilisation of HCFCs. Emissions from PUR foam products decreased slightly as of 2005.

Along with HFC-134a, since 2002 HFC-365mfc (with small quantities of added HFC-227ea) has also been used as a blowing agent. Since 2004, HFC-245fa has also been used as such an agent. HFC-245ca is not used in Germany.

4.7.2.1.2 Methodological issues (2.F.2)

Emissions are determined by means of Equation 1 und Equation 2. The production emissions consist of the quantity of HFC emitted within no more than one year after production (first-year loss).

Emission factors

The emission factors used are shown in Table 137. In the case of PUR hard foams with HFC-134a, the factors are in line with the standard values given in IPCC-GPG (2000), on page 3.96. The emission factors for all other HFCs have been approved by national experts and adjusted where necessary. For example, the emission factor for production of PUR hard foam with use of 365mfc/227ea was increased from 10 % to 15 %, because that HFC mixture has been used increasingly since 2004 in open on-site applications, especially in spray foams.

The emission factor for HFKW-365mfc from stocks was taken from an estimate based on test products.

In the case of integral foams, all of the blowing agent (apart from small residual amounts) escapes during the foaming process. Since the residual amounts in question escape within no more than 2 years (so the domestic experts who were consulted), an emission factor of 100 % for production is considered suitable for Germany, instead of the value given in IPCC-GPG (2000).

Activity data

The figures for new domestic consumption, for each blowing agent and each product group, are based on the amounts of foam products produced in Germany. The data for products in service are based on the amounts of foam products used in Germany (sales in Germany) since the introduction of HFCs. Given a product lifetime of at least 20 years, removals from products in service do not yet play any significant role.

New domestic consumption and domestic sales of foam products are determined annually via surveys of manufacturers, users and blowing-agent suppliers, and via information from the relevant industry association (IVPU – the polyurethane-foam industry association).

4.7.2.2 PUR foam sealants (2.F.2)

4.7.2.2.1 Source category description (2.F.2)

The term "foam sealant" refers to polyurethane foam that is sprayed, on site, from pressurised containers (cans). The blowing agents now used for such foam, following the prohibition of HCFCs, include mixtures of HFCs and propane, butane or dimethyl ether (DME). At the same time, the HFC quantities in such cans have been continually reduced since 1996.

HFC-134a has been used in Germany since 1992, in production of PUR one-component foam (in cans). HFC-152a was used from 2002 to 2004. Imported cans of PUR foam sealant used in Germany contain HFC-134a (since 1992) or HFC-152a (since 1995). Emissions from PUR foam sealants have been decreasing since 1997. Since 4 July 2008, a ban has been in force in the EU, with a few permitted exceptions, on sale of one-component-foam products filled with fluorinated greenhouse gases with a global warming potential (GWP) greater than 150. For that reason, future emissions can be expected to remain relatively constant, at low levels.

4.7.2.2.2 Methodological issues (2.F.2)

Pursuant to the IPCC Guidelines (1996b: p. 2.58), in each case the emissions for this open use are considered the same as the HFC quantity sold with the can. In contrast to the IPCC method, it is assumed that all emissions occur in the year of sale, however, since use and disposal occur promptly. At the same time, used cans are not completely empty when they go to waste management; they still contain about 8 % of their original foam contents, including the relevant blowing agent. The majority of that blowing agent eventually also enters the atmosphere, after a certain delay.

Filling emissions are calculated from the number of cans filled per year in Germany and the blowing-agent loss per can.

Emissions from use are calculated with Equation 2.

Emission factors

The $EF_{production}$ was determined via surveys of experts and of manufacturers. From 1992 to 2002, it amounted to 1.5 g/can, while as of 2003 it has been only 0.5 g/can, since the total fill quantities in cans have decreased.

Activity data

The following data are required for determination of new domestic HFC consumption for filling and the resulting filling losses (production emissions):

- Number of cans filled annually, in Germany, with HFC-134a or HFC-152a,
- HFC content per can, in grams,
- Specific filling loss.

These data are obtained via surveys of experts.

The following information is required for determination of use emissions per year:

- Number of cans with blowing agent 134a or 152a that are sold annually in Germany,
- HFC content per can, in grams.

These data are provided by the manufacturers themselves.

The pre-1995 data for foam sealants were obtained via discussion, in 2006, with leading foreign OCF sellers and from older publications.

4.7.2.3 XPS hard foam (2.F.2)

4.7.2.3.1 Source category description (2.F.2)

HFC consumption and emissions from production of XPS insulation boards have occurred only since 2001, since HCFCs or $CO_{2\ /\ ethanol}$ were used in this area prior to that time. HFC-152a and 134a, either by themselves or in mixtures, are used.

4.7.2.3.2 Methodological issues (2.F.2)

Total emissions from this area are calculated with Equation 1 and Equation 2. For both of the HFCs used, the new inland consumption is reported directly by the European association CEFIC[53] or by its industry group EXIBA[54].

Trials with HFC collection and recovery have been conducted, but to date no relevant systems have been implemented, for both technical and economic reasons.

Use emissions are calculated from the average amount of HFCs in XPS insulating foams in domestic service. This amount increases annually solely through new addition of insulation boards containing 134a. Given a product lifetime of 50 years, removals from products in service do not yet play any significant role. The new HFC additions are not equivalent to annual new consumption, minus production emissions. The reason for this is that, as a result

[53] CEFIC – The European Chemical Industry Council
[54] EXIBA – European Extruded Polystyrene Insulation Board Association

of foreign trade, especially exports of 134a-based XPS, only 25 % (the complementary value for the export rate) of the HFC-134a contained in products amounts to new additions to domestic HFC stocks.

Disposal emissions thus play no significant role to date.

Emission factors

The production emissions (HFC first-year losses) for HFC-152a are practically 100 % ($EF_{production}$ of HFC-152a = 1), since the substance is used solely as a blowing agent in production. With HFC-134a, only part of consumption is emitted upon blowing; most of the substance enters into the product. The $EF_{production}$ for HFC-134a is determined empirically and communicated by the CEFIC[55] association or by its EXIBA[56] industry association.

A representative of the FPX extruded-polystyrene-foam association estimated the annual releases from enclosed HFC-134a cell gas as being less than 1 % in 2002. That figure is based, inter alia, on an internal study of BASF regarding the half-lives of various cell gases, including HFC-134a (WEILBACHER 1987). The EF_{use} from that laboratory study has been used for HFC-134a. Fugitive emissions from boards depend on board thickness, and they can be given only as average values, or as values for specific board thicknesses. The value used, EF_{use} = 0.66 %, is based on average board thickness, and it lies below the value proposed in IPCC-GPG (2000), 3 %.

Activity data

All of the data required for emissions calculation, including new domestic consumption, loss rate in production and the foreign trade balance for HFC-134a-containing insulation boards, are provided by the relevant European industry association (CEFIC or EXIBA).

4.7.2.4 Uncertainties and time-series consistency (2.F.2)

The uncertainties for the "foams" sub- source category have been systematically quantified.

The emissions data for prior years, for PUR foam products, are considered fairly accurate, since the quantities of HFCs used are still rather small at present. In future, however, it will become more difficult to obtain a good market overview in view of the anticipated product diversity.

Because it includes only a small number of manufacturers, the German XPS market is not complex. Since the EF and AD were prepared in co-operation with manufacturers, they are considered sufficiently precise.

Since 2001, the relevant industry association has determined the input quantities of HFC-152a and HFC-134a (AD) in production of XPS hard foams. Since only three manufacturers use HFC for XPS blowing, there is little reason to doubt the reliability of the activity data. This also applies to the export rate and the HFC production emissions determined for use of HFC-134a.

The production emissions in use of HFC-152a, 100 %, do not agree with the existing IPCC estimates. Nonetheless, the industry association considers them to be realistic.

[55] CEFIC – The European Chemical Industry Council
[56] EXIBA – European Extruded Polystyrene Insulation Board Association

The value for the emissions rate from current stocks, as determined by a laboratory study, will be used as long as no reliable measurements with insulation boards in actual service have been carried out; such measurements would be considered more conclusive than laboratory values.

4.7.2.5 Source-specific recalculations (2.F.2)

No recalculations are required.

4.7.2.6 Planned improvements (source-specific) (2.F.2)

No improvements are planned at present.

4.7.3 Fire extinguishers (2.F.3)

4.7.3.1 Source category description (2.F.3)

Halons, which until 1991 were permitted fire extinguishing agents, have since been largely supplanted by ecologically safe substances – especially inert gases, such as nitrogen and argon, for systems for flooding rooms; and by powder, CO_2 and foams in handheld fire extinguishers.

In 1998, HFC-227ea was certified in Germany as a halon substitute. In 2001, HFC 236fa also received such certification. That substance is used solely in the military sector, however. HFC-23, while certified since 2002, did not begin to be used until 2005. Today, certification of fire extinguishing agents is no longer required. Nonetheless, the list of fire extinguishing agents in use has not grown, since all application areas can be covered with halogen-free agents and with the aforementioned HFCs (especially 227ea and 236fa).

HFC-based fire extinguishing agents are imported and filled into fire extinguishing systems in Germany. Virtually no foreign trade with filled systems takes place. The time series do not begin until after 1995.

4.7.3.2 Methodological issues (2.F.3)

The annual new HFC additions in domestic systems are identical with the amounts added to new systems within the country (new HFC consumption).

IPCC-GPG (2000, Chapter 3.7.6) proposes that a "sales-based top-down" approach be used for determining emissions in connection with fire extinguishing agents. A bottom-up Tier-2 approach is considered unsuitable because the activity data required for that approach are unavailable for many countries. Since activity data are available in Germany for HFC-227ea and 236fa, a bottom-up approach is used. Unlike the top-down approach of the IPCC-GPG (2000), the bottom-up approach takes filling emissions into account.

Due to a lack of pertinent data, the installed quantities of HFC 23 are estimated by the Federal Environment Agency.

Pursuant to the *IPCC Guidelines 2006*, fire extinguishing systems have an average service life of 15 years.

Emission factors

The $EF_{production}$ are based on experts' assessments.

For HFC-236a, the $EF_{production}$, according to experts' assessments, has to increase from 1 % to 4 % by the year 2007, in order to take account of the greater probability of leaks in older systems. The 4 % figure conforms to the IPCC Guidelines 2006. The emission factor for use of HFC-23 has also been set at 4 %. With regard to HFC-227ea, concrete figures are available relative to installed and refilled quantities. They were obtained via up-scaling from the pertinent company's market share (as estimated by the company) to the German market as a whole.

For all HFCs, the emission factor for disposal is 100%.

Activity data

The emission figures for HFC 227ea are based on statistical surveys by one company, covering the aspects of input quantities, refill quantities, accidental releases, releases in cases of fire, and flooding tests in Germany (by analogy to Tier 2). Up-scaling was carried out on the basis of the market shares estimated by the company. The data for HFC-236fa are based on company information provided on a voluntary basis. The figures for HFC-23 are based on estimates of the Federal Environment Agency.

4.7.3.3 Uncertainties and time-series consistency (2.F.3)

The uncertainties for the "fire extinguishing agents" sub- source category have been systematically quantified.

4.7.3.4 Source-specific recalculations (2.F.3)

No recalculations are required.

4.7.3.5 Planned improvements (source-specific) (2.F.3)

No improvements are planned at present.

4.7.4 Aerosols (2.F.4)

This area includes metered-dose inhalers (MDI), which are used in medical applications, as well as general-purpose aerosols and so-called "novelty aerosols".

4.7.4.1 Metered-dose inhalers (2.F.4.a)

4.7.4.1.1 Source category description (2.F.4.a)

Metered-dose inhalers are used in the medical sector, primarily for treatment of asthma. Metered-dose inhalers with an HFC propellant first reached the German market in 1996. They contained the propellant HFC-134a. Since then, the number of available preparations has grown continually. Domestic filling of such devices did not begin until 2001. Since 1999, HFC-227ea has also been used, in addition to HFC-134a, as a propellant for metered-dose inhalers.

The time series shows an emissions increase that correlates with increasing use of HFCs as CFC substitutes. A large change occurred in 2001. As of that year, CFCs were prohibited for the largest group of active ingredients, the short-acting betamimetics.

4.7.4.1.2 Methodological issues (2.F.4.a)

With regard to the activity data, the method is equivalent to a bottom-up approach. Since 98 % of the contents of such inhalers consist of propellant, their contents are considered to consist solely of HFCs.

Most inhalers are sold by chemists (pharmacies). An estimated 10 percent are used by hospitals, for their own needs, while 3 percent are samples, "not for sale", for doctors and pharmaceutical representatives. These two categories are taken into account by adding 13 % to sales by chemists/phamarcies.

The time period between pharmacy sales and use is short. The reference figure for emissions – in contrast to IPCC-GPG (2000, equation 3.35) – is thus not the sum of half the purchases (sales) of the previous year and half the purchases (sales) of the current year, but all purchases (sales) for the current year. The IPCC-GPG approach would be a useful choice if the available data covered produced inhalers – rather than sold inhalers – since considerable time, for transport and storage, indeed passes between production and use.

The production emissions are added to the usage emissions. Part of the emissions are collected with cold traps and then incinerated. Without such collection, the emissions would be higher.

Emission factors

The EF_{use} on which production-emissions data are based is itself based on very precise producer determination of filling emissions. These amount to about 1 %, with respect to new consumption for filling. This translates to about 0.15 g per 10 ml inhaler.

In agreement with IPCC specifications (IPCC-GPG (2000), p. 3.85), a 100 % emissions level in use (EF_{use} = 1) is assumed. Inhaled HFCs are not broken down in bronchial passages; they are released into the atmosphere, without undergoing any changes, upon exhalation. The inhalers are assumed to have a lifetime of only one year, however. The emission factor has thus been classified as "country-specific".

Activity data

The emissions data for the period until reporting years 2005 (production) and 2006 (use) are based on sales figures (sales in pharmacies) for metered-dose inhalers in Germany, as obtained via surveys of producers. The total unit numbers, the average fill quantity in ml and the propellant used have all entered into relevant calculations. As of the 2006 reporting year, the activity-rate figures for production are based on experts' estimates. As of the 2007 reporting year, the activity-rate figures for use are based on such estimates. In the category "metered dose inhalers", the results of the *Federal Statistical Office's* annual surveys of certain climate-relevant substances normally do not become available on time for the corresponding current report year. Retroactive data cross-checking is carried out when necessary, however.

4.7.4.2 Other aerosols (2.F.4.b)

4.7.4.2.1 Source category description (2.F.4.b)

In Germany, six types of general-purpose aerosols (includes neither medical sprays nor novelties) containing HFC are sold:

- Compressed-air sprays,
- Cooling sprays,
- Drain-opener sprays,
- Lubricating sprays,
- Insecticides, and
- Self-defence sprays.

Production and use of general-purpose aerosols with HFC-134a began in 1992; production and use of such aerosols with HFC-152a began in 1995. The HFC quantities filled in Germany remained constant from 1995 to 2005. Since 2006, those quantities have been decreasing slightly.

Other aerosols include "novelty" aerosols (artificial snow, "silly string", etc.). Such products are not produced in Germany, however. Use of novelty sprays with HFC-134a began in 1995, while use of sprays with HFC-152a began in 2000. The relevant emissions have been decreasing sharply since 2003. That trend is the result of a EU ban, in force as of 4 July 2009, on sale of novelty aerosols filled with hydrofluorocarbons (HFCs). Producers were quick to respond by choosing other propellants for their products.

4.7.4.2.2 Methodological issues (2.F.4.b)

Imports and exports are roughly in balance, and thus the domestic market can be considered equivalent to consumption for domestic filling. Domestic consumption refers to spray cans filled in Germany, regardless of where the cans are ultimately used.

Emission factors

In keeping with IPCC specifications (IPCC-GPG (2000), p. 3.85), a 100 % emissions level for use ($EF_{Anwendung}$ = 1) is assumed; this is appropriate and justified. Of the numbers of spray cans sold in Germany, it is assumed that half are used in the same year they are purchased and half are used in the following year. This is in keeping with the pertinent proposal in IPCC-GPG (2000). The emission factor has thus been classified as "default".

The EF_{use} = 1.5 % on which production-emissions data for other aerosols are based is itself based on experts' assessments.

Activity data

The data for the period prior to 1995 are based on estimates of experts. In keeping with a bottom-up approach, all quantity data as of 1995 are provided directly by producers, fillers and operators, as well as by relevant industry associations. Emissions data for general-purpose aerosols also include filling emissions (= production emissions). Estimates are based on EU-wide data.

4.7.4.3 Uncertainties and time-series consistency (2.F.4 all)

The uncertainties for the "aerosols" sub- source category have been systematically quantified.

In the case of metered dose inhalers, the surcharge factor for hospitals and doctors' samples can vary, by ± 3 %, from the above-cited 13%.

In comparison to the emissions data for metered dose inhalers, the data for other aerosols are considered to be not as good, since the large number of products involved makes it difficult to obtain an overview of the market. Large quantities of imports, especially in the area of "novelties", also complicate the situation. The uncertainties are thus considerably higher (more than 20 %).

Since the shift from CFCs to chlorine-free propellants had already been completed by the beginning of the 1990s, the time series for the period 1995-2005 showed virtually no changes. Slight emissions decreases have been seen since 2006.

4.7.4.3.1 Source-specific recalculations (2.F.4 all)

No recalculations are required.

4.7.4.3.2 Source-specific planned improvements (2.F.4 all)

No improvements are planned at present.

4.7.5 Solvents (2.F.5)

4.7.5.1 Source category description (2.F.5)

Use of HFCs as solvents was banned in Germany until the year 2001 (2nd Ordinance on the Implementation of the Federal Immission Control Act – 2. BimSchV) and remains heavily restricted to this day. Individual applications must be submitted for each form of use, and such applications are approved only in special cases.

4.7.5.2 Methodological issues (2.F.5)

Emissions are calculated in keeping with Tier 2 as described in IPCC-GPG 2000 (Equation 3.36).

Emission factors

Emissions in use are assumed to be completed within 2 years.

Activity data

The emissions data are based on sales data of the authorised vendor, and they apply solely to HFC-4310mee. Since the data are confidential, they are reported under CRF 2.G.

4.7.5.3 Uncertainties and time-series consistency (2.F.5)

All of the uncertainties for the sub- source category *solvents* have been identified.

4.7.5.4 Source-specific recalculations (2.F.5)

No recalculations are required.

4.7.5.5 Source-specific planned improvements (2.F.5)

No improvements are planned at present.

4.7.6 Other applications that use ODS substitutes (2.F.6)

Germany reports no emissions in this source category.

4.7.7 Semiconductor manufacturing (2.F.7)

4.7.7.1 Source category description (2.F.7)

The semiconductor industry currently emits PFCs (CF_4, C_2F_6, C_3F_8, c-C_4F_8), HFCs (CHF_3), nitrogen trifluoride (NF_3) and SF_6 from production processes. These gases are used for etching structures on thin layers and for cleaning reaction chambers following chemical vapour deposition (CVD). In the production process, some of the PFCs fed into plasma chambers are converted partly into CF_4.

The semiconductor industry's emissions depend partly on the degree to which the industry uses waste-gas-scrubbing equipment. They also depend directly on semiconductor-production levels (in the present case, annual levels). As a result of these dependencies, emissions tend to fluctuate rather strongly from year to year.

4.7.7.2 Methodological issues (2.F.7)

The emissions cannot be determined solely on the basis of input quantities (sales by gas vendors), because the difference between consumption and emissions depends on a number of factors, including only-partial chemical transformation in plasma reactors and the effects of downstream waste-gas-scrubbing systems.

Emission factors

During the etching process, only about 15 % of the added CF_4 reacts chemically. The emission factor, an inverse reaction quota, thus amounts to 85 % of the CF_4 consumption.

Activity data

Reliable emissions data are available for 1990 and 1995. Linear interpolation was carried out for the years 1991 to 1994.

Until the 2000 report year, emissions data were based on surveys carried out by the EECA-ESIA (European Electronic Component Manufacturers Association – European Semiconductor Industry Association). National manufacturers were queried regarding production capacities, amounts of substances used and waste-gas treatment equipment.

As the result of a voluntary commitment by the semiconductor industry, emissions figures are available for this sub- source category, for all individual substances, from the year 2001 onwards. In keeping with a standardised calculation formula (Tier 2c approach), the emissions data are calculated for each production site, from annual consumption, aggregated and then reported by the German Electrical and Electronic Manufacturers Association (Zentralverband Elektrotechnik- und Elektroindustrie eV. – ZVEI, electronic components and systems) to the Federal Environment Agency.

4.7.7.3 Source-specific recalculations (2.F.7)

No recalculations are required.

4.7.7.4 Source-specific planned improvements (2.F.7)

No improvements are planned at present.

4.7.8 Electrical equipments (2.F.8)

This source category consists primarily of use of electrical equipments (2.F.8.a), which is further sub-divided into high-voltage (HS – Hochspannungs-), medium-voltage (MS – Mittelspannungs-) and other electrical equipments. The area of particle accelerators is reported under 2.F.8.b.

4.7.8.1 Use of electrical equipments (2.F.8.a)

4.7.8.1.1 Source category description (2.F.8.a)

In electricity transmission and distribution, SF_6 is used primarily in switchgear and controlgear and equipment in high-voltage (52-380 kV) and, increasingly, medium-voltage (10-52 kV) networks. It serves as an arc-extinguishing and insulation medium (in the latter function, in place of air). In addition, it is used in production of components installed in gas-insulated indoor switchgear and controlgear (instrument transformers, bushings) or supplied directly to operators (high-voltage instrument transformers for outdoor installations).

As a result of first-time inclusion, in report year 2002, of additional SF_6 applications, the time series shows a marked jump in emissions in 2002. In report year 2005, new companies were included in reporting, especially in the new category "Other electrical equipments". For reasons having to do with the economy as a whole, more systems were sold in 2005 and 2006. Nonetheless, absolute emissions are falling overall, due to considerable reductions in the area of "other" equipments and as a result of again-lower emissions rates in switchgear and controlgear. In 1996, industry, represented by producers' and operators' associations and the SF_6 producer, committed itself to reducing emissions in life cycles of switchgear and controlgear and to provide annual progress reports. In 2005, this voluntary commitment was extended, in co-operation with the Federal Environment Agency and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), to include additional energy-transmission and energy-distribution installations above the 1 kV level. In addition, specific reduction targets were added to the commitment. The scope of voluntary reporting was enlarged and refined accordingly. In subsequent years, manufacturers and the gas producer made further investments in reduction measures. Substitutes for SF_6 foams were introduced in some sub-areas of bushings. This brought about further reductions in specific emissions rates and absolute emissions, even though production continued to increase.

4.7.8.1.2 Methodological issues (2.F.8.a)

The emissions figures are based largely on a mass balance. Increasingly, they are also being combined with emission factors for sub-areas in which the technical measurement limits for mass-balancing have been reached or in which mass-balancing would necessitate unreasonably high costs.

The methods used are based on the new "2006 IPCC Guidelines for National Greenhouse Gas Inventories; Volume 3", Chapter 8. For further information, the reader is referred to "Tier 3, Hybrid Life-Cycle Approach" in sub-chapter 8.2.

Usage emissions

Ongoing emissions from products in service include the amount of SF_6 in service, as accumulated since 1970 via annual additions of switchgear and controlgear; they are given as the average for year n.

The final amount of SF_6 in all electrical equipments for a given year n changes annually by the balance of new additions and removals. Some removals (high voltage) have been registered since 1997; large-scale removals of first-generation high-voltage switchgear and controlgear and equipment cannot be expected until after 2015, in light of the products' estimated service lifetime of at least 40 years.

Three special aspects must be taken into account in reporting relative to switchgear and controlgear:

- Calculation of the final stocks for a given year n is based on the final stocks for the previous year (n-1); this does not extend back to the first year of service, however. Such backward extension, an otherwise customary procedure, is not used for switchgear and controlgear, because operators/manufacturers estimated the SF_6 stocks in service for 1995. Their estimate was broken down into high-voltage and medium-voltage categories (770 t and 157.6 t, respectively).
- In the area of high-voltage switchgear and controlgear, stocks and emissions are determined via direct surveys of the some 100 operators. In such surveys, the operators are asked to provide data on their current stocks of SF_6 in electrical equipments (gas-insulated HV switchgear (GIS), circuit breakers, outdoor instrument transformers). Emission factors determined on the basis of reference systems are then applied to such stocks data.
- The group of operators of medium-voltage switchgear is very numerous and highly diverse. It is thus not feasible to conduct direct surveys. Manufacturers of medium-voltage switchgear have themselves taken responsibility for updating their domestic stock data on the basis of their sales data. The emissions can be determined in that the systems are practically maintenance-free and, by definition (IEC 62271-1), require no refilling throughout their entire lifetimes. The emissions are minimal (usually, they occur only as a result of external influences), and they can be accounted for via a lump-sum emission factor (resulting from survey of experts): the emissions rate has been set at a constant 0.1 % since 1998, since virtually all of the systems added to domestic stocks since the mid-1990s are systems that are "sealed for life" (hermetically sealed pressurised systems pursuant to IEC). In their voluntary commitment of 2005, the operators also promised to use only such systems. As a result, the impact of the few older systems that have emissions rates greater than 0.1 % has diminished. The stocks are calculated on the basis of the previous year's stocks, plus new deliveries and less decommissioned systems.

Disposal emissions

Because switchgear and controlgear have long service lifetimes (40 years), and because the first use of SF_6 dates from the late 1960s, disposal emissions were very low until 2004. For the period until 2004, therefore, the quantities of SF_6 (AD), in old switchgear and controlgear (high-voltage and medium-voltage), that were slated for disposal have been roughly estimated (at a constant 3 t/a). As of the 2005 report year, amounts for disposal from systems removal were determined precisely for the first time, by the relevant associations. This also applies to emissions from disposal, which prior to 2005 were estimated at 0.06 t.

Activity data

In the framework of the manufacturers' voluntary commitment, annual consumption by manufacturers of electrical equipments, and stocks of medium-voltage switchgear and controlgear, are reported to the Federal Environment Agency by the German Electrical and Electronic Manufacturers' Association (ZVEI), while stocks of high-voltage switchgear and controlgear, outdoor-mounted instrument transformers, gas-insulated lines and transformers are reported by the Forum network technology / network operation (FNN) in the Association for Electrical, Electronic & Information Technologies (VDE) and, since 2004, by the Association of the Energy and Power Generation Industry (VIK). Participants in the voluntary commitment jointly determine quantities of decommissioned units.

Table 142 shows the inventory data for the current year, broken down by sub- source categories and with explanatory remarks. The sum total for electrical equipments for energy transmission and distribution agrees with the data in Table 2 (II)F, Sheet 2, source category 2.F.8 in the CRF.

Table 142: 2011 inventory data for source category 2.F.7, including relevant sub- source categories

Source category 2.F.7 – electrical equipments for energy transmission and distribution, with sub- source categories – 2009 inventory	Activity data			Emissions	
	Annual consumption, production	Stocks	Decommissioned	Production	Operation
	(tonnes of SF_6)				
Electrical equipments for energy transmission and distribution 2.F.8 (Total), including:	889.4	2134	8.1	12.4	6.8
MV switchgear and controlgear and equipment (in hermetically sealed pressurised systems)*	170.4	197.1	0.72	0.6	0.9
HV switchgear and controlgear and equipment (in hermetically sealed pressurised systems)**	632.7	921.6	7.3	3.5	5.3
Other electrical equipments ***	86.4	197.1	IE	8.3	0.5

IE= included in "HV switchgear and controlgear…"; marginal

Explanatory remarks:

* Hermetically sealed pressurised systems pursuant to IEC 62271-1 for the range 1kV through 52 kV; also known as "sealed for life" systems

** Sealed pressurised systems pursuant to IEC 62271-1 for the range above 52 kV

*** Gas-insulated transformers: marginal residual stocks in the network; (no production emissions) + high-voltage instrument transformers for outdoor installation (all emissions categories) + gas-insulated lines (GIL) (all emissions categories) + high-voltage bushings (only production emissions) + medium-voltage cast-resin instrument transformers (only production emissions) + testing of medium-voltage components (only production emissions) + 1000V capacitors (only production emissions)

4.7.8.1.3 Uncertainties and time-series consistency (2.F.8.a)

Since there are only about ten different manufacturers of electrical equipments (including bushings and instrument transformers), the consumption data, and the new-additions and decommissioned-units figures, are highly reliable. This holds all the more in that such data and figures are based on internal accounting, and that fill amounts are determined with great precision and then noted on devices' name plates. The pertinent uncertainty is in the area of ± 5 %.

Determination of emissions is more difficult, since the plants typically concerned have several different emissions sources, each quite small. Gas losses occur in filling of devices, in testing, in opening of products that fail to pass quality inspections, in product development, etc.. On the other hand, all domestic plants proceed in accordance with a standardised questionnaire that lists all possible emissions sources and that is checked for correctness during surveys. For this reason, and because there are few manufacturers (see above), the precision of data collection ultimately depends on the precision of the relevant measurements. The resulting figures lie within ±10 % of estimates.

Emissions from operations in the high-voltage sector are determined by selected operators, via monitoring of annual refilling of reference systems (refills are carried out when levels fall below 90 % of the desired fill level, and the devices themselves normally display such fill requirements as soon as they occur). This method can be considered very reliable, i.e. the deviations from the actual value are about ±5 %. All surveys to date have produced similar results for emissions rates; all results are within a range from 0.55 to 0.88 %. The one-time emissions-rate peak for high-voltage switchgear and controlgear that occurred in 2004 is the result of special events. In the main, it was due to simultaneous refilling of old, older-model systems that were less well-sealed.

In the year 2000, a decrease with respect to the previous year occurred in high-voltage in-service stocks and, thus, in emissions, both of which had been increasing since 1995. For in-service stocks, the decrease amounted to over 25 t, while for emissions it amounted to 0.85 t. That decrease, which was due to trends in gas-insulated HV switchgear (GIS) (600 to 567 t), cannot be explained as the result of decommissioning removals, since the role of such removals is still insignificant. According to the association of network operators (VDN), which carried out the surveys at the time, the underlying problem is both statistical and organisational in nature. At the end of the 1990s, electricity-market liberalisation led to profound operator regrouping (through mergers and changes in ownership of various parts of companies). Along with those changes, personnel assignments relative to electrical equipments in service were repeatedly changed. As a result, it is possible that double-counting occurred in 1999, and that some operating equipment was not counted in 2000. In light of experience gained in recent years, the uncertainty today can be assumed to lie in the range of ± 5 % for high-voltage stocks.

Pursuant to the IEC, the emissions rate of 0.1 % in the medium-voltage sector is a normal rate for hermetically sealed pressurised systems.

4.7.8.1.4 Source-specific recalculations (2.F.8.a)

No recalculations are required.

4.7.8.1.5 Source-specific planned improvements (2.F.8.a)

No improvements are planned at present.

4.7.8.2 Use in particle accelerators (2.F.8.b)

4.7.8.2.1 Source category description (2.F.8.b)

SF_6 is used in elementary particle accelerators as an insulating gas. High-voltage accelerator systems (0.3 to more than 23 MV) are used by university institutes, research groups and industry. In industry, low-voltage devices with less than 0.3 MV are also used. Yet another relevant category consists of radiation-therapy devices in medical facilities.

4.7.8.2.2 Methodological issues (2.F.8.b)

In early 2004, Öko-Recherche, working under commission to the Federal Environment Agency, carried out a complete survey of particle accelerators within the country, with the aim of updating pertinent data, some of which date from 1996. In the process, both users and producers of the devices/systems were queried. The questions posed had to do with the quantities of SF_6 in their devices and with refills of SF_6 carried out during the last seven years.

The CSE assumes responsibility for structuring the survey. For all five relevant categories, it contains annual data on SF_6 stocks and on replacements to compensate for emissions. The emissions in question include both ongoing emissions and minor filling and disposal losses.

For the 2011 report year, another exhaustive survey was carried out out. For the first time, data on electron microscopes were gathered.

4.7.8.2.3 Uncertainties and time-series consistency (2.F.8.b)

The uncertainties for this source category have been systematically quantified.

4.7.8.2.4 Source-specific recalculations (2.F.8.b)

The following recalculations have been carried out:

	Units	1995	1996	1997	1998	1999	2000	2001	2002
AR (AD) use									
Submission 2012	t	65.152	69.685	71.268	72.751	72.080	73.663	73.567	73.900
Submission 2013	t	65.632	70.085	71.588	72.991	72.240	73.743	73.567	73.809
Difference	t	**0.480**	**0.400**	**0.320**	**0.240**	**0.160**	**0.080**	**0.000**	**-0.091**
EM use									
Submission 2012	t								
Submission 2013	t								
Difference	t								
	Units	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
AR (AD) use									
Submission 2012	t	74.142	74.305	74.308	74.312	74.315	74.319	74.322	74.326
Submission 2013	t	73.801	73.769	73.736	73.704	73.672	73.640	73.607	73.727
Difference	t	**-0.341**	**-0.536**	**-0.572**	**-0.608**	**-0.643**	**-0.679**	**-0.715**	**-0.599**
EM use									
Submission 2012	t	4.891	4.897	4.905	4.913	4.920	4.928	4.936	4.943
Submission 2013	t	4.879	4.892	4.906	4.920	4.934	4.947	4.961	4.131
Difference	t	**-0.012**	**-0.004**	**0.001**	**0.007**	**0.013**	**0.019**	**0.025**	**-0.812**

4.7.8.2.5 Source-specific planned improvements (2.F.8.b)

No improvements are planned at present.

4.7.9 Other (2.F.9)

This source category comprises the uses *Sound-proof glazing* (2.F.9.a), *Automobile tyres* (2.F.9.b), *Sport shoes* (2.F.9.c), *Trace gas* (2.F.9.d), *AWACS maintenance* (2.F.9.e), *Welding* (2.F.9.f), *Optical glass fibres* (2.F.9.g) and *Photovoltaics* (2.F.9.h).

4.7.9.1 Sound-proof glazing (2.F.9.a)

4.7.9.1.1 Source category description (2.F.9.a)

Since 1975, SF_6 has been used to enhance the soundproofing properties of multi-pane windows. In such use, the gas is inserted into the spaces between the panes. The disadvantages of such use are that it reduces windows' thermal-insulation performance and that SF_6 is a powerfully acting greenhouse gas. The higher priority given to thermal insulation – e.g. by the Thermal Insulation Ordinance (Wärmeschutzverordnung) – along with improved SF_6-less window technologies, have led to a reduction in use of SF_6 in this application since the mid-1990s.

In Germany, sound-proof windows have been produced by numerous companies and filled with gas. Exports of assembled windows play no significant role.

Since 4 July 2007, a ban has been in force in the EU on sale of windows, for residential uses, that are filled with fluorinated greenhouse gases. As of 4 July 2008, that ban also applies to other windows. Current and future emissions in this source category thus come primarily from open waste management of old windows, which is assumed to occur an average of 25 years after the windows were filled. For this reason, total emissions are expected to continue growing until the year 2020.

4.7.9.1.2 Methodological issues (2.F.9.a)

Emissions occur during filling of spaces between panes, as a result of overfilling (production emissions), during use (use emissions) and in disposal (disposal emissions). Emissions are calculated in keeping with with equations 3.24 – 3.26 of IPCC-GPG (2000) on the basis of new domestic consumption, average annual stocks and remaining stocks 25 years ago.

The time series for sound-proof glazing begin in 1975, since the filling quantities of the year 1975 are of relevance for emissions from stocks in 1995. These data, which were reconstructed with the help of industry experts in 1996, were published in 2004 for the first time.

Emission factors

According to expert-level information from manufacturers of windowpanes and gas-filling equipment, provided to industry experts and to a scientific institute, one-third of the SF_6 used in the process of pumping SF_6 into spaces between windowpanes escapes. The $EF_{production}$ is thus 33 %, with respect to new annual consumption.

This emission factor is obtained in the following manner: In use of both manual filling devices and automatic gas-filling presses, gas-swirling in the space between the panes cannot be avoided. As a result, the escaping gas consists not only of the air originally between the panes, it also includes an air-SF_6 mixture. More and more mixed gases escape as the filling process progresses. The gas loss, the "overfill", ranges from 20 to 60 % of the amount filled.

The smaller the window concerned, the greater the overfill's relative importance. On average, i.e. throughout the entire spectrum of filled windows, of all shapes and sizes, the overfill level amounts to 50 % of the amount actually contained between the panes. This corresponds to one-third (33 %) of the relevant consumed amounts. This emission factor continues to be used, since neither filling technologies nor the range of window geometries have changed.

A DIN standard (DIN EN 1279-3, DIN 2003) specifies an upper limit of 10 per mil for annual losses of filled gas from panes' peripheral seals. This value also takes account of gas losses resulting from glass breakage in transport, installation and use, as well as from age-related increasing leakage from peripheral seals. The result is an emission factor EF_{use} of 1 % with respect to the average SF_6 stocks that have accumulated since 1975 and that are in place in year n.

Finally, disposal losses are incurred at the end of windows' service lifetimes (utilisation periods), or an average of 25 years after the windows were filled. For this reason, emissions from disposal do not have to be taken into account until the year 2000.

Since each year a window loses 1 % of its gas, with respect to the previous year's value, only part of a window's original quantity of gas is emitted when the window undergoes disposal. Since no gas collection upon disposal takes place, however, the emissions level is 100% ($EF_{disposal}$ = 1).

Activity data

The new annual consumption was determined via top-down survey (domestic sales by the gas industry).

4.7.9.2 Automobile tyres (2.F.9.b)

4.7.9.2.1 Source category description (2.F.9.b)

Beginning in 1984, automobile tyres were filled with SF_6 for reasons of image (the resulting improved pressure constancy is not relevant in practice). The peak consumption year was 1995. In that year, over 500 of the some 3,500 tyre-sales outlets in Germany had equipment for filling tyres with SF_6 gas. Because SF_6 is a powerfully acting greenhouse gas, many tyre dealers began filling tyres with nitrogen instead. This practice led to a considerable reduction in use of SF_6. Since 4 July 2007, a ban has been in force in the EU on sale of new automobile tyres filled with fluorinated greenhouse gases. The bulk of today's emissions originates from gas in older filled tyres.

4.7.9.2.2 Methodological issues (2.F.9.b)

For the sake of simplicity, gas emissions during tyres' service lifetimes are not taken into account; as a result, emissions occur only when tyres are dismantled. Given an intended service lifetime of about 3 years, and the fact that there is no foreign trade with filled types, emissions follow domestic consumption for filling with a three-year time lag (ÖKO-RECHERCHE, 1996). The emissions are calculated using equation 3.23 of IPCC-GPG (2000).

Emission factors

The very small losses incurred in filling of tyres are not taken into account. Since SF_6 escapes completely when tyres are dismantled, $EF_{disposal}$ = 1.

Activity data

Annual sales are determined via surveys, carried out by the Federal Statistical Office, of gas suppliers, regarding their domestic sales to tyre dealers and automobile service centres.

4.7.9.3 Sport shoes (2.F.9.c)

4.7.9.3.1 Source category description (2.F.9.c)

SF_6 was inserted into the soles of sport shoes in order to enhance cushioning. 2003 was the last year in which this practice occurred anywhere in Europe. As of 2004, PFC-218 (C_3F_8) was used in this application. Use of that gas was then discontinued in 2006. Today, nitrogen is usually used for this purpose. Sale of footwear produced with fluorinated greenhouse gases has been prohibited in the EU since 4 July 2006. Current emissions occur only in disposal of sport shoes.

4.7.9.3.2 Methodological issues (2.F.9.c)

The emissions are calculated using equation 3.23 of IPCC-GPG (2000).

Production emissions occur only in foreign countries. Current emissions from stocks are not determined.

In keeping with a commitment to maintain confidentiality, data relative to sport-shoe soles are reported under CRF 2.G.

Emission factors

Manufacturers do not report production emissions.

It is assumed that no emissions occur during use.

In disposal, emissions may be equated with input quantities ($EF_{disposal}$ = 1). In addition, in a procedure similar to the IPCC method for automobile tyres, a time lag of three years is assumed.

Activity data

The filled quantities are based on manufacturers' European-wide sales figures. These figures are broken down, on the basis of Germany's population, to obtain figures for Germany. While such data have been available to the Federal Environment Agency since the 2001 report year, they are published only in aggregate form, for reasons of confidentiality.

4.7.9.4 Trace gas (2.F.9.d)

4.7.9.4.1 Source category description (2.F.9.d)

SF_6, as a stable and readily detectable trace gas, even at extremely low concentrations, is used by research institutions to investigate a) ground-level and atmospheric airflows and gas dispersions and b) water currents.

As of report year 2007, use of SF_6 as a trace gas decreased considerably with respect to earlier years.

4.7.9.4.2 Methodological issues (2.F.9.d)

In contrast to the procedure followed for equation 3.22 in IPCC GPG (2000), the quantities used are determined via experts' assessments, and not via gas-sellers' sales figures. New consumption for this open use is listed in CRF Table 2(II).Fs2 under "amount of fluid filled in new manufactured products", because this description covers the manner in which the gas is actually used in this application.

Emission factors

An "open use" is assumed, i.e. annual new inputs are completely emitted in the same year and are treated as consumption for production ($EF_{production}$ = 1). No recovery takes place.

Activity data

In 1996, total domestic use was estimated by experts of all relevant research institutions. Since then, use levels have been estimated by one expert at three-year intervals. These assessments indicate that the quantities used vary only slightly.

4.7.9.5 AWACS (Airborne Warning and Control System) maintenance (2.F.9.e)

4.7.9.5.1 Source category description (2.F.9.e)

SF_6 is used as an insulating medium for radar in Boeing E-3A (NAEWF; formerly, AWACS) aircraft, which are large military surveillance aircraft. It is used to prevent electrical arcing, towards the antenna, in waveguides with high voltages in excess of 135 kV. Ongoing emissions are relatively high, since SF_6 is released to equalize pressure as aircraft climb.

4.7.9.5.2 Methodological issues (2.F.9.e)

Activity data

The emissions figures are based on reported purchased quantities for filling and refilling of NATO's NAEWF fleet. Reported sales figures are double-checked against gas-sellers' statistics. The emissions data for report years until 2001 are based on estimates that are themselves based on a survey from the year 1996. For this reason, the emissions data for the years 1997 to 2001 are imprecise. For report year 2002, a new survey of consumed quantities was carried out. This showed a significant increase over relevant quantities in report year 2001.

Experts consider the annual SF_6 requirements for the NAEWF fleet to be constant.

Data on AWACS maintenance are reported under CRF 2.G, since the data are confidential.

4.7.9.6 Welding (2.F.9.f)

4.7.9.6.1 Source category description (2.F.9.f)

According to gas suppliers, use of SF_6 in welding began in 2001. SF_6 is used as a protective gas in welding of metal. Since there is only one user in Germany, the pertinent data are subject to confidentiality protection.

4.7.9.6.2 Methodological issues (2.F.9.f)

Because they are confidential, data relative to data on consumption and emissions in connection with welding are reported under CRF 2.G.

Emission factors

No reliable data are available on SF_6 decomposition during use. Experts presume that the entire relevant input SF_6 quantities are emitted completely into the atmosphere during use. For this reason, consumption and emissions are considered equal for welding applications. The emission factor for welding is specified as $EF_{use} = 1$.

Activity data

The annual amounts consumed are determined via enquiry of the company that uses SF_6 for welding purposes.

4.7.9.7 Optical glass fibre (2.F.9.g)

4.7.9.7.1 Source category description (2.F.9.g)

Use of SF_6 in production of optical glass fibre began in 2002. In such production, SF_6 is used for fluorine doping. Numerous production operations are in place in Germany.

4.7.9.7.2 Methodological issues (2.F.9.g)

Emissions occur in production of optical glass fibre cable.

Emission factors

The 2006 IPCC Guidelines[57] contain no information on use of SF_6 in production of optical glass fibre. According to experts, 70 % of the input SF_6 quantities escape. For this reason, an emission factor of $EF_{production} = 0.7$ is used.

Activity data

The annual consumption figures are obtained via surveys, carried out by the Federal Statistical Office, of gas suppliers, with regard to their domestic sales.

4.7.9.8 Photovoltaics (2.F.9.h)

4.7.9.8.1 Source category description (2.F.9.h)

In wafer production in Germany, SF_6 and other fluorine compounds are used for structure etching and for cleaning of reaction chambers during production processes. Since the purity

[57] IPCC GL 2006, Vol. 6, Chapter 6: Electronics Industry

of the process gas is lower than that of the gas used in the similar production process in the semiconductor industry, use for *photovoltaics* is reported separately. In Germany, use of SF_6 in solar technology began in 2002.

The time series shows a continuous emissions increase between 2002 and 2006; this is due to increases in production. A large jump occurred in 2007 and 2008, when quantities of produced wafers and, thus, the quantities of SF_6 used, increased sharply. In 2009, the opposite effect occurred.

Since 2008, NF_3 has substituted for SF_6 in all new production lines for production of Si thin-film cells.

In addition, in 2002/2003 the hydrocarbon CF_4 was introduced for "edge insulation" of crystalline solar cells. The procedure using that substance was soon supplanted by a different procedure that is easier to handle, however. Consumption of CF_4, which peaked in 2004, has been decreasing sharply since then.

4.7.9.8.2 Methodological issues (2.F.9.h)

Like emissions in the semiconductor industry, emissions in photovoltaics occur during production. The relevant production emissions cannot be determined solely on the basis of the quantities used (sales by the gas trade). The differences between consumption and emissions result from a) the fact that chemical conversion in plasma reactors is only partial and b) the effects of downstream waste-gas-scrubbing systems.

Emission factors

In 2009, only one producer in Germany did not have a waste-gas-scrubbing system. For this reason, the IPCC emission factor of 40% is used only for the first year of pertinent use, 2003. Thereafter, the emission factor decreases, as the percentage of wafer production connected to downstream waste-gas-scrubbing systems increases. In 2010, it was just less than 6%.

Activity data

The annual consumption figures are obtained via surveys, carried out by the Federal Statistical Office, of gas suppliers, with regard to their domestic sales. In addition, the data were checked in a separate study entitled "SF_6 and NF_3 in the German photovoltaic industry" ("SF_6 und NF_3 in der deutschen Photovoltaik-Industrie") (ÖKO-RECHERCHE, 2009: FKZ 360 16 027).

4.7.9.9 Uncertainties and time-series consistency (2.F.9 all)

In the case of sound-proof glazing, since 2006 data from the top-down survey of annual new consumption, carried out on the basis of commercial sales data, have been compared with data from the *Federal Statistical Office's* pertinent annual surveys. This procedure, which may be considered reliable and complete, has increased data reliability. Due to the wide range of influencing factors, the $EF_{production}$ cannot be measured reliably. Estimates resulting from a survey of ten industry experts, conducted in 1996 and 1999 (the experts represented window manufacturers, suppliers of filling devices and one scientific institute) indicate, virtually conclusively, that the mean filling loss ranges between 30 % and 40 %. A 1 % rate is considered realistic for ongoing gas losses.

With regard to sport shoes, in spite of the good quality of the data for the EU, the filled-quantities breakdown, by Member States, is subject to considerable uncertainties.

4.7.9.10 Source-specific recalculations (2.F.9 all)

For the period as of report year 2007, the input quantities for SF_6 as a tracer gas were again corrected downward (from 150 kg/a to 20 kg/a). No other source-specific recalculations were required.

4.7.9.11 Source-specific planned improvements (2.F.9 all)

No improvements are planned at present.

4.7.10 Source-specific QA/QC and verification (2.F all)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data for the 2003 report year, like the data for most of the previous years, were collected by an external expert working in the framework of a research project under commission to the Federal Environment Agency.

For the most part, quality assurance was carried out by an external expert. In addition, the data are checked by the relevant Federal Environment Agency specialist upon receipt.

The collected data on the size of source-category-specific HFC stocks, on composition of those stocks with regard to various HFC refrigerants, on EF, etc. are subject to continual quality assurance / control and verification, although this process has not yet been standardised. On a regular basis, various sources (environmental statistics[58], production and sales figures[59], etc.) are consulted, and experts (users, refrigerant manufacturers, suppliers, etc.) are consulted to determine the sources' reliability.

The data for electrical equipments and semiconductor production have undergone an internal association process of quality assurance / control and verification.

Due to the large number of manufacturers involved (nearly 400), no double-checking via bottom-up survey (manufacturers' purchase data) is carried out for sound-proof glazing. From 2006 through 2009, data for annual new consumption were checked against the *Federal Statistical Office's* pertinent annual surveys.

The entire sector of F-gas emissions was subjected to voluntary trilateral review. Experts from England, Germany and Austria reviewed the F-gas inventories of the other countries involved. That review had a positive outcome, namely that Germany has a good F-gas inventory. As a result, no recommendations were issued for improvements of the German F-gas inventory.

[58] Surveys pursuant to Art. 11 of the Environmental Statistics Act (UstatG).
[59] Surveys pursuant to the Foreign Trade Statistics Act (AHStatGes) and production statistics.

4.8 Other areas (2.G.)

CRF 2.G	Gas	Key category		1995 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Consumption of halocarbons and SF_6	SF_6	-	-	C	C	C	C	C

Gas	Method used	Source for the activity data	Emission factors used
SF_6		s. Table 137	

Emissions of SF_6 from use in *sport shoes* (2.F.9.c Other – sport shoes), use in connection with *AWACS maintenance* (2.F.9.e Other – AWACS maintenance) and use in *welding* (2.F.9.f Other – welding) are reported under 2.G, for reasons of confidentiality.

Emissions of HFCs from uses as solvents (2.F.5 Solvents) are reported under 2.G, for reasons of confidentiality.

PFC emissions from use in sport shoes (2.F.9.c Other – sport shoes) and in photovoltaics (2.F.9.h) are reported under 2.G, for reasons of confidentiality.

In keeping with a recommendation of the Expert Review Team, it is noted that all information relative to the emissions reported under 2.G – including source-category description, methodological issues, uncertainties & time-series consistency, source-specific recalculations & verification and planned improvements – is presented in the pertinent category chapters.

No other sources of relevant greenhouse-gas emissions are known.

5 SOLVENTS AND OTHER PRODUCT USE (CRF SECTOR 3)

5.1 Overview (CRF Sector 3)

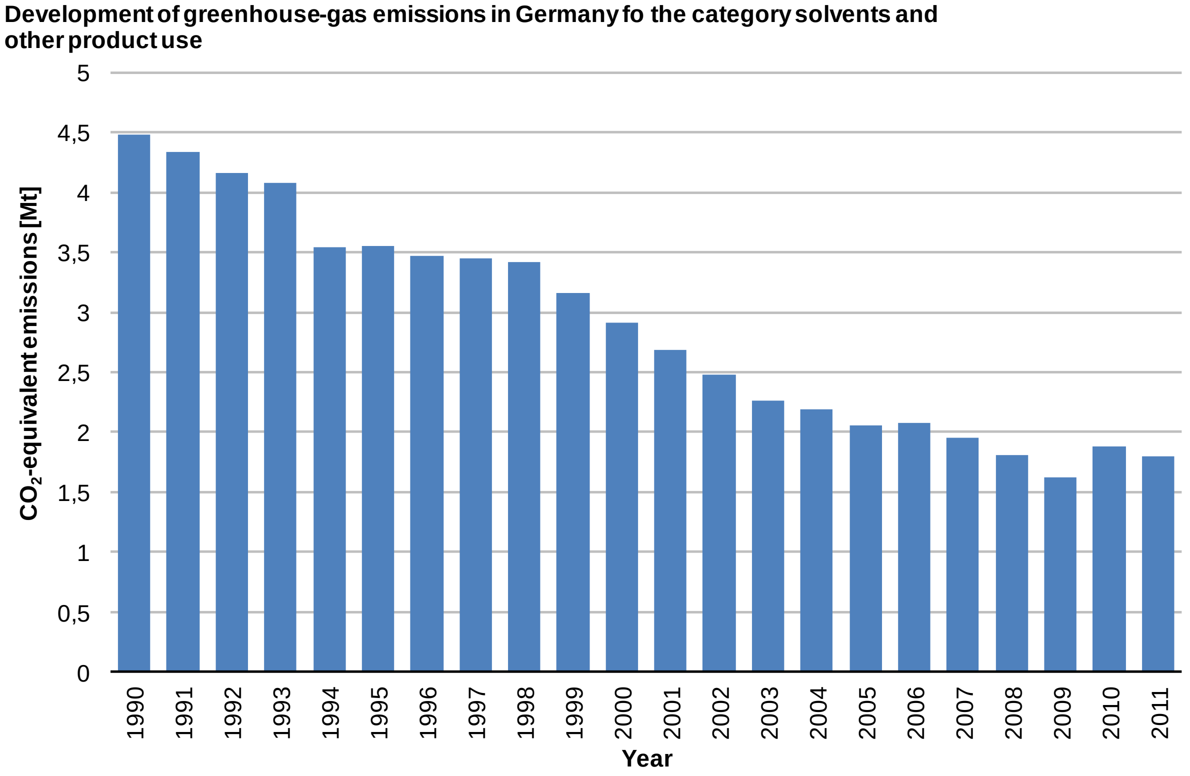


Figure 42: Overview of greenhouse-gas emissions in CRF Sector 3

This source category comprises emissions from the use of chemical products. Currently, the source category includes information on solvent emissions from applications in the industry, commercial/institutional and residential sectors, as well as detailed information about release of N_2O during its use.

Source category 3, *Solvents and other product use*, is divided into the sub- source categories *Paint application* (3.A), *Degreasing and dry cleaning* (3.B), *Chemical products, manufacture and processing* (3.C) and *Other product use* (3.D). *Other product use* (3.D) includes emissions of laughing gas (cf. Chapter 5.3), emissions from selective catalytic reduction (SCR) systems and the above-detailed other solvent uses that cannot be allocated to source categories 3.A through 3.C.

The N_2O emissions from source category 3.D *Other product use* are reported separately from other emissions categories, in Chapter 5.3.

5.2 Solvents - NMVOC (3.A-3.C & 3.D)

5.2.1 Source category description (3.A-3.C & 3.D)

CRF 3.A-3.C, 3.D (NMVOC)	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Total Solvent and Other Product Use	CO_2	-	-	2,552.0	(0.21%)	1,506.0	(0.16%)	-40.99%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	RA	NS	D
NMVOC	Tier 2	NS	CS

The source category indirect CO_2 from NMVOC emissions from the area of *Solvents and other product use* (CRF 3.A-3.C and 3.D) is not a key category.

The NMVOC emissions released through use of solvents and solvent-containing products all belong to sub-categories of this source category.

The four reporting categories of this source category vary widely in structure. To take account of this variation, inventory data were calculated in keeping with the UNECE/EMEP sub-structures based on the CORINAIR97 (CORINAIR: COordination d' INformation Environmentale; sub-project AIR) SNAP system[60].

Source category 3.D *Other product use* includes the following uses and activities:

- Treatment of glass and rock wool
- Printing industry (printing applications)
- Extraction of oils and fats
- Use of glues and adhesives
- Use of wood preservatives
- Undersealing and wax treatments for automobiles
- Household use of solvents (not including paints and lacquers)
- Automobile-wax stripping
- Manufacturing of pharmaceutical products
- Household use of pharmaceutical products
- Other

"NMVOC" is defined in keeping with the VOC definition found in the EC solvents directive[61]. For purposes of the definition of solvents, the term "solvent use" is also defined in keeping with the EC solvents directive[62].

It is important to note that some volatile organic compounds are used both as solvents and as chemical reactants – for example, toluene, which is used as a solvent in lacquers and glues and as a reactant for production of toluenediisocyanate (TDI), and methyl ethyl ketone (butanone), which is used as a solvent in printing inks and as a base material for synthesis of methyl ethyl ketone peroxide. Consequently, VOC (either substances or fractions of

[60] In the present area, this involves "SNAP Level 3" detailing.

[61] In this definition, volatile organic compounds (VOC) include all organic compounds that are volatile at 293.15 K, at a vapour pressure of at least 0.01 kPa or under the usual conditions for their use.

[62] In this definition, an organic solvent is a volatile organic compound that, either by itself or in combination with other raw materials, products or waste substances, and without changing chemically, either dissolves or is used as a cleanser for dissolving dirt accumulations, as a solvent, as a dispersing agent, as an agent for adjusting viscosity or surface tension, or as a softener or preservative.

substances or products) used as chemical reaction components are not included in this source category.

Delimitation of this source category as outlined above takes a highly diverse range of emissions-causing processes into account. The factors considered with regard to such processes include:

- Concentrations and volatility of VOC used.
  The relevant spectrum includes use of volatile individual substances as solvents – for example, in cleansing; use of products with solvent mixtures – for example, in paints and lacquers; and applications in which only small parts of mixtures used (also) have solvent properties (as is the case, for example, in polystyrene-foam production).
- The great differences in emissions conditions.

Solvent uses can be open to the environment – as is the case in use of cosmetics – or largely closed to the environment – as in extraction of essential oils or cleaning in chemical dry-cleaning systems.

5.2.2 Methodological aspects (3.A-3.C & 3.D)

NMVOC emissions are calculated via an approach oriented to product consumption. In this approach, the NMVOC input quantities allocated to these source categories, via solvents or solvent-containing products, are determined and then the relevant NMVOC emissions (for each source category) are calculated from those quantities via specific emission factors. This method is explicitly listed, under "consumption-based emissions estimating", as one of two methods that are to be used for emissions calculation for this source category.

Use of this method is possible only with valid input figures – differentiated by source categories – in the following areas:

- Quantities of VOC-containing (pre-) products and agents used in the report year,
- The VOC concentrations in these products (substances and preparations),
- The relevant application and emission conditions (or the resulting specific emission factor).

To take account of the highly diverse structures throughout this source category, these input figures are determined on the level of 37 differentiated source categories (in a manner similar to that used for CORINAIR SNAP Level 3), and the calculated NMVOC emissions are then aggregated. The product / substance quantities used are determined at the product-group level with the help of production and foreign-trade statistics. Where possible, the so-determined domestic-consumption quantities are then further verified via cross-checking with industry statistics.

The values used for the average VOC concentrations of the input substances, and the emission factors used, are based on experts' assessments (expert opinions and industry dialog) relative to the various source categories and source-category areas. Not all of the necessary basic statistical data required for calculation of NMVOC emissions for the most current relevant year are available in final form; as a result, the data determined for the previous year are used as a basis for a forecast for the current report. The forecast for NMVOC emissions from solvent use for the relevant most current year is calculated on the basis of specific activity trends. As soon as the relevant basic statistical data are available for the relevant most current year, in their final form, the inventory data for NMVOC emissions from solvent use are recalculated.

Since 1990, NMVOC emissions from use of solvents and solvent-containing products have decreased by about 41 %. The greatest part of this emissions reduction has occurred in the years since 1999. This successful reduction has occurred especially as a result of regulatory provisions such as the *Ordinance, under chemicals law, for limiting emissions of volatile organic compounds (VOC) through limitations on the placing on the market of solvent-containing paints and varnishes (Chemikalienrechtliche Verordnung zur Begrenzung der Emissionen flüchtiger organischer Verbindungen (VOC) durch Beschränkung des Inverkehrbringens lösemittelhaltiger Farben und Lacke (Lösemittelhaltige Farben- und Lack-Verordnung - ChemVOCFarbV)*, the 31st Ordinance on the Implementation of the Federal Immissions Control Act *(Ordinance on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain facilities – 31. BImSchV)*, the 2nd such ordinance *(Ordinance on the limitation of emissions of highly volatile halogenated organic compounds* – 2. *BImSchV)* and the Technical Instructions on Air Quality Control (TA Luft). The German "Blauer Engel" ("Blue Angel") environmental quality seal, which is used to certify a range of products, including paints, lacquers and glues with low solvent concentrations, has also played an important role in this development.

While product sales increased in some areas – even over periods of several years – thereby adding to emissions, the above-described measures have largely offset this trend. These successes, which have occurred especially in recent years, are reflected in the updated emissions calculations – which, thanks to methods optimisation, now feature greater differentiation of VOC concentrations and emission factors.

Since the 2009 report, indirect CO_2 emissions are calculated from NMVOC.

Since compatibility with EU greenhouse-gas reporting is the primary methodological backdrop for conversion of NMVOC emissions into indirect CO_2 emissions, for the current report we have used the Reference Approach proposed in *Chapter 7 Precursors and Indirect Emissions* of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories:

$$EM_{Indirect\ CO2} = EM_{NMVOC} * \text{molar mass } CO_2 / \text{molar mass C} * 60\ \%$$

5.2.3 Uncertainties and time-series consistency (3.A-3.C & 3.D)

At the time of the report, errors had been estimated for NMVOC emissions; this was carried out using the error-propagation method and on the basis of experts' assessments for all input figures (in all 37 differentiated source categories). The main source of current uncertainties consists of inadequate precision in separation of basic statistics (production and foreign-trade statistics), with regard to categorisation in VOC-containing and VOC-free products, and with regard to use in different source categories with highly differing emissions conditions.

5.2.4 Source-specific quality assurance / control and verification (3.A-3.C & 3.D)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

5.2.5 Source-specific recalculations (3.A-3.C & 3.D)

The data used in the emissions inventory for the NMVOC emissions of the previous year are subjected to routine source-specific recalculations. That procedure, which is grounded in the methodology for the product-consumption approach, is required because the relevant final data from foreign-trade statistics do not become available until after the report for the pertinent reported year has been completed. No corrections were required for the NMVOC emissions of 2010, since no adjustments in foreign-trade statistics resulted.

5.2.6 Planned improvements (source-specific) (3.A-3.C & 3.D)

No further source-category-specific improvements are planned at present.

5.3 Other – use of N_2O (3.D)

CRF 3.D (N_2O)	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Total Solvent and Other Product Use	**N_2O**	**-**	**T**	**1,924.6**	**(0.16%)**	**287.9**	**(0.03%)**	**-85.04%**

Gas	Method used	Source for the activity data	Emission factors used
N_2O	CS	AS/Q	CS

The source category *Solvents and other product use* is a key category for N_2O emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-84.45 %), and thus an extremely low emissions level has been attained, the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

5.3.1 Source category description (3.D.1)

The German nitrous oxide market is dominated by Air Liquide, Linde AG and Westfalen AG, all of which are leading producers as well as importers. No nitrous oxide emissions occur in nitrous oxide production and in filling of the gas into gas bottles. Emissions occur solely in use of the gas. Medical applications represent the most important N_2O-emissions source. Other emissions sources include use of laughing gas as a propellant in whipped-cream aerosol cans and use in the semiconductor industry. N_2O is also released, in small amounts, in blasting. Nitrous oxide emissions in anaesthesia, a predominant emissions source since 1990, have been decreasing sharply, due to increasing use of intravenously administered anaesthetics instead of nitrous oxide. This trend is expected to continue.

Medicine – anaesthesia

In medicine, nitrous oxide, a gas with analgesic properties, is used for anaesthetic purposes. In such applications, nitrous oxide is mixed with pure oxygen, to produce an active gas mixture consisting of 70 % nitrous oxide and 30 % oxygen. In modern anaesthesia, the effects of nitrous oxide are enhanced through addition of other anaesthetics. While medical use of N_2O is not prohibited, there is strong resistence – especially in the German medical sector – against widespread, general use of the substance. Medical use of laughing gas has thus been decreasing continuously since 1990.

Food industry – whipped-cream aerosol cans

In the food industry, nitrous oxide is used as an additive known as "E 942". Foods sold in pressurised containers are extracted from such containers with the help of propellants. As it exits such a container, a food takes on either a foamy or a creamy consistency, depending on what type of food it is. Examples of relevant foods with added N_2O include whipped cream (from spray cans), quark, and various desserts such as ready-to-eat puddings (DIE VERBRAUCHER INITIATIVE E.V, 2005; LINDE GAS GMBH, 2005).

Semiconductor manufacturing

A wide range of different chemicals and gases is used in semiconductor production. Argon, ultra-pure oxygen, hydrogen, ultra-pure helium and nitrogen account for the lion's share of the gases used. Special process gases, such as nitrous oxide (dinitrogen monoxide), ammonia and hexafluorethane, are used only in relatively small amounts, and the amounts involved have remained nearly constant over the past few years (AMD Saxony LLC&Co. KG, Dresden, Umweltbericht (environmental report) 2002/2003, page 16).

Explosives

Explosives are used in both military and industrial contexts. Civil and commercial explosives are used in mining, in construction in rocky terrain, in demolition, in geology and in fireworks.

Nitrous oxide emissions occur primarily in detonation of explosives that contain ammonium nitrate, such as ANFO (ammonium nitrate / fuel oil) and emulsion explosives. In general, commercial / civil explosives consist to some 60 to 80 % of ammonium nitrate (AN). By contrast, Andex, an ANFO explosive, contains up to 94 % ammonium nitrate.

In Germany, two companies produce explosives for civil use: Orica Mining (formerly Dynamit Nobel) and Westpreng GmbH (Wasag Chemie).

While no nitrous oxide emissions occur in manufacturing of explosives, nitrous oxide can form in thermal decomposition of explosives. The reason for this is that ammonium nitrate (AN) forms nitrous oxide (laughing gas) and water as it decomposes thermally.

Under careful warming to a temperature above the melting temperature, the reaction is as follows:

$$NH_4NO_3 \longrightarrow N_2O + 2H_2O$$

But in a fast, detonative reaction of an AN-containing explosive, the reaction occurs as follows:

$$NH_4NO_3 \longrightarrow 2H_2O + N_2 + 0{,}5O_2$$

This means that under high pressure and temperature AN primarily forms nitrogen, oxygen and water as it reacts. Only a small concentration of primarily formed N_2O remains intact in the detonation process. For example, detonation clouds of amatols[63], which contain some 80 % AN, have only 0.1 mole N_2O per mole of ammonium nitrate. From this figure, a theoretical maximum of about 68 g (this figure was provided by an explosives expert; the

[63] Amatol x/y : military explosives – pourable mixtures, generally consisting of x % TNT and y % ammonium nitrate

stoichiometric value would be 44 g/mole amatol (80%-AN)) per kilogramme AN can be calculated (ORELLAS, D.L., 1982; VOLK, F,, 1997, page 74). According to experts, this AN-content figure can be used as a basis for assumptions regarding N_2O emissions for other explosives.

N_2O in automobile tuning

In automotive technology, nitrous oxide is used to improve combustion in gasoline / petrol engines, via so-called "laughing-gas injection". In the process, laughing gas is broken down into nitrogen and oxygen. The nitrogen cools the combustion process, and the oxygen increases combustion power. This "tuning" tactic can quickly increase engine performance. To date, one company in Germany offers such tuning measures. Research has shown that the equipment used for such tuning is designed to consume the input laughing gas completely, without producing significant emissions.

5.3.2 Methodological issues (3.D.1)

Anaesthesia

The 1990 figure for N_2O emissions from medical applications is based on an extrapolation of a statistical plant survey conducted in 1990 in the territory of the former GDR. At the time, it was ascertained that one plant for the production of N_2O for anaesthetic purposes had existed in the former GDR. Also at the time in question, the plant had not yet been operational for long (it was constructed in 1988). The annual production capacity was approximately 1,200 t. Research indicated that there were no exports or imports of this substance, and thus it was assumed that all of the substance was used for domestic consumption. Via the per-capita emissions calculated from this for the former GDR, and assuming identical conditions, N_2 emissions of 6,200 t were estimated, as a rough approximation, for Germany in 1990. The N_2 figure for 2001 was obtained via a written memorandum, dating from 2002, of the Industriegaseverband e.V. (IGV) industrial-gas association. That figure was tied to a range of 3,000 ~ 3,500 t/a. The mean value from that range (3,250 t/a) was then used for generation of an N_2-emissions time series.

Since 2005, the Industriegaseverband (IGV) industrial-gas association has carried out surveys of N_2O sales for all applications in Germany. In addition, the IGV has made the data from those surveys available to the Federal Environment Agency for reporting purposes. In 2010, the IGV entered into a voluntary agreement, with the Federal Ministry of Economics and Technology (BMWi), regarding annual provision of N_2O-sales data for purposes of emissions reporting.

The gaps in the data relative to uses in anaesthesia are closed via interpolation and extrapolation.

The pertinent emission factor is 100%.

Whipped-cream aerosol cans

Use of N_2O in aerosol cans for whipped cream, in Germany, has to be carefully differentiated. In Germany, there is one maker of aerosol cans for whipped cream. That maker also fills the cans in Germany. In emissions calculations, it is assumed, on the basis of the above-described research, that that company accounts for a share of about 3 % of the laughing-gas sales of the IGV industrial-gas association. Most of the companies who deal with such aerosol cans have them filled abroad and then import them into Germany. The relevant sales of such companies are thus not included in the data of the IGV industrial-gas association. The MIV dairy-industry association has reported to the Federal Environment Agency the results of a one-time survey that showed that 50.2 million units of whipped-cream aerosol cans were sold in 2008. At the same time, the MIV association reported that the units involved vary in size, and that it is not possible to break the figures down by can sizes. Internet research showed that pressurized cartridges for this area are sold in Germany: cartridges with 8g of N_2O, for 0.5l (whipped-cream) cans, and cartridges with 16g of N_2O, for 1.0l cans. Comparison calculations have shown that 8g of N_2O is a safe approximation, for purposes of calculation, for the amount of laughing gas contained per sold unit (whipped-cream aerosol can). That, in turn, leads to an input figure of 401.6 t N_2O for whipped-cream aerosol cans in 2008 in Germany. Since no pertinent data are available for the years prior to 2008, that value is assumed to be constant.

The emission factor for whipped-cream aerosol cans is assumed to be 100%.

Semiconductor manufacturing

On a one-time basis, the German Electrical and Electronic Manufacturers' Association (ZVEI) has provided information on quantities of laughing gas sold in the years 1990, 1995, 2000, 2001 and 2008. Values between those points are obtained via interpolation.

In addition, the ZVEI estimated the emission factor for 2008 to be about 40 %, in keeping with conversion of laughing gas within the pertinent process and with downstream treatment processes. The ZVEI was unable to provide any figures for 1990. But since it can be assumed that levels of waste-gas treatment in 1990 were not nearly as high as they were in 2008, an emission factor of 100 % is used as a conservative estimate for 1990. The emission factor for the period between 1990 and 2008 was obtained via interpolation.

Explosives

In 2003, a total of 59 kt of explosives was produced in Germany. Of that figure, 13 kt were exported abroad, and 5.8 kt were imported into Germany[64]. Those figures, in turn, yield a figure of 51.8 kt for the amount of explosives used in Germany. Of that amount, ANFO accounts for a share of 60 %, emulsion explosives account for 25 % and dynamite explosives account for 15 %. ANFO explosives consist of 94 % ammonium nitrate and 6 % fuels. The corresponding relationship for emulsion explosives is 80 % to 20 %; for dynamite explosives, it is 50 % to 50 %.

At present, nitrous oxide amounts in detonation clouds are not determined, while amounts of NO and NO_2 are determined.

Normally, N_2 formation plays a significant role only in explosives that contain ammonium nitrate (AN). That said, no precise analyses of detonation clouds of ANFO explosives have been carried out. For this reason, it must be assumed that the N_2 concentrations formed upon detonation of ANFO are similar, with regard to AN content, to those formed upon detonation of amatols and ammonites[65], for which analyses have been carried out that

[64] Personal communication: Federal Office for Material Research and Testing (BAM).
[65] Ammonite: Composition: 70-88 % ammonium nitrate, with 5-20 % nitroaromates, 1-6 % vegetable flour and, in some cases, 4 % nitroglycerine, aluminium powder and potassium perchlorate

support relevant estimates. The following result has been obtained: upon detonation, amatoles and ammonites form about 0.1 mole N_2O per mole of ammonium nitrate (AN).

According to the *Federal Office for Material Research and Testing* (BAM), levels of explosives use in Germany remained constant from 1990 to 2005.

The emission factor for use of explosives is 0.1036 kg N_2O/t explosives. That emission factor was determined, via measurement, by the BAM in February 2010. As a result, the emission factor has been corrected downward, considerably, with respect to the 2010 Submission.

For whipped-cream aerosol cans and the semiconductor industry, the pertinent emissions are reported in aggregation with confidential emissions data from N-dodecandiacid production (2.B.5).

5.3.3 Uncertainties and time-series consistency (3.D.1)

Since 2005, activity data for anaesthetic uses have been obtained from association information. For that reason, the uncertainty is estimated to be 20 %. The data on consumption for whipped-cream aerosol cans are subject to a very high level of uncertainty (75 %), since the relevant calculation is based on several assumptions and since a definite figure is available only for 2008. The uncertainty of the activity data for the semiconductor industry is estimated at 10 %, since the data have been obtained from facility operators themselves.

The uncertainty in the emission factors for anaesthesia and whipped-cream aerosol cans is set as 0 %, since at present it is assumed that N_2O undergoes no transformation in use, and that the gas thus escapes completely into the atmosphere following its use. The emission factor for use in semiconductor manufacturing is estimated to have an uncertainty of 15 %, since the data have been obtained from facility operators themselves. The emission factor for explosives is estimated to have an uncertainty of 5 %, since the emission factor has been determined via an official measurement.

With these results, the time series can be considered to show a normal distribution (distribution type).

5.3.4 Source-specific quality assurance / control and verification (3.D.1)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

5.3.5 Source-specific recalculations (3.D.1)

No recalculations are required.

5.3.6 Source-specific planned improvements (3.D.1)

No improvements are planned at present.

6 AGRICULTURE (CRF SECTOR 4)

6.1 Overview (CRF Sector 4)

6.1.1 *Source categories and total emissions, 1990 - 2011*

In Germany, source category 4, "Agriculture", includes Enteric fermentation (4.A), Manure management (4.B) and Agricultural soils (4.D).

Emissions from rice cultivation (4.C) do not occur in Germany, while clearance of land by prescribed burning (4.E) is not practiced in Germany (NO). Field burning of agricultural residues (4.F) is prohibited in Germany, although it must be noted that some exemptions are permitted, and these do not lend themselves to surveys. Such exceptions are considered to be irrelevant (NO).

For the present NIR 2013, Figure 43 provides an overview of the development of greenhouse-gas emissions, over time, in the areas 4.A, 4.B and 4.D. The pertinent data have been calculated with the GAS-EM inventory model (cf. Chapter 6.1.2).

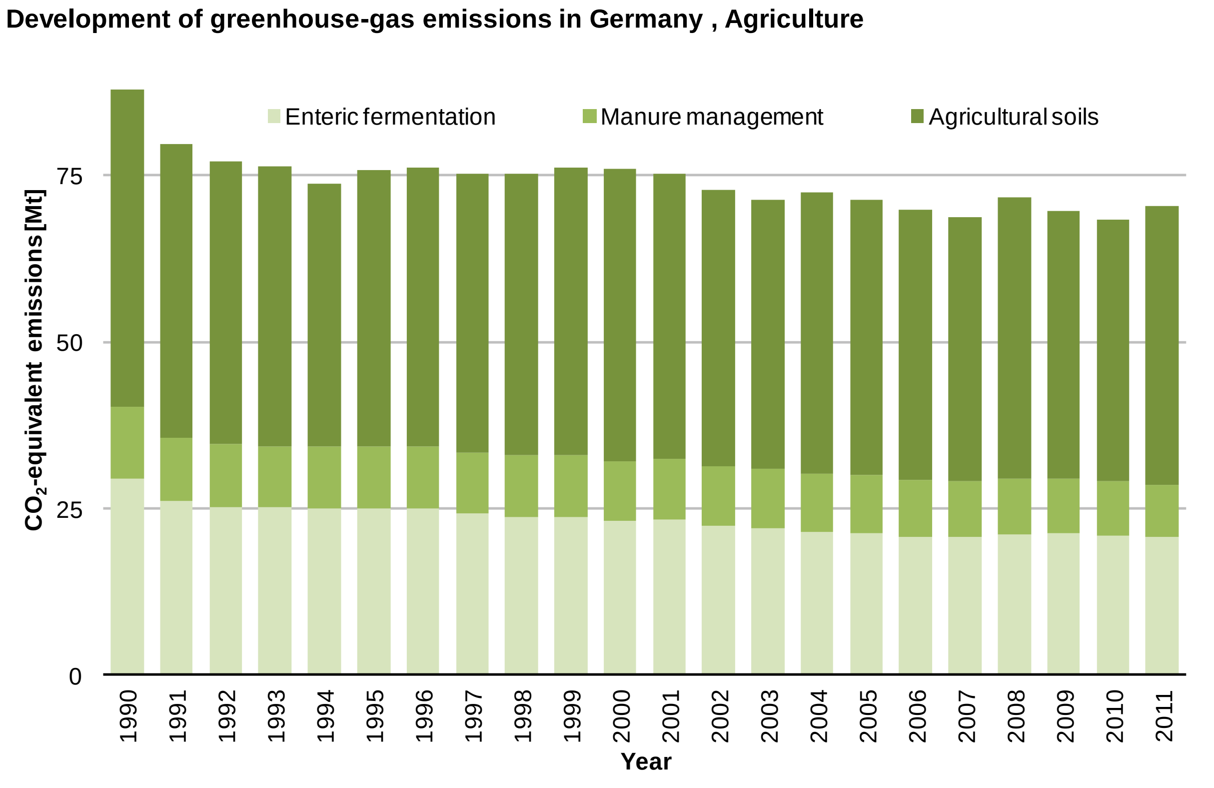


Figure 43: Overview of greenhouse-gas emissions in CRF Sector 4

6.1.2 *The GAS-EM emissions-inventory model*

The German calculations of agricultural-sector emissions of the gases methane (CH_4), ammonia (NH_3), nitrous oxide (N_2O) and nitrogen monoxide (NO) are carried out with the GAS-EM (Gaseous Emissions) inventory model.

6.1.2.1 Guidelines applied, and detailed report

The GAS-EM emissions-inventory model is based on implementation of the relevant sets of guidelines (greenhouse gases: IPCC, 1996b; IPCC, 2000; IPCC 2006; gases, especially NH_3: EMEP, 2007; EMEP, 2009).

Over the past few years, many of the methods described in the guidelines have been refined for purposes of GAS-EM. A comprehensive description of the GAS-EM inventory model, including listings of relevant additional sources, is presented in the pertinent detailed report (RÖSEMANN et al., 2013). The following remarks summarise the detailed report with regard to the aims for the NIR 2013.[66]

The following chapters on the methods used in sectors 4.A (Chapter 6.2.2.1), 4.B (Chapter 6.3.2.2.1, and 6.3.4.2.1) and 4.D (Chapter 6.5.2) present an overview of the manner in which GAS-EM functions.

6.1.2.2 Basic structure of the GAS-EM emissions-inventory model

Feed intake serves as the basis for emissions calculations in the animal husbandry sector. It is calculated as a function of basic and yield-related energy requirements, as Figure 44 shows with the example of dairy cattle. That approach provides the CH_4 emissions from enteric fermentation (4.A), as well as the carbon and nitrogen excretions data needed to calculate emissions from manure management (4.B). The latter, in turn, enter into calculations of nitrogen discharges into agricultural soils (4.D).

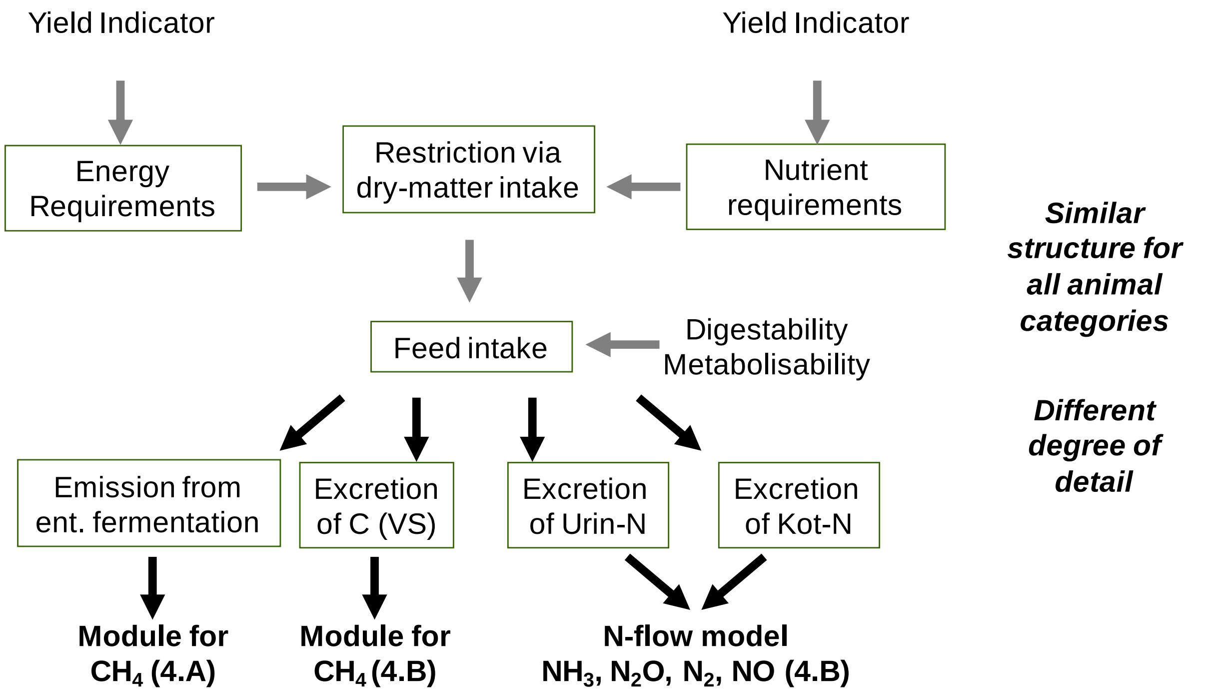


Figure 44: Logical structure behind national methods for calculating emissions from animal husbandry, illustrated with the example of dairy cattle. ("Yield indicator" stands for the sum of basic and yield-related requirements.)

Figure 45 illustrates how, and on what spatial level (depending on data availability), the GAS-EM model, for calculation of emissions from source categories 4.A and 4.B, first breaks the

[66] An electronic version of the detailed report is available from: dieter.haenel@vti.bund.de claus.roesemann@vti.bund.de.

sector down by animal categories and sub-categories, and then breaks those categories / sub-categories down by housing systems, storage systems and manure-application techniques. CH_4 emissions are calculated separately for each animal sub-category in 4.A and 4.B. For source categories 4.B and 4.D, N_2O emissions are calculated on the basis of an N-flow concept (cf. Chapter 6.1.2.4).

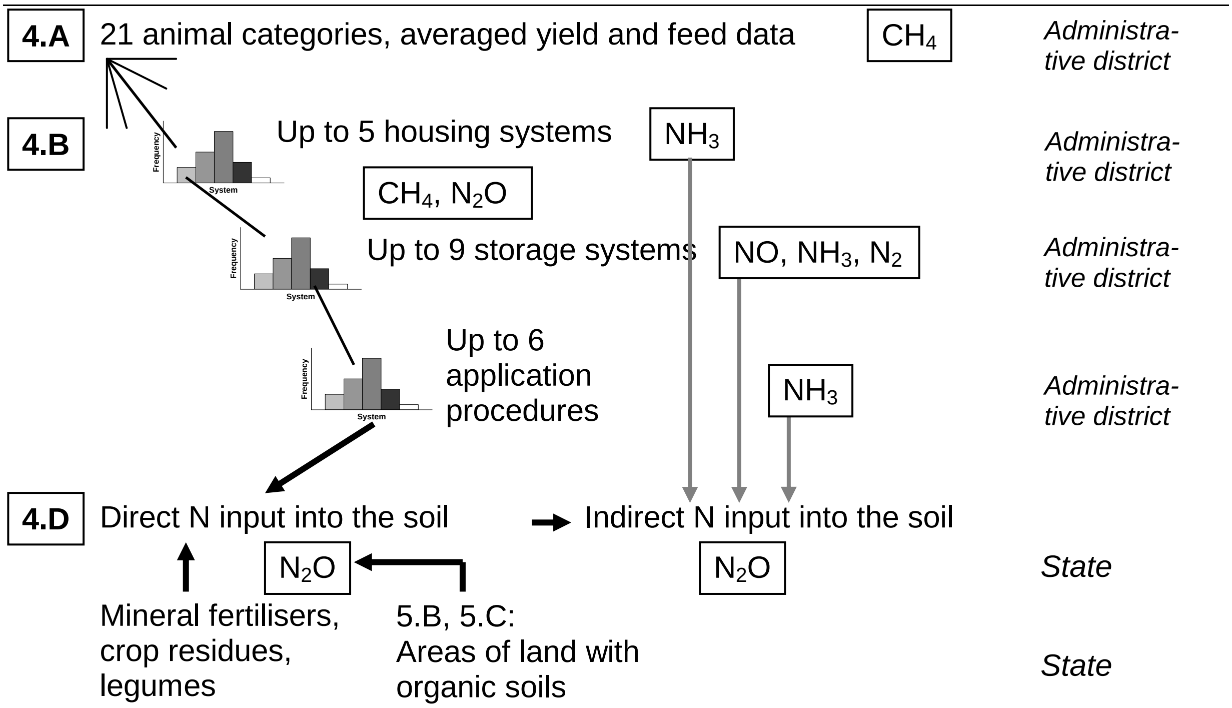


Figure 45: The GAS-EM model: basic concept, thematic content and spatial resolution

6.1.2.3 Treatment of carbon within the emissions inventory

The GAS-EM inventory model is used to calculate CH_4 emissions from enteric fermentation and VS excretions of agricultural livestock (cf. Chapters 6.2 and 6.3.2), taking account of slurry-based and straw-based systems and their typical forms of storage. In the present inventory, anaerobic digestion of slurry in biogas plants is taken into account for the first time (cf. Chapter 6.1.3.6.5). In keeping with the IPCC Guidelines, VS contributions from bedding material are not taken into account (cf. Chapter 6.3.1).

6.1.2.4 The nitrogen-flow concept (4.A, 4.B)

With the GAS-EM model, N-species emissions are calculated on the basis of the N-flow concept (DÄMMGEN & HUTCHINGS, 2005).

To make it possible to apply the concept, the N amounts excreted in animal husbandry have to be determined. For dairy cattle, heifers, male beef cattle, swine, laying hens, pullets, broilers, ducks and turkeys, males and hens, N excretions are calculated as the difference between the amount of N taken in with feed and basic and yield-based N requirements (animal weight, weight gain, annual milk production or egg production (i.e. numbers of eggs) and, if relevant, numbers of young). The N intake with feed is determined on the basis of animal energy requirements and the energy and N content of the feed. For other animals, N-excretion data are taken from the pertinent German technical literature (cf. in this regard RÖSEMANN et al., 2013).

In the case of N excretions, a distinction is made between the two fractions "organic N" and "TAN readily converted into NH_3" (TAN – "total ammoniacal nitrogen"). TAN is present in the urine of mammals; in the GAS-EM model, in each case TAN is considered to be equivalent to the N content of urine. Poultry excrete "UAN" (uric acid nitrogen); in the inventory, UAN is treated as TAN. In calculation of N emissions from different stations throughout the spectrum from animal N excretions and N discharges into the soil, two N pools are carried throughout the calculations: the total N amount present within the relevant station, and the fraction of that amount that is present as TAN. As a result of the manner in which the relevant emission factors are defined, NH_3 emissions are calculated in proportion to the available TAN amount, while N_2O emissions, NO emissions and N_2 emissions are calculated in proportion to the available N amount, i.e. weighted by N fractions from the TAN pool and from the organic N pool.

The N excretions determined for a given animal category are divided into pasture emissions and stable emissions. The line between the two categories is drawn in accordance with the proportion of time spent in pasture.

In the case of solid-manure systems, N inputs from bedding material are also taken into account, along with N excretions.

For each animal category, the amounts of N occurring in housing systems are divided in accordance with the relative shares of the animal-housing systems commonly used in Germany, which systems vary in terms of their emissions behaviour. In stables, losses of N from the amounts of N excreted result, via NH_3 emissions from the TAN pool. The remaining N and TAN amounts for all stables are combined separately, for slurry-based and straw-based systems, and are transferred into the correspondent storage systems.

The N and TAN amounts accruing to the storage systems are divided, separately for the categories solid manure and slurry, among the different storage systems commonly used in Germany, in keeping with the applicable percentage shares. In the present inventory, anaerobic digestion of slurry in biogas plants is taken into account for the first time (cf. Chapter 6.1.3.6.5). From storage, NH_3 emissions from the TAN pool occur. The N losses resulting via emissions of N_2O, NO and N_2 are subtracted, jointly for housing and storage systems, from the total N pool (sum of animal N excretions and N input from bedding material). In NIRs up to and including the NIR 2012, it was assumed, for the sake of simplicity, that such N losses could be deducted solely from the TAN pool. The remaining N and TAN amounts are added to the "application" category.

The amount of N applied is divided among the different application techniques commonly used in Germany, also taking account of the different durations of incorporation commonly observed. In the process, the relevant different emission factors for such different procedures and durations are applied. This is carried out in accordance with the different application techniques' relative proportions of the total amount of manure applied, differentiated by animal category and by the categories of solid manure and slurry. The N losses occurring during application, via NH_3 emissions, are deducted from the TAN pool. NO emissions occurring during application are deducted from the total N pool. The then remaining total-N amount yields the N amount available in the soil that is used for calculation of N_2O emissions from manure application.

The total amount of N excreted during grazing yields the N amount available in the soil that is used for calculation of N_2O emissions from grazing.

6.1.3 Characterisation of animal husbandry

6.1.3.1 Animal categories (CRF 4.A, 4.B)

For calculation of emissions from animal husbandry in German agriculture, animal stocks are divided into sub-categories, to permit description of sub-stocks that are homogeneous with regard to yield and to housing systems. Table 143 compares the animal categories to be reported on in the in CRF tables with the animal categories used in the German inventory. In NIRs up to and including the NIR 2012, cows for fattening and for slaughter were counted as part of the "heifers" category. As of the present NIR 2013, they are included as part of the "suckler cows" category, due to changes in the Federal Statistical Office's counting methods for the entire time series as of 1990.

Table 143: CRF animal categories and the sub-categories used for purposes of German emissions reporting

CRF animal categories	Animal categories in the German inventory	
1.a Dairy cattle	"Dairy cattle"	
1.b Other cattle	"Calves" (to 2 months old) Young female cattle as of 2 months old ("heifers") Young male cattle as of 2 months old ("male beef cattle") "Suckler cows" (including cows for fattening and for slaughter) [a] "Mature males > 2 years"	
2. Buffalo	"Buffalo"	
3. Sheep	*CH_4:* "Sheep"	*N species:* "Sheep, without lambs" "Lambs"
4. Goats	"Goats"	
5. Camels and llamas	---	
6. Horses	"Heavy horses" "Light horses and ponies"	
7. Mules and asses	"Mules and asses"	
8. Swine	"Sows" (incl. suckling piglets to 8 kg) "Weaners" "Fattening pigs" "Boars"	
9. Poultry	"Laying hens" "Broilers" "Pullets" "Geese" "Ducks" "Turkeys, males" "Turkeys, females"	
10. Other	---	

[a] As of the NIR 2013, cows for fattening and for slaughter are counted with suckler cows – instead of with heifers, as was done through the NIR 2012 – as a result of changes in the counting methods of the Federal Statistical Office. The time series has been adjusted accordingly back to 1990.

In German reporting, the animal category "cattle" (CRF 4.A.1.A, CRF 4.B.1.A) consists of dairy cattle (CRF 4.A.1.a, CRF 4.B.1.a) and the group of "other cattle" (CRF 4.A.1.b, CRF

4.B.1.b). The "other cattle" category comprises the sub-categories "calves", "heifers", "male beef cattle", "suckler cows" and "mature males > 2 years".

The category "swine" (CRF 4.A.8, CRF 4.B.8) is divided into the sub-categories "sows" (including suckling piglets weighing up to 8 kg), "weaners", "fattening pigs" and "boars".

For calculation of methane emissions, the category "sheep" (CRF 4.A.3, CRF 4.B.3) is not divided into sub-categories. For calculation of emissions of nitrogen species, sheep are divided into the sub-categories of "lambs" and "sheep (without lambs)". The results are reported in aggregated form, for "sheep".

The category "poultry" (CRF 4.A.9, CRF 4.B.9) is divided into the categories of "laying hens", "broilers", "pullets", "geese", "ducks", "male turkeys" and "female turkeys".

For "horses" (CRF 4.A.6, CRF 4.B.6), heavy horses and light horses are considered separately, since the two groups differ in terms of their energy requirements. The results for the two categories are aggregated to form the total results for the category "horses".

6.1.3.2 Animal place data (CRF 4.A, 4.B)

The emissions reported by Germany refer to animal places in agricultural facilities that are used year-round for production. An "animal place" within the meaning applied to this context refers to an animal place occupied on a reference date for a relevant official livestock census. In the following, "animal number" is used as a synonym for "animal places".

6.1.3.2.1 Surveys of the Federal and Länder statistical offices

The Federal Statistical Office and the statistical offices of the Länder carry out agricultural-structure surveys[67] that, in addition to collecting other data, carry out censuses of cattle, swine, sheep, horses (as of 2010: equids) and poultry. In the periods 1990 – 1996 and 1999 – 2007, such agricultural structural surveys were carried out every other year. In 2010, they were then carried out in the framework of the 2010 agricultural census (Landwirtschaftszählung 2010 – LZ 2010)[68]. The total number of goats in Germany was officially determined for the first time in connection with the LZ 2010. The 1990, 1992, 1994 and 1996 surveys were each carried out on 3 December. Surveys during the years 1999 - 2007 were referenced to 3 May, while the 2010 survey was referenced to 1 March.

In addition to agricultural-structure surveys, annual livestock censuses are carried out (STATISTISCHES BUNDESAMT, Fachserie 3, Reihe 4.1). Through 1998, such surveys were carried out semiannually for cattle and sheep (June, December), every four months for swine (April, August, December), and every two years, in even-numbered years (in December), for all animal species, i.e. also for horses and poultry. In each case, the reference date was the third calendar day of the pertinent month. Since 1999, the livestock census has been carried out twice yearly, and referenced to 3 May and 3 November, for cattle and swine; for sheep, it has been carried out once yearly, referenced to 3 May (as of 2011, to 3 November).

Census data from official surveys are thus available for cattle, swine and sheep for all years since 1990. In the inventories through 1998, the December data were used (for sheep, the June data). Thereafter, through 2010, the May data were used. As of 2011, by agreement

[67] https://www.destatis.de/DE/Meta/AbisZ/Agrarstrukturerhebung.html

[68] https://www.destatis.de/DE/ZahlenFakten/Wirtschaftsbereiche/LandForstwirtschaft/Landwirtschaftszaehlung2010/Ergebnisse.html

with the Federal Statistical Office, the November reference date is to be used. For horses or equids, and for poultry, animal numbers are available only at two-year intervals (reference dates: through 1998, 3 December; 1999 – 2007, 3 May; 2010, 1 March; and 2011, 3 November). Also by agreement with the Federal Statistical Office, no corrections are to be made to account for the variations in reference dates.

Chapter 6.1.3.2.2 discusses the animal numbers for the other animals, as well as special aspects related to use, in the inventory, of official census data for cattle, swine and sheep.

6.1.3.2.2 Special aspects of animal-place figures in the inventory

Since 2008 / since the preparation of the NIR 2009, animal numbers for cattle have been taken from a special database ("origin-tracing and information system for animals" (HIT - Herkunftssicherungs- und Informationssystem für Tiere; http://www.hi-tier.de) in which every animal is registered. Via the new survey method, systematically higher animal numbers result for years as of 2008 than result for earlier years in which not all animals were counted, due to the survey thresholds applied. A comparison carried out by the Federal Statistical Office for 2007 reveals that the animal numbers for cattle shown in HIT are 2.9 % higher than those resulting via the conventional survey method (for dairy cattle alone, the animal numbers are 2.8 % higher). The Federal Statistical Office reports that the cattle time series for the period prior to 2008 will not be adjusted in this regard. As a result, emissions from keeping of cattle are slightly underestimated for the years 1990 to 2007. In the interest of obtaining maximally homogeneous animal categories, some of the cattle categories used in official surveys have been modified for purposes of the inventory.

Some of the animal categories used in official surveys have been modified in the interest of obtaining maximally homogeneous swine sub-categories: The official animal numbers for piglets weighing up to 20 kg animal^{-1}, and for young pigs and fattening pigs weighing at least 20 kg animal^{-1}, have been converted, using the procedure described in HAENEL et al. (2011), into animal numbers for the inventory categories "weaners" and "fattening pigs". This transformation has no impact on the total number of swine in the emissions inventory, however. On the other hand, the total number of swine reported in the inventory is reduced with respect to the officially determined total number. The reason for this is that the piglets weighing up to 8 kg that are included in the official census figure for piglets need to be classified as suckling piglets, with emissions implicitly included in those of the "sows" category. Those piglets thus do not appear as a separate animal category in the inventory.

The numbers of goats in Germany were not surveyed between the years 1977 and 2010. Until 2004, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) estimated goat populations at the national level. As of 2005, the pertinent time series was continued via estimation by the Federal Statistical Office. In 2010, the total number of goats was officially determined for the first time, in the framework of the 2010 agricultural census (LZ 2010). That figure is considerably lower than the estimates for earlier years, which are still being used, by agreement with the Federal Statistical Office. For 2011, the figure for 2010 was retained, by agreement with the Federal Statistical Office.

Horse-count data are lacking for the years between the agricultural-structure surveys. Lacking figures within a time series are filled in via linear interpolation. In a first in the 2010 agricultural census, "equids", rather than "horses", were counted. While the equid population includes mules and asses, in the inventory that population is interpreted as a horse population, since it is not possible to deduct numbers of mules and asses, which are estimated only at the national level (see below), from the relevant numbers of equids at the Länder level. The resulting overestimation of horse head counts is insignificant, due to the very small numbers of mules and asses involved (see below). To prevent any underestimation of the animal numbers for horses that are lacking for 2011, those figures were obtained not through extrapolation of the 2009/2010 trend, but through retention of the corresponding figures for 2010. In the inventory, animal numbers for horses are subdivided into the two categories "heavy horses" and "light horses" (including ponies), to take account of the differences in emissions behaviour between the two categories.

For mules and asses, no separate figures from official statistics are available. Figures published in 2003 by Interessengemeinschaft für Esel und Maultiere (IGEM, interest association for mules and asses; Deutsches Eselstammbuch (German book of donkey pedigrees), 2003) indicate that some 6,000 to 8,000 donkeys, and about 500 mules and hinnies, were being kept in Germany as of that time. More recent figures from the 2009 Deutsches Eselstammbuch are considerably lower. On the other hand, those figures are subject to large uncertainties. For that reason, calculations are currently being carried out with a constant figure of 8,500 mules and asses.

The Federal Statistical Office does not publish animal numbers for buffalo. For this reason, figures of the Deutscher Büffelverband (German buffalo association) have been used for the period as of 2000. In keeping with a recommendation in the final report for the "Initial Review under the Kyoto Protocol and Annual 2006 Review under the Convention", for the years prior to 2000 the time series for the buffalo population at the national level was completed via linear extrapolation. For the years 1990 to 1995, mathematically negative animal numbers result; they are replaced with zeros.

Poultry-count data are lacking for the years between the agricultural-structure surveys. Lacking figures within time series have been filled in via linear interpolation. Except for animal numbers for pullets and laying-hens, the poultry counts lacking for 2011 were obtained via extrapolation from the years 2009 and 2010. In official counting, pullets are counted as pullets up to an age of six months, in contrast to what is suggested by common housing practice (housing as laying hens at the end of their 18th week of age). As a result, in all years of the relevant time series in the inventory, a portion of the pullet population was shifted into the laying-hen category. This did not change the total combined number of pullets and laying hens, however. The 2011 census data for pullets and laying hens were lacking. They were estimated by carrying the corresponding 2010 data forward, since the actual population trends, following the prohibition on cage housing and the related changes in the area of egg production, will not become apparent until the year 2012. In the inventory, the official census data for turkeys were broken down by the categories "turkeys, males" and "turkeys, females", for all years since 1990, to take account of the pertinent differences in emissions behaviour.

6.1.3.2.3 Animal place data used in the inventory (CRF 4.A, 4.B)

Table 144 presents a compilation of the animal-place figures on which German reporting is based. With regard to the uncertainties for the animal numbers, cf. Table 176 in Chapter 6.1.5.

Table 144: Animal-place figures used in German reporting (4.A, 4.B), in thousands

[in thousands]	Dairy cattle	Other cattle	Swine	Sheep	Goats	Horses	Mules and asses	Buffalo	Poultry
1990	6,355	13,133	26,502	3,266	90	491	8.5	0.00	113,879
1991	5,632	11,502	22,183	3,250	86	511	8.5	0.00	108,770
1992	5,365	10,843	22,618	2,999	90	531	8.5	0.00	103,662
1993	5,301	10,597	22,238	3,001	92	565	8.5	0.00	106,805
1994	5,273	10,690	21,148	2,882	95	599	8.5	0.00	109,948
1995	5,229	10,661	20,387	2,991	100	626	8.5	0.00	111,228
1996	5,195	10,565	20,809	2,953	105	652	8.5	0.05	112,507
1997	5,026	10,201	21,248	2,885	115	594	8.5	0.17	114,439
1998	4,833	10,110	22,500	2,869	125	535	8.5	0.30	116,371
1999	4,765	10,131	22,138	2,724	135	476	8.5	0.42	118,303
2000	4,570	9,968	21,768	2,743	140	491	8.5	0.63	120,180
2001	4,549	10,055	21,792	2,771	160	506	8.5	0.63	122,056
2002	4,427	9,560	22,110	2,722	160	516	8.5	0.76	122,732
2003	4,371	9,273	22,352	2,697	160	525	8.5	0.89	123,408
2004	4,285	8,911	21,758	2,714	160	512	8.5	1.02	121,984
2005	4,236	8,799	22,743	2,643	170	500	8.5	1.19	120,561
2006	4,082	8,667	22,417	2,561	180	521	8.5	1.32	123,712
2007	4,071	8,615	22,985	2,538	180	542	8.5	1.54	126,863
2008	4,218	8,752	22,677	2,437	190	515	8.5	1.79	127,542
2009	4,205	8,739	23,021	2,350	220	489	8.5	2.11	128,221
2010	4,183	8,626	22,244	2,089	150	462	8.5	2.36	128,900
2011	4,190	8,338	22,788	1,660	150	462	8.5	2.68	132,344

6.1.3.3 Yield, energy and feed data (CRF 4.A, 4.B)

To calculate emissions in accordance with a Tier 2 method, one requires data on animal yield (animal weight, weight gain, milk yield, milk protein content, milk fat content, numbers of births, numbers of eggs and weights of eggs) and on the relevant feed (phase feeding, feed components, protein and energy content, energy metabolisability and digestibility of organic matter). To divide the total numbers of turkeys, as reported by the Federal Statistical Office, into cocks and hens, one must know the applicable sex ratio. For the most part, such data are not available from official statistics. In the present case, such data were obtained from the open literature, from association publications, from regulations for agricultural consulting in Germany and via surveys of experts. Some data for turkeys were provided by hatcheries.

With respect to the NIR 2012, the following changes were made in yield or yield-related data (cf. also RÖSEMANN et al., 2013):

- Updating of data for amount of lifetime spent as a dairy cow or heifer,
- Correction of a transfer error in the categories final weights of dairy cattle and heifers in Mecklenburg – West Pomerania, Saxony, Saxony-Anhalt and Thuringia in 1990 (this error did not occur, however, in calculation of mean animal weights; cf. Table 145),
- Updating of milk yield in 2010,
- Complete inclusion of N input into manure management via skin and hair of dairy cattle,
- Reallocation of cows for fattening and for slaughter to the "suckler cows" category, from the "heifers" category (cf. Chapter 6.1.3.1),
- Updating of the number of "suckling piglets per sow",
- Updating of the final life weights, after fattening, of broilers, for the period as of 2000.
- Updating of animal weights for pullets and laying hens for the year 2010.

As a result of these changes, the data shown in the following tables differ somewhat from the corresponding data of the NIR 2012. In the category "average animal weights of dairy cattle and cattle", the discrepancies are too small to appear at the level of numerical precision chosen (numbers rounded off to one decimal place). The changes in the mean weights of swine are the result of increases in the population fractions with below-average weights (suckling piglets, weaners).

Table 145 shows the mean animal weights for dairy cattle, other cattle, swine and poultry. For details on calculation of average animal weights, cf. RÖSEMANN et al. (2013).

Table 145: Mean animal weights (4.B)

[kg animal^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	607.9	599.1	619.3	631.1	623.1	621.8	631.9	626.7	636.2	640.4
Other cattle	300.1	299.3	309.5	314.0	312.8	313.7	319.2	319.1	326.3	326.1
Swine	72.8	71.0	71.7	72.0	72.9	74.1	73.7	74.1	73.6	72.9
Poultry	1.77	1.79	1.81	1.77	1.73	1.71	1.68	1.70	1.74	1.69
[kg animal^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	644.3	654.0	648.3	644.6	641.3	645.8	647.4	651.3	645.3	642.0
Other cattle	329.5	334.6	329.4	328.8	327.4	326.4	330.6	333.8	327.7	328.4
Swine	72.4	72.4	72.6	72.9	72.9	72.4	72.6	72.9	72.4	72.4
Poultry	1.80	1.82	1.78	1.89	2.02	2.01	1.94	2.01	1.95	1.93
[kg animal^{-1}]	**2010**	**2011**								
Dairy cattle	646.8	648.0								
Other cattle	330.0	327.2								
Swine	70.5	69.0								
Poultry	1.96	1.97								

For the remaining animal categories, weight does not enter into emissions calculations. Nonetheless, such weights are reported in the CRF tables (on the basis of IPCC default values or German standard values).

Table 146 shows the mean daily milk yield for dairy cattle.

Table 146: Mean daily milk yield for dairy cattle (4.A)

[kg d^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Milk yield	12.9	13.2	13.8	14.4	14.4	14.9	15.1	15.3	15.6	16.2
[kg d^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Milk yield	16.6	17.0	17.2	17.9	18.0	18.5	18.8	19.0	18.7	19.1
[kg d^{-1}]	**2010**	**2011**								
Milk yield	19.4	19.8								

For dairy cattle, heifers, male beef cattle, sows, weaners and fattening pigs, the gross energy intake (GE) is calculated as a function of yield. For such calculations, feeding is assumed to exactly meet animal net-energy-for-lactation (NEL) and metabolisable energy (ME) requirements[69]. Those energy requirements depend on animal yield. The quantity of feed, of a given composition, required to meet NEL and ME energy requirements is calculated on the basis of the energy requirements and the mean NEL and ME energy content of the feed (RÖSEMANN et al., 2013). The gross energy intake (GE) for a given animal is calculated on the basis of the feed quantity ingested and the mean gross energy content of the feed. The GEIs for calves, suckler cows, male cattle more than 2 years old, boars, goats, sheep,

[69] The energy requirements for dairy cattle are given in terms of the "net energy for lactation (NEL)" (cf. KIRCHGESSNER et al., 2008), while the term "metabolisable energy (ME)" is used for other animals for which the German inventory includes energy-requirements calculations (for example, cf. GfE, 2006).

buffalo, horses and mules and asses are calculated with the help of standard values. No GEIs are calculated for poultry.

Table 147 shows the daily gross energy intake (GE) for dairy cattle, other cattle and swine. Chapter 6.2.5 discusses the relevant changes with respect to the NIR 2012.

Table 147: Mean daily gross energy intake (GE) (4.A)

[MJ place^{-1}]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Dairy cattle	257.1	262.0	271.0	276.1	275.7	278.7	282.4	284.2	288.6	291.8
Other cattle	102.4	103.8	107.2	108.0	106.8	107.6	108.2	107.9	108.3	109.2
Swine	27.4	27.9	28.3	28.4	28.7	28.9	29.2	29.2	29.6	29.3
[MJ place^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	295.9	301.1	302.7	306.0	306.8	310.4	312.0	315.0	311.2	314.4
Other cattle	109.5	109.8	108.9	108.8	108.4	108.4	109.0	109.5	108.8	109.0
Swine	29.4	29.8	29.9	29.7	30.0	29.8	30.0	30.1	30.1	30.2
[MJ place^{-1}]	**2010**									
Dairy cattle	315.3									
Other cattle	109.2									
Swine	30.1									

Table 148 through Table 150 show, for dairy cattle, other cattle and swine, the input data for the VS calculation on which the calculation of CH_4 emissions from manure management is based (cf. Chapter 6.3.2.2.1). The data include dry-matter intake, digestibility of organic matter and ash content of feed. The dry-matter intake is obtained from the feed intake, taking account of the dry-matter content of the various feed components (cf. RÖSEMANN et al., 2013). The digestibility of organic matter, and the ash content of feed, are given as feed property data (BEYER et al., 2004; information from producers); where the data are not available, suitable substitute values are used (cf. RÖSEMANN et al., 2013).

Table 148: Daily dry-matter intake (4.B(a)s1)

[kg $^{-1}$ place^{-1} d^{-1}]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Dairy cattle	14.15	14.25	14.72	14.98	14.95	15.09	15.29	15.38	15.61	15.77
Other cattle	5.73	5.67	5.83	5.87	5.81	5.86	5.86	5.86	5.90	5.98
Swine	1.74	1.77	1.79	1.80	1.82	1.83	1.85	1.85	1.88	1.86
[kg $^{-1}$ place^{-1} d^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	15.98	16.25	16.32	16.50	16.54	16.72	16.80	16.96	16.75	16.92
Other cattle	5.97	6.02	5.93	5.93	5.90	5.90	5.92	5.92	5.88	5.90
Swine	1.86	1.89	1.89	1.88	1.90	1.89	1.90	1.91	1.90	1.91
[kg $^{-1}$ place^{-1} d^{-1}]	**2010**	**2011**								
Dairy cattle	17.09	17.23								
Other cattle	5.90	5.87								
Swine	1.90	1.88								

Table 149: Digestibility of organic matter in feed (4.B(a)s1)

[%]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Dairy cattle	72.8	72.9	73.1	73.3	73.3	73.3	73.4	73.5	73.6	73.7
Other cattle	72.6	72.6	72.6	72.6	72.5	72.5	72.5	72.5	72.5	72.4
Swine	85.2	85.1	85.1	85.1	85.1	85.1	85.1	85.1	85.1	85.2
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	73.8	73.9	74.0	74.1	74.1	74.2	74.2	74.3	74.2	74.3
Other cattle	72.5	72.5	72.5	72.5	72.5	72.5	72.6	72.6	72.6	72.6
Swine	85.2	85.2	85.2	85.2	85.2	85.2	85.2	85.2	85.2	85.2
[%]	**2010**	**2011**								
Dairy cattle	74.4	74.5								
Other cattle	72.6	72.6								
Swine	85.2	85.2								

Table 150: Ash content of feed

[kg kg^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	0.096	0.096	0.095	0.094	0.093	0.093	0.092	0.092	0.091	0.091
Other cattle	0.089	0.090	0.090	0.090	0.091	0.091	0.091	0.091	0.091	0.092
Swine	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
[kg kg^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	0.091	0.090	0.090	0.089	0.089	0.089	0.088	0.088	0.088	0.088
Other cattle	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091
Swine	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
[kg kg^{-1}]	**2010**	**2011**								
Dairy cattle	0.088	0.087								
Other cattle	0.091	0.091								
Swine	0.057	0.057								

The following chapters present further information relative to animal husbandry – for example, excretion data (VS, N).

Mean percentages of pregnant animals doe not enter into any of the animal models used. They are reported in CRF Table 4.A, however, in the interest of completeness.

6.1.3.4 N excretions (CRF 4.B)

For dairy cattle, heifers, male beef cattle, swine, laying hens, pullets, broilers, ducks and turkeys, males and turkeys, females, N excretions are calculated as a function of yield. For other animals, N-excretion data are taken from the pertinent German literature (cf. RÖSEMANN et al., 2013).

The method for calculating N excretions as a function of yield is based on the assumption that feeding precisely meets energy requirements (cf. Chapter 6.1.3.3). For a given animal category, the N amount ingested by an animal is calculated on the basis of the feed quantity ingested and the mean N amount of the feed ration in question. The data for mean N content of feed rations were reviewed for consistency with national recommendations on feeding. The amount of N that remains from the ingested N amount, following deduction of growth-related N retention, N release via products (milk/eggs) and N losses via pregnancy/young, is the amount of N excreted:

- For the animal category "dairy cattle", N excretions are calculated as a function of milk yield, milk-protein content, milk-fat content, weight, weight gain, number of births per year and feed composition.
- For the animal categories "heifers" and "male beef cattle", N excretions are calculated as a function of weight gain, final weight and feed characteristics.
- For all sub-categories of swine, N excretions are determined from animal yields (for sows: number of piglets per year; for weaners and fattening pigs: weight gain) as well as animal weights and feed composition.
- For laying hens, pullets, broilers, ducks, turkeys, males and turkeys, females, excretions are calculated as a function of weight gain, final life weight and feed characteristics. For laying hens, laying yields are also taken into account.

For animal categories with grazing, calculated N excretions per animal place and year are broken down into in-pasture and in-stable excretions, since only in-stable excretions can enter into calculation of N_2O emissions in 4.B. Such division of excrements into in-stable and in-pasture categories is based on the relative time proportions for time in stable and time in pasture.

Table 151 shows the N-excretion data per animal place and year for the present NIR 2013 and in comparison to the corresponding values on which the NIR 2012 was based. For the animal categories that are not listed, N excretions are considered constant over time and thus are the same in the NIR 2012 and the NIR 2013: goats (11.0 kg place^{-1} a^{-1}), mules and asses (33.4 kg place^{-1} a^{-1}) and buffalo (82.0 kg place^{-1} a^{-1}). The discrepancies with respect to the NIR 2012, for dairy cattle, other cattle, swine and poultry, are the result of changes in yields (cf. Chapter 6.1.3.4).

Table 151: N excretions per animal place and year (4.B(b)), as calculated for the NIR 2013 and for the NIR 2012

[kg place^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2013	97.4	99.2	102.6	104.7	102.1	103.0	104.2	104.6	106.2	107.2
Dairy cattle, 2012	95.1	98.4	101.8	103.9	101.3	102.2	103.4	103.8	105.4	106.4
Other cattle, 2013	41.8	41.8	43.0	43.4	43.3	43.8	44.0	44.1	44.4	44.9
Other cattle, 2012	40.3	41.3	42.6	43.1	42.9	43.4	43.7	43.7	44.0	44.3
Swine, 2013	11.8	12.0	12.2	12.2	12.3	12.4	12.5	12.5	12.6	12.4
Swine, 2012	11.8	12.0	12.2	12.2	12.3	12.4	12.5	12.5	12.6	12.5
Sheep, 2013	7.7	7.6	7.6	7.8	7.7	7.7	7.8	7.7	7.7	7.9
Sheep, 2012	7.7	7.6	7.6	7.8	7.7	7.7	7.8	7.7	7.7	7.9
Horses, 2013	48.4	48.4	48.5	48.4	48.4	48.3	48.3	48.6	49.0	49.4
Horses, 2012	48.4	48.4	48.5	48.4	48.4	48.3	48.3	48.6	49.0	49.4
Poultry, 2013	0.68	0.68	0.69	0.66	0.65	0.64	0.64	0.64	0.65	0.63
Poultry, 2012	0.68	0.68	0.69	0.66	0.65	0.64	0.64	0.64	0.65	0.63
[kg place^{-1} a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2013	108.5	110.6	110.6	111.6	111.9	113.2	113.8	115.0	112.9	114.0
Dairy cattle, 2012	107.7	109.8	109.8	110.7	111.1	112.4	113.0	114.2	112.4	113.7
Other cattle, 2013	44.9	45.1	44.6	44.7	44.6	44.6	44.7	44.6	44.4	44.5
Other cattle, 2012	44.5	44.5	44.2	44.2	44.2	44.2	44.3	44.5	44.2	44.3
Swine, 2013	12.4	12.6	12.6	12.5	12.6	12.4	12.4	12.3	12.2	12.1
Swine, 2012	12.4	12.6	12.6	12.5	12.5	12.4	12.4	12.3	12.2	12.1
Sheep, 2013	7.8	7.8	7.8	7.9	7.8	7.8	7.8	7.7	7.7	7.8
Sheep, 2012	7.8	7.8	7.8	7.9	7.8	7.8	7.8	7.7	7.7	7.8
Horses, 2013	49.2	49.0	49.1	49.1	49.1	49.1	49.0	49.0	49.0	49.0
Horses, 2012	49.2	49.0	49.1	49.1	49.1	49.1	49.0	49.0	49.0	49.0
Poultry, 2013	0.66	0.67	0.67	0.68	0.73	0.74	0.72	0.74	0.73	0.74
Poultry, 2012	0.66	0.67	0.66	0.68	0.73	0.74	0.72	0.74	0.73	0.73
[kg place^{-1} a^{-1}]	**2010**	**2011**								
Dairy cattle, 2013	115.3	116.6								
Dairy cattle, 2012	114.1									
Other cattle, 2013	44.5	44.3								
Other cattle, 2012	44.4									
Swine, 2013	11.9	11.7								
Swine, 2012	11.9									
Sheep, 2013	8.2	8.4								
Sheep, 2012	8.2									
Horses, 2013	49.0	49.0								
Horses, 2012	49.0									
Poultry, 2013	0.76	0.77								
Poultry, 2012	0.73									

The annual total N-excretion figures calculated for the three different key categories of housing systems (slurry-based, straw-based, pasture) are listed in Table 152 through Table 154.

Table 152: Total annual N excretions for slurry-based systems (4.B(b))

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	339.8	309.3	305.0	306.2	381.4	381.5	384.0	372.9	370.9	369.9
Other cattle	319.2	284.5	271.3	264.3	262.3	259.4	256.1	245.1	243.2	245.5
Swine	250.5	211.1	218.3	217.6	225.1	219.1	226.4	230.2	250.9	243.8
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo [a]	NA	NA	NA	NA	NA	NA	0.00	0.01	0.01	0.01
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	359.7	366.0	356.9	356.3	350.4	350.9	340.5	343.9	350.2	352.5
Other cattle	234.7	234.0	216.6	206.5	193.3	187.3	181.0	175.6	173.0	169.3
Swine	240.5	244.5	250.2	251.0	245.6	254.2	250.9	257.3	252.0	254.5
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg a^{-1}]	**2010**	**2011**								
Dairy cattle	354.7	359.1								
Other cattle	162.9	157.0								
Swine	243.4	244.9								
Sheep	NO	NO								
Goats	NO	NO								
Horses	NO	NO								
Mules/asses	NO	NO								
Buffalo	0.08	0.09								
Poultry	NO	NO								

[a] Through 1995, the system included no buffalo

Table 153: Total annual N excretions for straw-based systems (4.B(b))

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	166.4	146.5	144.3	146.7	83.7	83.4	83.5	81.2	73.8	73.1
Other cattle	144.3	122.0	119.4	120.1	122.9	126.4	126.3	123.4	122.8	125.0
Swine	62.8	55.6	56.8	54.0	35.1	33.8	34.3	34.9	32.8	31.8
Sheep	12.6	12.2	11.3	11.5	11.1	11.5	11.4	11.1	11.0	10.7
Goats	0.65	0.62	0.65	0.67	0.69	0.72	0.76	0.83	0.90	0.98
Horses	18.9	19.7	20.5	21.7	23.0	24.0	25.0	22.9	20.8	18.7
Mules/asses	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Buffalo [a]	NA	NA	NA	NA	NA	NA	0.00	0.01	0.01	0.01
Poultry	77.1	74.2	71.2	70.8	71.6	71.7	71.6	73.3	75.8	74.2
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	72.4	74.0	73.2	73.3	73.0	73.9	72.4	73.6	75.1	76.2
Other cattle	129.0	134.7	130.4	130.7	129.2	131.4	132.9	135.4	141.2	145.1
Swine	30.4	30.2	29.5	28.6	27.5	27.2	26.0	25.7	24.0	23.1
Sheep	10.7	10.8	10.6	10.6	10.5	10.3	9.9	9.8	9.4	9.1
Goats	1.01	1.16	1.16	1.16	1.16	1.23	1.30	1.30	1.37	1.59
Horses	19.2	19.7	20.1	20.5	20.0	19.5	20.3	21.1	20.1	19.0
Mules/asses	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Buffalo	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07
Poultry	79.8	82.2	81.6	84.3	89.2	89.2	89.0	94.3	93.5	95.2
[Gg a^{-1}]	**2010**	**2011**								
Dairy cattle	77.0	77.9								
Other cattle	146.8	141.6								
Swine	21.4	21.0								
Sheep	8.4	6.9								
Goats	1.08	1.08								
Horses	18.0	18.0								
Mules/asses	0.23	0.23								
Buffalo	0.08	0.09								
Poultry	98.3	102.1								

[a] Through 1995, the system included no buffalo

Table 154: Total annual N excretions in pasture (4.B(b))

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	113.0	103.4	101.5	102.4	74.4	74.5	74.8	72.5	69.3	68.7
Other cattle	84.9	74.7	75.1	75.9	77.5	81.2	82.3	81.0	82.8	83.9
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	12.7	12.4	11.6	11.7	11.2	11.6	11.6	11.2	11.1	10.8
Goats	0.34	0.32	0.34	0.35	0.36	0.38	0.40	0.43	0.47	0.51
Horses	4.9	5.1	5.3	5.6	5.9	6.2	6.5	5.9	5.4	4.8
Mules/asses	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Buffalo [a]	NA	NA	NA	NA	NA	NA	0.00	0.00	0.00	0.01
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	64.5	63.9	60.3	58.9	56.5	55.1	51.9	50.9	51.1	50.8
Other cattle	84.2	84.8	79.6	76.9	75.0	74.1	73.4	73.3	74.3	74.6
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	10.7	10.9	10.6	10.8	10.7	10.4	10.0	9.9	9.4	9.2
Goats	0.53	0.60	0.60	0.60	0.60	0.64	0.68	0.68	0.72	0.83
Horses	5.0	5.1	5.2	5.3	5.2	5.0	5.3	5.5	5.2	4.9
Mules/asses	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Buffalo	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg a^{-1}]	**2010**	**2011**								
Dairy cattle	50.4	51.5								
Other cattle	74.0	71.1								
Swine	NO	NO								
Sheep	8.8	7.1								
Goats	0.56	0.56								
Horses	4.6	4.6								
Mules/asses	0.06	0.06								
Buffalo	0.03	0.04								
Poultry	NO	NO								

[a] Through 1995, the system included no buffalo

6.1.3.5 VS excretions (CRF 4.B)

For the categories dairy cattle, other cattle, swine and poultry (not including geese), VS excretions are calculated with the national procedure of DÄMMGEN et al. (2011a):

Equation 5: Calculation of VS excretions

$$VS_{\mathrm{i}} = m_{\mathrm{feed,\,DM,\,i}} \cdot (1 - X_{\mathrm{DOM,\,i}}) \cdot (1 - x_{\mathrm{ash,\,feed}})$$

VS_{i}	VS excretions for animal category i (in kg animal place^{-1} d^{-1})
$m_{\mathrm{feed,\,DM,\,i}}$	Dry-matter intake, animal category i (in kg animal place^{-1} d^{-1})
$X_{\mathrm{DOM,\,i}}$	Digestibility of organic matter, animal category i (in kg kg^{-1})
$X_{\mathrm{ash,\,i}}$	Ash content of feed, animal category i (in kg kg^{-1})

For sheep, goats, horses, mules and asses and buffalo, IPCC default values for VS are used. For geese, no VS-excretion values are required, since calculations for geese are carried out in accordance with the Tier 1 method.

The input data for the VS calculation include: dry-matter intake, digestibility of organic matter and ash content of feed; for a pertinent overview for dairy cattle, other cattle and swine, cf. Chapter 6.1.3.3.

The VS excretions, calculated with national input data, for dairy cattle, other cattle, swine and poultry (not including geese), are shown in Table 155.

The VS values shown in Table 155 are lower than the default values of the IPCC (1996b) for dairy cattle (5.1 kg d^{-1} VS), other cattle (2.7 kg d^{-1} VS), swine (0.5 kg d^{-1} VS) and poultry (0.1 kg d^{-1} VS). With the exception of those for poultry, the IPCC default values (2006) are similar in level to the corresponding values in IPCC (1996). For poultry, IPCC (2006) lists values ranging from 0.01 kg d^{-1} VS for broilers to 0.07 kg d^{-1} VS for turkeys.

Table 155: Daily VS excretions, for dairy cows, other cattle, swine and poultry (without geese) (4.B(a)s1)

[kg place^{-1} d^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	3.48	3.49	3.58	3.63	3.63	3.65	3.69	3.70	3.75	3.77
Other cattle	1.43	1.41	1.45	1.47	1.45	1.46	1.46	1.46	1.47	1.50
Swine	0.24	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.26	0.26
Poultry, without geese	0.022	0.022	0.022	0.022	0.021	0.021	0.021	0.021	0.021	0.021
[kg place^{-1} d^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	3.81	3.86	3.87	3.90	3.90	3.93	3.94	3.97	3.94	3.96
Other cattle	1.50	1.51	1.48	1.48	1.47	1.47	1.47	1.47	1.46	1.47
Swine	0.26	0.26	0.27	0.26	0.27	0.26	0.27	0.27	0.27	0.27
Poultry, without geese	0.022	0.023	0.022	0.024	0.025	0.025	0.025	0.026	0.026	0.026
[kg place^{-1} d^{-1}]	**2010**	**2011**								
Dairy cattle	3.99	4.01								
Other cattle	1.47	1.46								
Swine	0.26	0.26								
Poultry, without geese	0.026	0.027								

For all other animals, the VS default values pursuant to IPCC (2006), Tables 10A-6 and 10A-9, were used; cf. Table 156. Those values are either in keeping with those from IPCC (1996b), p. 4.47, Table B-7, or are higher (for goats and horses). The VS excretions of light horses and ponies were derived from those of heavy horses, on the basis of the ratio of pertinent energy requirements (cf. Chapter 6.2.2.2):

Table 156: Daily VS excretions per animal place, for sheep, goats, horses, mules and asses, buffalo and poultry (without geese) (4.B(a)s1)

[kg place^{-1} d^{-1}]	*VS*
Sheep	0.40
Goats	0.30
Heavy horses	2.13
Light horses and ponies	1.38
Mules and asses	0.94
Buffalo	3.90
Poultry (without geese)	0.027

6.1.3.6 Housing systems, storage systems and application techniques, and grazing periods (CRF 4.A, 4.B, 4.D)

6.1.3.6.1 Frequency distributions (CRF 4.A, 4.B, 4.D)

The German inventory uses annual frequency distributions for the various husbandry systems (proportions for grazing / housing; proportions for different housing systems), storage systems and manure-application techniques and time allotted to grazing, by animal sub-categories. Chapter 6.1.3.6.5 discusses the data on slurry digestion and on storage of digested slurry, a separate storage procedure that the present Submission 2013 takes into account for the first time in emissions calculation.

For the years 1990 through 1999, the frequency distributions for the various housing systems, storage systems and application techniques, and the various time periods allotted to grazing, were obtained with the help of the RAUMIS (Regionalisiertes Agrar- und

UmweltInformationsSystem für Deutschland – Regionalised Agricultural and Environmental Information System for Germany) agricultural sector model[70]. The data that entered into RAUMIS included specialised national statistics at the sectoral and district levels, standardisation data of the Association for Technology and Structures in Agriculture (KTBL-Normdaten) relative to description of production processes, data from the Economic Accounts for Agriculture (EAA), special evaluations of the Federal Ministry of Food, Agriculture and Consumer Protection (herd-size-class distribution) and survey data. Where relevant statistical data were missing, models were formulated with the aid of experts.

Updating of the aforementioned RAUMIS data was no longer possible after 1999. Current data for the year 2010 are now available for purposes of emissions reporting – from the 2010 agricultural census (LZ 2010), from a survey of agricultural production methods, and from a survey on farm-manure application carried out in calendar year 2010. In most cases, gaps between the data from the LZ 2010 and the RAUMIS data of 1999 have been closed via linear interpolation. In some cases, LZ 2010 data were used in the inventory for the period beginning in 1990, however, instead of comparatively uncertain RAUMIS data or data based on comparatively uncertain assumptions. For example, the 2010 agricultural census (Landwirtschaftszählung 2010; LZ 2010) provided the first official data on grazing of sheep. Those data are now being used for years as of 1990, and they have replaced the pertinent assumptions used before the data became available.

In addition, the following determinations have been made on the basis of assessments by experts of the Association for Technology and Structures in Agriculture (KTBL):

- Until 2002, 50 % of all calves were housed in tied systems with solid floors and bedding material and 50 % were housed with deep bedding material; as of 2003, as a result of a ban on tied systems, 100 % were housed with deep bedding material.
- For housing of heifers, all straw-based systems are deemed to have solid floors and bedding material, since such systems are the systems most commonly used in Germany.
- For suckler cows, all straw-based systems are deemed to have deep bedding material, since such systems are the systems most commonly used in Germany.

Current data were available for the year 2011 relative to the distribution of housing systems for laying hens. For all other animal categories, the distribution of housing systems in 2011 was assumed to be the same as it was in 2010, since the basic framework for the animal husbandry sector did not change significantly from 2010 to 2011.

Table 360, Table 361 and Table 362 in Annex Chapter 19.4.1 show the applicable distributions of housing systems, storage systems and application techniques, and they provide data on pasture access. The tables also include the category of anaerobic digestion of slurry in biogas plants, which the present inventory covers for the first time, and which, pursuant to IPCC (2000), is to be treated as a separate storage procedure; cf. Chapter 6.1.3.6.5.

[70] RAUMIS is operated by the Institute for Rural Studies of the Johann Heinrich von Thünen Institute (vTI; until 2008: Federal Agricultural Research Institute (FAL). For a pertinent introduction, cf. WEINGARTEN (1995); a detailed description is provided in HENRICHSMEYER et al. (1996).

The following tables show the significances of the various manure management systems, which are to be reported in the CRF tables, in % of total excreted N. The data reflect the fact that until 1995 the sector included no buffalo.

Table 157: Relative shares of slurry-based systems, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	54.9	55.3	55.4	55.2	70.8	70.8	70.9	70.9	72.3	72.4
Other cattle	58.2	59.1	58.2	57.4	56.7	55.5	55.1	54.5	54.2	54.0
Swine	80.0	79.2	79.4	80.1	86.5	86.6	86.9	86.8	88.4	88.5
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo	NA	NA	NA	NA	NA	NA	42.0	42.0	42.0	42.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	72.5	72.7	72.9	73.0	73.1	73.2	73.3	73.5	73.5	73.5
Other cattle	52.4	51.6	50.8	49.9	48.6	47.7	46.7	45.7	44.5	43.5
Swine	88.8	89.0	89.5	89.8	89.9	90.3	90.6	90.9	91.3	91.7
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	2010	2011								
Dairy cattle	73.6	73.5								
Other cattle	42.5	42.5								
Swine	91.9	92.1								
Sheep	NO	NO								
Goats	NO	NO								
Horses	NO	NO								
Mules/asses	NO	NO								
Buffalo	42.0	42.0								
Poultry	NO	NO								

Table 158: Relative shares of straw-based systems, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	26.9	26.2	26.2	26.4	15.5	15.5	15.4	15.4	14.4	14.3
Other cattle	26.3	25.3	25.6	26.1	26.6	27.1	27.2	27.5	27.4	27.5
Swine	20.0	20.8	20.6	19.9	13.5	13.4	13.1	13.2	11.6	11.5
Sheep	49.6	49.5	49.3	49.5	49.6	49.7	49.5	49.9	49.8	49.7
Goats	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8
Horses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Mules/asses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Buffalo	NA	NA	NA	NA	NA	NA	42.0	42.0	42.0	42.0
Poultry	100	100	100	100	100	100	100	100	100	100
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	14.6	14.7	14.9	15.0	15.2	15.4	15.6	15.7	15.8	15.9
Other cattle	28.8	29.7	30.6	31.6	32.5	33.4	34.3	35.2	36.3	37.3
Swine	11.2	11.0	10.5	10.2	10.1	9.7	9.4	9.1	8.7	8.3
Sheep	49.9	49.7	49.9	49.6	49.7	49.6	49.8	49.7	49.9	49.9
Goats	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8
Horses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Mules/asses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Buffalo	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
Poultry	100	100	100	100	100	100	100	100	100	100
[%]	2010	2011								
Dairy cattle	16.0	15.9								
Other cattle	38.3	38.3								
Swine	8.1	7.9								
Sheep	48.9	49.0								
Goats	65.8	65.8								
Horses	79.5	79.5								
Mules/asses	79.5	79.5								
Buffalo	42.0	42.0								
Poultry	100	100								

Table 159: Grazing: relative shares for housing systems, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	18.3	18.5	18.4	18.5	13.8	13.8	13.8	13.8	13.5	13.4
Other cattle	15.5	15.5	16.1	16.5	16.8	17.4	17.7	18.0	18.5	18.5
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	50.4	50.5	50.7	50.5	50.4	50.3	50.5	50.1	50.2	50.3
Goats	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Horses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Mules/asses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Buffalo	NA	NA	NA	NA	NA	NA	16.0	16.0	16.0	16.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	13.0	12.7	12.3	12.1	11.8	11.5	11.2	10.9	10.7	10.6
Other cattle	18.8	18.7	18.7	18.6	18.9	18.9	19.0	19.1	19.1	19.2
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	50.1	50.3	50.1	50.4	50.3	50.4	50.2	50.3	50.1	50.1
Goats	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Horses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Mules/asses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Buffalo	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	**2010**	**2011**								
Dairy cattle	10.4	10.5								
Other cattle	19.3	19.2								
Swine	NO	NO								
Sheep	51.1	51.0								
Goats	34.2	34.2								
Horses	20.5	20.5								
Mules/asses	20.5	20.5								
Buffalo	16.0	16.0								
Poultry	NO	NO								

6.1.3.6.2 Bedding material in connection with solid-manure systems (CRF 4.B)

In calculation of N_2O and NO emissions from manure management, the N amounts introduced into the system via bedding material are taken into account. Bedding material is reported as straw with an N fraction of 0.58 %, with respect to the relevant dry-matter content. Table 360 (cf. Annex Chapter 19.4.1) lists the amounts of bedding material used for the various animal-husbandry systems, in terms of fresh-matter content. In the inventory, such bedding material is assumed to have a dry-matter content of 86 %. Table 160 shows the resulting total N inputs from bedding material, broken down by years and animal categories, for Germany.

Except for those in the "other cattle" category, the values are identical with those that were reported in the NIR 2012. In the "other cattle" category, the values are slightly increased from their values in the NIR 2012. This is due to the change in allocation of cows for fattening and for slaughter (cf. Chapter 6.1.3.2). Transfer of "cows for fattening and for slaughter" from the "heifers" category to "suckler cows", which require larger amounts of bedding material (cf. Table 360 in Annex Chapter 19.4.1), increases the amount of bedding material for other cattle overall.

Table 160: Annual totals for N inputs via bedding material, in straw-based systems (4.B(b))

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	17.2	14.7	13.9	13.8	7.8	7.7	7.6	7.4	6.6	6.5
Other cattle	20.3	17.1	16.8	16.9	17.6	18.1	18.0	17.6	17.6	18.0
Swine	3.18	2.86	2.91	2.79	1.87	1.78	1.80	1.83	1.70	1.65
Sheep	0.92	0.89	0.83	0.84	0.81	0.84	0.83	0.82	0.81	0.78
Goats	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06
Horses	6.46	6.73	7.00	7.43	7.87	8.22	8.57	7.84	7.12	6.40
Mules/asses	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Buffalo [a]	NA	NA	NA	NA	NA	NA	0.00	0.00	0.00	0.00
Poultry	0.77	0.78	0.78	0.82	0.85	0.89	0.93	0.96	0.99	1.02
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	7.2	7.1	7.0	6.9	6.7	6.7	6.5	6.5	6.7	6.7
Other cattle	18.5	19.1	18.4	18.2	17.9	18.1	18.1	18.3	19.0	19.3
Swine	1.58	1.53	1.51	1.48	1.40	1.41	1.36	1.35	1.28	1.26
Sheep	0.78	0.79	0.78	0.78	0.77	0.75	0.72	0.72	0.69	0.67
Goats	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.11
Horses	6.57	6.75	6.88	7.00	6.84	6.67	6.95	7.22	6.87	6.51
Mules/asses	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Buffalo	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Poultry	1.08	1.13	1.19	1.25	1.25	1.24	1.27	1.30	1.35	1.42
[Gg a^{-1}]	**2010**	**2011**								
Dairy cattle	6.7	6.7								
Other cattle	19.4	18.7								
Swine	1.18	1.18								
Sheep	0.61	0.50								
Goats	0.07	0.07								
Horses	6.15	6.15								
Mules/asses	0.08	0.08								
Buffalo	0.01	0.01								
Poultry	1.48	1.53								

[a] Through 1995, the system included no buffalo

6.1.3.6.3 Maximum methane producing capacity B_o (CRF 4.B)

For purposes of emissions calculation (cf. Chapter 6.3.2.2.1), the methane formation tied to manure storage is characterised by two parameters: the animal-specific methane producing capacity B_o and the storage-specific methane conversion factor *MCF*, which indicates the methane-formation fractions, with respect to maximum possible methane formation, that are actually produced in the various storage systems.

In the present submission, a derived national value is used for cattle and swine, for the first time (DÄMMGEN et al., 2012a), for the maximum methane producing capacity B_o. For the other animal categories, IPCC default values are used (IPCC, 2006: 10.77 ff). Those values are either in keeping with those from IPCC (1996b), p. 4.45 / Table B-5 and p. 4.47 / Table B-7, or, with the exception of those for horses, are higher. IPCC (1996b) puts the emissions for horses at 0.33 $m^3\ kg^{-1}\ CH_4$. Table 185 shows the B_o values used in the inventory.

Table 161: Maximum methane producing capacity B_o

[$m^3\ kg^{-1}$]	B_o
Cattle	0.23
Swine	0.30
Sheep	0.19
Goats	0.18
Horses	0.30
Mules and asses	0.33
Buffalo	0.10

For pullets, the maximum B_o value that IPCC (2006), Table 10A-9, provides for poultry is used, as a conservative approach : 0.39 $m^3\ kg^{-1}\ CH_4$ (laying hens). That value is higher than the value given in IPCC (1996b), Table B-7, for poultry overall (0.32 $m^3\ kg^{-1}\ CH_4$).

Table 186 shows the time series for the German mean value of B_o for poultry. The values have been weighted in accordance with the VS excretions in the various poultry sub-categories. Using a conservative approach, the value for geese has been made identical with the value used for laying hens, even though calculations for geese are made in accordance with the Tier 1 method and no B_o for geese is used in inventory calculations. The B_o mean value for poultry is consistently higher than the value given by IPCC (1996b), Table B-7, for poultry overall, 0.32 $m^3\ kg^{-1}\ CH_4$.

Table 162: Maximum methane producing capacity B_o for poultry (4.B(a)s1)

[$m^3\ kg^{-1}$]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Poultry	0.374	0.374	0.373	0.373	0.373	0.372	0.372	0.372	0.371	0.371
[$m^3\ kg^{-1}$]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Poultry	0.371	0.371	0.371	0.370	0.370	0.370	0.370	0.370	0.369	0.369
[$m^3\ kg^{-1}$]	**2010**	**2011**								
Poultry	0.368	0.368								

6.1.3.6.4 Methane conversion factors MCF (CRF 4.B)

For description of the methane emissions related to manure storage, (cf. Chapter 6.3.2.2.1), Germany uses the methane conversion factors *MCF* derived by DÄMMGEN et al. (2012a), along with the maximum methane producing capacity B_o.

Table 163 shows the *MCF* values used in the inventory for cattle and the storage systems most commonly used in Germany (the values assumed pursuant to DÄMMGEN et al. (2012a) are shown in boldface type). The values are in keeping with the values given in IPCC (2006)-10.44ff for a mean annual temperature of ≤10°C, which is typical for Germany. The IPCC (2000) default values have been used for "deep bedding material" and "pasture". In a conservative approach, the *MCF* applying to "slurry without natural crust" was used for "slurry with solid cover" (including tent structures) and "slurry with floating cover".

Table 163: Methane conversion factors *MCF* used in the German inventory for cattle (4.B(a)s1). The values in boldface type are from DÄMMGEN et al. (2012a) (see the text for further details).

		MCF [$m^3\ m^{-3}$] [a]
Slurry	Open tank, without natural crust	**0.17**
	Solid cover	**0.17**
	Natural crust	**0.10**
	Floating cover (chaff)	0.17
	Floating cover (plastic film)l	0.17
	Below slatted floor > 1 month	**0.17**
Solid manure	Deep bedding and sloped floor	0.17
	Heap	**0.02**
Pasture		0.01

[a] IPCC gives *MCF* in percent (of B_o), which is why the units $m^3\ m^{-3}$ are used in the German inventory.

In a procedure similar to that used for cattle husbandry, methane conversion factors *MCF* for manure storage in swine husbandry are calculated with national *MCF* for the most common storage systems (DÄMMGEN et al., 2012a) and with conservatively selected IPCC default values (Table 164). Free-range management of swine ("pasture") is not included in the German inventory.

Table 164: Methane conversion factors *MCF* used in the German inventory for swine (4.B(a)s1). The values in boldface type have been taken from DÄMMGEN et al. (2012a)

		MCF [m^3 m^{-3}] [a]
Slurry	Open tank, without natural crust	**0.25**
	Solid cover	**0.25**
	Natural crust	**0.15**
	Floating cover (chaff)	0.25
	Floating cover (plastic film)	0.25
	Below slatted floor > 1 month	**0.25**
Solid manure	Deep bedding	0.25
	Heap	**0.03**

[a] IPCC gives *MCF* in percent (of B_o), which is why the units m^3 m^{-3} are used in the German inventory.

The *MCF* values for slurry digestion and storage of digested slurry, for cattle and swine (cf. Chapter 6.1.3.6.5), are not included in Table 163 and Table 164, since they are not constant.

For manure storage for other animals (sheep, goats, buffalo and poultry), IPCC default values are used (cf. Table 165); to ensure consistency with the MCF values for cattle and swine, data from IPCC (2006)-10.44ff were used for this purpose. While the values are temperature-sensitive, in Germany mean annual temperatures above 10°C occur only in regions in which animal husbandry plays only a secondary role (Rhine valley, Ruhr region).

Table 165: Methane conversion factors *MCF* used in the German inventory for sheep, goats and buffalo (4.B(a)s1).

MCF [m^3 m^{-3}] [a]	≤10°C	11°C
Slurry with natural crust	**0.10**	**0.11**
Solid manure, heap	**0.02**	**0.02**
Pasture	0.01	0.01

[a] IPCC gives *MCF* in percent (of B_o), which is why the units m^3 m^{-3} are used in the German inventory.

In general, the *MCF* values used by Germany are higher than the values given by the IPCC (1996b) for cool climates (0.1 m^3 kg^{-3} for all systems except for deep bedding material, solid-manure storage systems and pasture; solid-manure storage systems and pasture: 0.01 m^3 kg^{-3}; no figures for deep bedding material).

For all poultry categories in Germany, an *MCF* of 0.015 m^3 m^{-3}, in keeping with IPCC (2006)-10.82, is used. IPCC (1996b), Table B-7 (poultry) and IPCC 2006, Table 10A-9 (ducks) give a lower *MCF*, 0.01 m^3 m^{-3}. It does not seem justified to use that value for ducks, however, since it is nearly impossible to keep bedding material in a duck house dry to an acceptable degree. The *MCF* used in the inventory model is thus higher, for all poultry categories, than the IPCC-1996 default value.

Table 166 lists the methane conversion factors *MCF* resulting, on an average for all slurry-based systems, for dairy cattle, other cattle and swine. In a departure from the *MCF* units used in the German inventory (m^3 m^{-3}), the figures in Table 166 are given in percent, since that is how the values are given in the CRF tables. For dairy cattle and swine, these mean values also include the *MCF* values for digestion of cattle/swine slurry in biogas plants with storage of digested slurry (cf. Chapter 6.1.3.6.5).

Table 166: Mean methane conversion factors (*MCF*) for slurry-based systems for dairy cattle, other cattle and swine (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	13.7	13.7	13.7	13.7	13.3	13.3	13.3	13.3	13.3	13.3
Other cattle	13.0	13.1	13.0	13.0	12.5	12.5	12.6	12.6	12.6	12.5
Swine	24.7	24.7	24.7	24.7	23.8	23.8	23.7	23.8	23.8	23.8
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	13.5	13.6	13.7	13.8	13.9	13.9	14.0	14.1	14.2	14.3
Other cattle	12.9	13.0	13.1	13.1	13.2	13.2	13.3	13.4	13.5	13.6
Swine	23.4	23.2	23.0	22.9	22.7	22.5	22.4	22.2	22.0	21.8
[%]	**2010**	**2011**								
Dairy cattle	14.4	14.4								
Other cattle	13.6	13.6								
Swine	21.7	21.7								

Table 167 lists the methane conversion factors *MCF* resulting, on an average for all straw-based systems, for dairy cattle, other cattle and swine. The noticeable increase for other cattle occurring from 2002 to 2003 is a result of a transition in housing of calves; for such housing, it is assumed that until 2002 50 % of all calves were housed in tied systems with solid floors and bedding material and 50 % were housed with deep bedding material, and that as of 2003, as a result of a ban on tied systems, 100 % were housed with deep bedding material (assessment of KTBL experts).

Table 167: Mean methane conversion factors (*MCF*) for straw-based systems for dairy cattle, other cattle and swine (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	2.0	2.0	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
Other cattle	5.5	5.4	5.6	5.6	6.1	6.0	5.9	5.9	6.0	6.1
Swine	8.6	8.5	8.5	8.6	8.8	8.8	8.8	8.8	8.9	8.9
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0
Other cattle	6.5	6.7	6.9	7.5	7.5	7.6	7.6	7.6	7.7	7.7
Swine	8.8	8.8	8.7	8.7	8.6	8.5	8.4	8.3	8.2	8.1
[%]	**2010**	**2011**								
Dairy cattle	2.0	2.0								
Other cattle	7.7	7.6								
Swine	7.9	8.0								

6.1.3.6.5 Slurry digestion and storage of digested slurry (CRF 4.B)

For the NIR 2013, the GAS-EM inventory model has been made, for the first time, to include anaerobic digestion of cattle and swine slurry, in biogas plants, and storage of digested slurry, pursuant to IPCC (2000). The underlying activity data and emission factors have been provided by the Association for Technology and Structures in Agriculture (KTBL) (2012).

Since the data show only the total (combined) amounts of slurry from cattle and swine that were digested in biogas plants, it was not possible to determine the individual contributions of the various cattle and swine categories to the total. As a simplification, it was assumed that all slurry that underwent digestion originated, in each case, in the most important animal sub-category: cattle slurry was considered to be slurry from dairy cattle, and swine slurry was considered to be slurry from fattening pigs. Table 361 in Annex Chapter 19.4.1 shows, for Germany, the applicable ratios, in percent by volume, of cattle slurry to slurry from dairy cattle and of swine slurry to slurry from fattening pigs. In a small number of cases (Thuringia in 2011, for cattle slurry; Mecklenburg – West Pomerania in 2010 and 2011, and

Brandenburg in 2011, for swine slurry), the relevant amounts of slurry in biogas plants exceeded the amounts of slurry produced by dairy cattle and fattening pigs, leading to slight underestimations of the biogas trend. As a result, the emissions reductions achieved via use of anaerobic digestion, instead of the customary slurry storage, have also been slightly underestimated (cf. also Chapter 6.3.2.6).

For 2010, the relative fractions of cattle slurry and swine slurry in biogas plants, at the national level, are known in terms of fractions of the total electrical output of biogas plants. Those fractions were back-extrapolated, on the basis of the applicable proportions of the total electrical output of biogas plants, to 1990. Table 168 shows the calculations for the applicable percentages, as used for the NIR 2013, of digestion of slurry from cattle and swine and of the total quantity of cattle and swine slurry. In the GAS-EM inventory model, these data have been interpreted as percentages of the amounts of N excreted (cf. Chapter 6.1.3.4) and VS (cf. Chapter 6.1.3.5) that undergo the process of slurry digestion.

Table 168: Percentages of slurry digested in biogas plants, as used for the NIR 2013, and broken down by cattle slurry, swine slurry and the combined total quantity of cattle and swine slurry (in %)

[%[1]]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cattle slurry	0.003	0.008	0.012	0.016	0.017	0.043	0.073	0.097	0.226	0.261
Swine slurry	0.005	0.012	0.016	0.022	0.027	0.068	0.112	0.139	0.299	0.341
Total amount of slurry	0.003	0.009	0.013	0.018	0.020	0.049	0.083	0.108	0.247	0.283
[%[1]]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Cattle slurry	0.441	0.639	0.959	1.17	1.59	3.18	5.09	7.66	9.21	11.7
Swine slurry	0.553	0.786	1.130	1.29	1.72	3.79	5.26	7.62	9.23	11.2
Total amount of slurry	0.472	0.680	1.009	1.21	1.63	3.36	5.14	7.65	9.21	11.5
[%]	**2010**	**2011**								
Cattle slurry	14.6	17.7								
Swine slurry	14.0	16.2								
Total amount of slurry	14.4	17.3								

IPCC (2000) views slurry digestion, including storage of digested slurry, as a separate type of manure storage – and applies to it the effective methane conversion factor *MCF*, which expresses the relevant summed emissions from fermentation and storage as a ratio of the maximum methane producing capacity B_o. The manner in which this effective *MCF* is calculated, as a function of the leakage rate of the digester, of the potential quantity of CH_4 offgas (with respect to B_o) and of the *MCF* of the system for storage of digested slurry, is described in the following. The pertinent N_2O emissions are calculated via the same procedure used for other forms of storage; cf. Chapter 6.3.4.2.1.

The effective *MCF* is calculated from the leakage rate of the digester, the "offgas" quantity and the *MCF* of the system for storage of digested slurry. The equation used for this purpose was derived from IPCC, 2000, p. 4.36, footnote 1 / formula 1; cf. RÖSEMANN et al. (2013):

Equation 6: Calculation of effective *MCF* for fermentation of slurry in biogas plants, with storage of digested slurry

$$MCF_{\text{dig}} = (1 - \mu_{\text{offgas}}) \cdot L_{\text{prod}} \; + \; \mu_{\text{offgas}} \cdot MCF_{\text{res}}$$

where

MCF_{dig}	effective *MCF* for the combination "digester + system for storage of digested slurry" (in m^3 m^{-3})
μ_{offgas}	relative offgas amount, with respect to B_o (with $0 \le \mu_{offgas} \le 1$ m^3 m^{-3})
L_{prod}	relative leakage rate of the digester, with respect to the quantity of CH_4 produced in the digester (with $0 \le L_{prod} \le 1$ m^3 m^{-3})
MCF_{res}	*MCF* for the system for storage of digested slurry (in m^3 m^{-3})

As the above equation indicates, the effective *MCF* is a weighted mean of the leakage rate of the digester (L_{prod}) and the *MCF* of the system for storage of digested slurry; the weighting is achieved via use of the relative fractions, for the relevant two production sites ("digester" and "storage system"), of the maximum possible total CH_4 production (expressed via the relative potential offgas amount μ_{offgas}).

The Association for Technology and Structures in Agriculture (KTBL) (2012) gives the typical leakage rate of German digesters (L_{prod}), with respect to the amount of CH_4 produced in digestion, as 1 % or 0.01 $m^3\ m^{-3}$. That value is a convention that is used in most calculations relative to total climate-gas production in biogas production. Examples of studies that use the 1% figure include BACHMEIER & GRONAUER (2007), BÖRJESSON & BERGLUND (2008), GÄRTNER et al. (2008) and ROTH et al. (2011).

The typical potential amount of CH_4 offgas, μ_{offgas}, with respect to the maximum methane producing capacity B_o, was determined as follows: In a first step, KTBL (2012) provided a figure for the potential offgas amount v_{offgas} with respect to the amount of CH_4 produced; v_{offgas} = 4.8 % (or 0.048 $m^3\ m^{-3}$). In the process, it was noted that offgas amounts produced at a digestion temperature of about 40° C (potential) differ from those produced at a digestion temperature of about 20° C (the offgas amounts typically occurring in practice). The value μ_{offgas} that is required in the IPCC concept is the value at about 40°C, although in practice the value is determined at about 20° C. KTBL (2012) first derived v_{offgas} for temperatures of 20 to 22° C, obtaining a value of 2.0 %, and then converted that value for a temperature of 37° C; that conversion yielded a value of 4.8 %. That value was then converted, with the formula below (RÖSEMANN et al., 2013), to obtain the μ_{offgas} = 4.6 % (or 0.046 $m^3\ m^{-3}$) that is used in the present emissions calculations.

Equation 7: Calculation of the potential amount of CH_4 offgas, with respect to B_o, from the quantity of CH_4 offgas resulting with respect to the produced amount of CH_4

$$\mu_{offgas} = \frac{v_{offgas}}{1 + v_{offgas}}$$

where

μ_{offgas}	relative potential offgas amount, with respect to B_o (with $0 \le \mu_{offgas} \le 1\ m^3\ m^{-3}$)
v_{offgas}	relative potential offgas amount, with respect to the amount of CH_4 produced (with $0 \le v_{offgas} \le 1\ m^3\ m^{-3}$)

Pursuant to IPCC (2000), a distinction is made, with regard to systems for storage of digested slurry, between gas-tight storage (*MCF* = 0) and open storage (*MCF* as with open storage of undigested slurry). On the basis of values given in the literature, KTBL (2012) has estimated the relative fraction of gas-tight storage, with respect to total storage of digested slurry, in percent by volume; cf. Table 169 and Table 170. For purposes of inventory calculations, those data have been interpreted as percentage figures with respect to the involved amounts of N.

Table 169: Relative fractions of storage of digested slurry in gas-tight and non- gas-tight storage systems, for cattle slurry (in % of total cattle slurry)

[%[1]]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
gas-tight	0.0	1.0	1.9	2.9	3.9	4.9	5.8	6.8	7.8	8.7
non- gas-tight	100.0	99.0	98.1	97.1	96.1	95.1	94.2	93.2	92.2	91.3
[%[1]]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
gas-tight	9.7	10.7	11.7	13.2	14.8	16.3	21.8	27.2	32.7	38.1
non- gas-tight	90.3	89.3	88.3	86.8	85.2	83.7	78.2	72.8	67.3	61.9
[%]	**2010**	**2011**								
gas-tight	43.5	49.0								
non- gas-tight	56.5	51.0								

Table 170: Relative fractions of storage of digested slurry in gas-tight and non- gas-tight storage systems, for swine slurry (in % of total swine slurry)

[%[1]]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
gas-tight	0.0	1.0	2.1	3.1	4.1	5.1	6.2	7.2	8.2	9.2
non- gas-tight	100.0	99.0	97.9	96.9	95.9	94.9	93.8	92.8	91.8	90.8
[%[1]]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
gas-tight	10.3	11.3	12.3	14.0	15.6	17.2	23.0	28.7	34.5	40.2
non- gas-tight	89.7	88.7	87.7	86.0	84.4	82.8	77.0	71.3	65.5	59.8
[%]	**2010**	**2011**								
gas-tight	46.0	51.7								
non- gas-tight	54.0	48.3								

In the case of gas-tight storage, the effective *MCF* is in the vicinity of 0.01 $m^3\ m^{-3}$ – and thus is an order of magnitude smaller than the *MCF* values for the other slurry-storage systems. The effective *MCF* in the case of non- gas-tight storage is an order of magnitude smaller than the *MCF* for open storage of undigested slurry. Overall, anaerobic digestion of slurry in biogas plants, with storage of digested slurry, results in a reduction of CH_4 emissions from manure management. The extent of such reduction depends on what fraction of relevant slurry is digested, as well as on the relative frequency of gas-tight systems for storage of digested slurry.

Since the N_2O emission factor for the complex "slurry digestion with storage of digested slurry" is considerably lower than that for conventional storage (cf. 6.3.4.2.2), slurry digestion in biogas plants also reduces the total N_2O emissions.

While spreading of digested slurry does not lead directly to additional greenhouse-gas emissions, it does cause NH_3 emissions that, via deposition of reactive nitrogen, trigger indirect N_2O emissions from the soil (cf. Chapter 6.5.2.1.2). The frequency distributions for the various relevant application techniques, for digested slurry from slurry digestion, and the pertinent NH_3 emission factors, are listed in Table 362 in Annex Chapter 19.4.1. For further details, cf. RÖSEMANN et al. (2013).

6.1.4 Activity data for N_2O emissions from agricultural soils

6.1.4.1.1 The N amounts behind direct N_2O emissions (CRF 4.D)

Table 171 shows those N amounts that enter the soil, from various sources, and that are used as a basis for calculation of direct N_2O emissions.

The N amount resulting from use of mineral fertiliser was obtained as the amount of N applied, via fertiliser, less the N losses from NH_3 and NO emissions as calculated in the inventory. The applied N amounts in fertiliser are obtained from the quantities of mineral fertiliser sold, as recorded in Länder-level statistics.

The N amount resulting from manure application was obtained from the amounts of N excreted, without N excretions from pasture (cf. Chapter 6.1.3.4), using the N-flow concept (Chapter 6.1.2.4).

Direct N_2O emissions from N excretions in pasture are calculated, in accordance with IPCC (1996b), in proportion to the excreted N amount (cf. Chapter 6.1.3.4). That amount has been calculated as the product of relevant animals' total N excretions and the relative proportion of time the animals spend in pasture.

For each Land (state) in Germany, N amounts from sewage sludges are taken from data of the Federal Environment Agency and (since 2009) of the Federal Statistical Office. In the process, the value for 2010 was updated. For 2011, for which a data value was lacking, the value for 2010 was carried forward as an estimate.

For each crop, the amount of N bound via biological N fixation was determined as the product of the pertinent cultivated area and the specific fixation rate. The relevant data for the cultivated areas are provided by the Federal Statistical Office, while the fixation data are obtained from FAUSTZAHLEN (1993), p. 477, and from Saxony's state institute for agriculture (Sächsische Landesanstalt für Landwirtschaft; LABER, 2005, p. 86).

The amounts of N remaining in the soil in crop residues were obtained from the relevant areas under cultivation, yields and crop-specific N content. The data on areas under cultivation and yields are reported by the FEDERAL STATISTICAL OFFICE (STATISTISCHES BUNDESAMT; Fachserie 3, Reihe 3). The relative N amounts contained in residues are taken from the Fertiliser Ordinance (DüV, 2007) and from a list prepared by the Institute of Vegetable and Ornamental Crops (IGZ, 2007). The amounts of N removed from relevant areas, for bedding material in animal husbandry, are deducted.

Changes in the available N amounts, in comparison to the corresponding figures in the NIR 2012, are discussed in Chapter 6.5.5.

Table 171: N amounts on which direct N_2O emissions data are based (4.Ds1.1.1 through 4.Ds1.1.4)

[Gg a^{-1} N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mineral fertiliser	2,089.3	1,943.3	1,863.1	1,744.9	1,552.9	1,720.8	1,702.7	1,689.9	1,718.2	1,827.7
Manure	897.4	796.0	785.2	783.7	800.6	798.4	804.4	789.0	792.5	787.2
Grazing	216.0	196.0	193.9	196.1	169.5	173.9	175.7	171.1	169.2	168.8
Sewage sludge	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5
N fixation, legumes	140.4	102.8	87.0	91.6	93.2	95.6	98.9	106.8	115.6	107.7
Crop residues	840.3	801.6	727.0	801.4	739.4	784.5	813.4	855.2	857.5	867.3
[Gg a^{-1} N]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Mineral fertiliser	1,935.9	1,768.3	1,713.9	1,710.8	1,747.6	1,704.1	1,705.6	1,525.9	1,728.8	1,467.3
Manure	778.8	793.1	776.4	771.6	757.0	762.3	749.9	760.9	764.6	770.6
Grazing	165.0	165.4	156.4	152.6	148.1	145.4	141.3	140.3	140.8	140.4
Sewage sludge	33.0	29.9	28.2	29.3	28.3	27.4	27.0	27.8	27.7	27.9
N fixation, legumes	95.6	102.3	97.5	95.5	91.7	94.7	92.7	83.2	76.4	78.3
Crop residues	851.3	881.3	828.4	728.2	932.9	890.5	828.5	890.4	956.4	999.6
[Gg a^{-1} N]	**2010**	**2011**								
Mineral fertiliser	1,499.3	1,701.6								
Manure	764.5	764.3								
Grazing	138.4	135.0								
Sewage sludge	28.4	28.4								
N fixation, legumes	77.0	79.6								
Crop residues	905.2	969.2								

6.1.4.1.2 Area of land with organic soils (CRF 4.D)

Area data for managed organic soils (cf. Table 172) were provided via the LULUCF sector (Chapter 7), and the pertinent values were updated with respect to the NIR 2012. The land areas with organic soils comprise the relevant areas of LULUCF cropland and grassland (in the narrower sense – "grassland" without "woody grassland"), less the total area of undrained grassland (16,786 ha) on organic soils.

Table 172: Areas of cultivated organic soils, in the NIR 2013 and in the NIR 2012, on which calculation of direct N_2O emissions is based (4.Ds1.1.5)

[thousands of ha]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Org. soils, 2013	1,235.4	1,236.1	1,236.8	1,237.4	1,238.1	1,238.8	1,239.4	1,240.1	1,240.8	1,241.4
Org. soils, 2012	1,235.4	1,236.1	1,236.8	1,237.4	1,238.1	1,238.8	1,239.4	1,240.1	1,240.8	1,241.4
[thousands of ha]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Org. soils, 2013	1,242.1	1,240.8	1,239.4	1,238.1	1,236.7	1,235.3	1,234.2	1,233.0	1,231.9	1,230.6
Org. soils, 2012	1,242.1	1,240.8	1,239.4	1,238.1	1,236.7	1,235.3	1,234.2	1,233.0	1,231.9	1,231.0
[thousands of ha]	2010	2011								
Org. soils, 2013	1,229.3	1,228.0								
Org. soils, 2012	1,230.1									

6.1.4.1.3 Deposition of reactive nitrogen (CRF 4.D)

Deposition of reactive nitrogen is derived from the sums, as calculated in the inventory, of NH_3 and NO emissions from the German agricultural sector. The relevant sums of such NH_3 and NO emissions are given in Table 173. Those figures, via multiplication by 14/17 for NH_3 and 14/30 for NO, yield the quantity of reactive nitrogen on which N_2O calculation is based; cf. Table 174.

Table 173: Sums, as calculated for the inventory, of NH_3 and NO emissions from German agriculture that serve as a basis for calculation of deposition-related indirect N_2O emissions

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NH3}	677.6	603.3	591.6	590.7	562.2	566.0	568.6	559.2	564.0	563.1
E_{NO}	90.5	82.8	80.2	77.1	71.6	76.1	75.8	74.8	75.6	78.4
[Gg a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
E_{NH3}	558.2	568.3	555.2	551.3	544.1	537.3	532.2	532.9	533.8	542.9
E_{NO}	80.8	77.0	74.8	74.4	74.8	73.5	73.1	68.7	74.1	67.6
[Gg a^{-1}]	2010	2011								
E_{NH3}	517.0	529.0								
E_{NO}	67.8	73.3								

Table 174: N_2O from deposition: Reactive nitrogen N_{reac} upon which the calculation is based (4.Ds1.3.1)

[Gg a^{-1}N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_{reac}	600.3	535.5	524.6	522.5	496.4	501.7	503.6	495.5	499.8	500.3
[Gg a^{-1}N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N_{reac}	497.4	503.9	492.1	488.7	483.0	476.8	472.4	470.9	474.2	478.6
[Gg a^{-1}N]	2010	2011								
N_{reac}	457.4	469.8								

Changes in the available N amounts, in comparison to the corresponding figures in the NIR 2012, are discussed in Chapter 6.5.5.

6.1.4.1.4 Leaching and surface run-off (CRF 4.D)

The N amount available in the soil is obtained as the sum of the following sub- activity data:

- Nitrogen from mineral-fertiliser and farm-manure application, and from grazing, comprising the amounts of applied / excreted N, less the N losses from direct N_2O emissions and from NH_3, NO and N_2 emissions.
- Nitrogen from sewage-sludge application, comprising the amount of N applied, less the N losses via direct N_2O emissions (no NH_3, NO and N_2 emissions are calculated);
- Nitrogen from biological N fixation, less the N losses via direct N_2O emissions, and NH_3 und N_2 emissions (with regard to the N amount fixed, cf. Chapter 6.1.4.1.1);
- For crop residues, the relevant sub- activity data are obtained as the applicable N content (with regard to calculation of these N amounts, cf. Chapter 6.1.4.1.1), less the N losses via direct N_2O emissions and via N_2 emissions (no NH_3 emissions are calculated).

With regard to calculation of NH_3 and NO emissions, and of direct N_2O emissions, cf. Chapter 6.5.2.1.1. The N_2 emissions are calculated via the same procedure used for calculation of direct N_2O emissions, with an N_2 emission factor of 0.1 kg kg^{-1} N being used instead of the N_2O-N emission factor of 0.125 kg kg^{-1} N – except for grazing. For grazing, an N_2 emission factor of 0.14 kg kg^{-1} N is used instead of the N_2O-N emission factor of 0.02 kg kg^{-1} N. With regard to the N_2 emission factors, cf. RÖSEMANN et al. (2013).

From the available N amount, the leached N amount (including surface runoff) – cf. Table 175 – is obtained via multiplication by $Frac_{LEACH}$ = 0.3 (cf. Chapter 6.5.2.2.2).

Table 175: Leached N fraction (including surface run-off) (4.Ds1.3.2)

[Gg a^{-1}N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_{leach}	1,118.0	1,026.9	977.8	967.5	898.2	958.7	964.5	968.7	978.8	1,007.0
[Gg a-1N]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
N_{leach}	1,025.6	993.7	956.8	926.8	984.8	963.1	942.0	911.1	982.0	926.0
[Gg a-1N]	**2010**	**2011**								
N_{leach}	907.0	977.7								

Changes in the available N amounts, in comparison to the corresponding figures in the NIR 2012, are discussed in Chapter 6.5.5.

6.1.5 Total uncertainty of all emissions in Sector 4

Along with emissions calculations, the total uncertainty for all emissions in Sector 4 was calculated; cf. Table 176. That calculation was carried out on the basis of the Tier 1 method described in IPCC Good Practice Guidance and Uncertainty Management (IPCC, 2000), "Quantifying Uncertainties in Practice". That procedure, in turn, is based on thorough application of Gaussian error correction. By way of convention, it is ignored that such error correction assumes a normal distribution, a distribution requirement that some of the activity data and emission factors that enter into the calculation do not meet or cannot be verified to meet. Furthermore, Gaussian error calculation is oriented to use of standard errors. In contrast to that orientation, the Tier 1 method described in IPCC (2000), "Quantifying Uncertainties in Practice" (cf. p. 6.14 in the paragraph relative to columns E and F), requires entry of half of the 95 % confidence interval, which value amounts to about double the standard error. That said, it can be shown that the calculation rules of Gaussian error calculation (cf. equations 6.3 and 6.4 in IPCC, 2000) are also valid for a multiple of the standard error.

With regard to asymmetric distributions, IPCC (2000), "Quantifying Uncertainties in Practice" (p. 6.14), requires, for the Tier 1 method, that the larger of the two intervals [2.5 percentile; mean value] and [mean value; 97.5 percentile] be used. That requirement has been fulfilled for Table 176. Details on Tier-1 uncertainties calculation for the German inventory are presented in RÖSEMANN et al. (2013).

By contrast, Tier-2 uncertainties calculation, which the Federal Environment Agency carries out every three years, takes both intervals into account.

Table 176 shows the total uncertainty, as calculated with the Tier-1 method, for all emissions of Sector 4, for the year 2010, along with the uncertainty for the overall trend since 1990. All emissions values are given in CO_2 equivalents, using the greenhouse warming potential (GWP) conversions customarily applied, 21 kg kg^{-1} for CH_4 and 310 kg kg^{-1} for N_2O.

In the interest of clarity, the presentation in Table 176 uses the collective animal categories "other cattle", "swine" and "poultry", and includes representative uncertainties for activity data and emission factors. Those uncertainties have been derived from the relevant uncertainties for the animal sub-categories included in the collective categories. The results in Table 176 (uncertainty in the level of the overall GG inventory of 74.0 %, and uncertainty in the trend of 33.7 %) are in accordance with the results obtained via complete calculation with the animal sub-categories contained in the collective categories (cf. RÖSEMANN et al., 2013).

Noticeably, the uncertainties for the emission factors tend to be considerably higher than those for the activity data, and thus the former uncertainties predominate in the combined uncertainty in the column "Combined uncertainty as % of total national emissions".

As the column "Combined uncertainty as % of total national emissions" also shows, the total uncertainty for all emissions from Sector 4 results predominantly from the uncertainties for N_2O emissions from the area of agricultural soils, especially the indirect emissions from leaching and surface runoff.

The increase in the uncertainty for the emissions level (74.0 %, valid for 2011), with respect to the corresponding figure in the NIR 2012 (72.1 %, valid for 2010), is due mainly to the considerable increase in mineral-fertiliser application that occurred from 2010 to 2011. That increase is reflected specifically in a noticeable increase in the uncertainty for the source category "Indirect N_2O emissions from leaching and surface runoff" (from 68.2 % to 70.4 %). By contrast, updating of uncertainties for animal numbers for poultry, and for the N amount occurring in pasture, does not play a significant role.

An uncertainty increase from the NIR 2012 to the present NIR 2013 has also occurred in the trend (from 33.1 %, valid for 2010, to 33.7 %, valid for 2011). Here as well, the increase is due very largely to the increase in the uncertainty for the source category "Indirect N_2O emissions from leaching and surface runoff", which resulted from the increase, from 2010 to 2011, in the quantities of mineral fertiliser applied.

Table 176: Total-uncertainties calculation for emissions from Sector 4 (animal husbandry and use of agricultural soils)

Source category	Gas	Base year emissions, in CO_2 equivalents	Year 2011 emissions, in CO_2 equivalents	Activity data uncertainty (half the 95 % confidence interval)	Emission factor uncertainty (half the 95 % confidence interval)	Combined uncertainty (half the 95 % confidence interval)	Combined uncertainty as % of total national emissions in year 2011	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		(GWP$_{CH4}$ = 21, GWP$_{N2O}$ = 310)										
		Gg a-1	Gg a-1	%	%	%	%	%	%	%	%	%
Enteric fermentation, dairy cows	CH_4	16002.7	11677.4	4	40	40.2	6.7	0.01	0.13	0.51	0.75	0.91
Enteric fermentation, other cattle	CH_4	12229.0	7996.3	4	40	40.2	4.6	0.02	0.09	0.81	0.51	0.96
Enteric fermentation, pigs	CH_4	600.1	558.2	4	40	40.2	0.3	0.00	0.01	0.04	0.04	0.05
Enteric fermentation, sheep	CH_4	548.7	278.9	10	60	60.8	0.2	0.00	0.00	0.11	0.04	0.12
Enteric fermentation, goats	CH_4	9.5	15.7	20	60	63.2	0.0	0.00	0.00	0.01	0.01	0.01
Enteric fermentation, horses	CH_4	169.7	161.3	10	60	60.8	0.1	0.00	0.00	0.02	0.03	0.03
Enteric fermentation, mules, asses	CH_4	1.8	1.8	100	60	116.6	0.0	0.00	0.00	0.00	0.00	0.00
Enteric fermentation, buffalo	CH_4	0.0	3.1	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, dairy cows	CH_4	2230.1	1771.9	4	40	40.2	1.0	0.00	0.02	0.01	0.11	0.11
Manure management, other cattle	CH_4	2285.5	1452.3	4	40	40.2	0.8	0.00	0.02	0.17	0.09	0.19
Manure management, pigs	CH_4	2063.4	1622.9	4	40	40.2	0.9	0.00	0.02	0.01	0.10	0.11
Manure management, sheep	CH_4	18.7	9.5	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, goats	CH_4	0.4	0.7	20	60	63.2	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, horses	CH_4	26.3	25.0	10	40	41.2	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, mules, asses	CH_4	0.2	0.2	100	40	107.7	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, buffalo	CH_4	0.0	0.3	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, poultry	CH_4	73.5	100.0	10	40	41.2	0.1	0.00	0.00	0.02	0.02	0.02
Manure management, dairy cows	N_2O	1621.3	967.9	4	100	100.1	1.4	0.00	0.01	0.37	0.06	0.38
Manure management, other cattle	N_2O	1455.1	1099.7	4	100	100.1	1.6	0.00	0.01	0.07	0.07	0.10
Manure management, pigs	N_2O	570.4	502.6	4	100	100.1	0.7	0.00	0.01	0.05	0.03	0.06
Manure management, sheep	N_2O	85.4	46.6	10	300	300.2	0.2	0.00	0.00	0.07	0.01	0.07
Manure management, goats	N_2O	4.4	7.3	20	300	300.7	0.0	0.00	0.00	0.01	0.00	0.01
Manure management, horses	N_2O	142.8	135.9	10	300	300.2	0.6	0.00	0.00	0.07	0.02	0.08
Manure management, mules, asses	N_2O	1.7	1.7	100	300	316.2	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, buffalo	N_2O	0.0	0.8	10	100	100.5	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, poultry	N_2O	37.6	49.8	10	100	100.5	0.1	0.00	0.00	0.02	0.01	0.02

Source category	Gas	Base year emissions, in CO_2 equivalents	Year 2011 emissions, in CO_2 equivalents	Activity data uncertainty (half the 95 % confidence interval)	Emission factor uncertainty (half the 95 % confidence interval)	Combined uncertainty (half the 95 % confidence interval)	Combined uncertainty as % of total national emissions in year 2011	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		(GWP_{CH4} = 21, GWP_{N2O} = 310)										
		Gg a-1	Gg a-1	%	%	%	%	%	%	%	%	%
Soils, mineral fertilisers	N_2O	12722.4	10361.6	1	80	80.0	11.8	0.00	0.12	0.17	0.17	0.24
Soils, application of manure	N_2O	5464.6	4653.8	60	80	100.0	6.6	0.00	0.05	0.26	4.49	4.50
Soils, N-fixing crops	N_2O	855.1	484.9	50	80	94.3	0.7	0.00	0.01	0.18	0.39	0.43
Soils, crop residues	N_2O	5116.8	5901.8	50	80	94.3	7.9	0.02	0.07	1.64	4.74	5.02
Soils, organic soils	N_2O	4814.7	4785.8	1	200	200.0	13.6	0.01	0.05	2.12	0.08	2.13
Soils, grazing	N_2O	2104.2	1315.4	20	200	201.0	3.8	0.00	0.01	0.84	0.42	0.94
Soils, indirect emissions (deposition)	N_2O	2924.1	2288.7	50	100	111.8	3.6	0.00	0.03	0.06	1.84	1.84
Soils, indirect emissions (leaching, runoff)	N_2O	13615.6	11907.0	170	380	416.3	70.4	0.01	0.14	4.38	32.54	32.84
Soils, sewage sludge	N_2O	166.9	173.1	20	80	82.5	0.2	0.00	0.00	0.04	0.06	0.07
Total		87962.6	70359.9									
Overall uncertainty (half the 95% confidence interval) (%)							74.0					33.7

6.1.6 *Quality assurance and control*

6.1.6.1 The Thünen Institute's quality management for emissions inventories

The Thünen Institute's quality management for emissions-inventory preparation has been developed in conformance with the IPCC guidelines and the QSE (Chapter 1.6.1). The framework for the quality management, and the process for carrying it out, are described in detail in the relevant concept (BMELV, 2012) and in the provisions for implementation of the concept (TI, 2012). Along with the customary QC checklists of the QSE, TI checklists were used, for the first time, that contain numerous criteria for goal achievement and thus permit detailed quality control of work steps during emissions-inventory preparation. In each case, either compliance with the criteria is confirmed or reasons for non-compliance are provided. The TI checklists, along with other documents of importance for quality control, are added to the inventory description that is archived by the Single National Entity.

6.1.6.2 Input data, calculation procedures and emissions results

The "four eyes" principle has been applied conscientiously to all updating and recalculations. The newly introduced national methods and data for CH_4 emissions from enteric fermentation in dairy cows, and for CH_4 emissions from manure storage, are based on peer-reviewed articles (Dämmgen et al, 2012a; Dämmgen et al, 2012b). The articles present conclusive evidence to the effect that the methods and data are appropriate for the situation prevailing in Germany. The national N_2O emission factor for solid-manure storage has been reviewed and approved by the KTBL working group "Emission factors for animal husbandry" [KTBL = Association for Technology and Structures in Agriculture]. The procedure for taking account of slurry digestion was agreed on in a biogas workshop held at the Federal Environment Agency (5 June 2012); the relevant data were taken from current national studies and standard data (KTBL, 2012).

Following the conclusion of calculations with the GAS-EM inventory model, the input data and the results of emissions calculations were reviewed in detail via comparison with the previous year's results and with the help of plausibility checks. Any resulting discrepancies were analysed and documented, along with any individual changes made in input data. A detailed list of the changes made in emissions calculations between the Submission 2012 and the Submission 2013 is provided by RÖSEMANN et al. (2013), Chapter 2.2.2.

After the relevant activity data and place-related emission factors (IEF) had been entered into the Central System of Emissions (CSE) database, the emissions as calculated in the CSE were compared against the emissions results that had been obtained with the GAS-EM inventory model.

6.1.6.3 Comparisons with the previous year's results

This year's emissions calculations were also checked via comparison with the previous year's results – cf. Chapter 6.1.6.1 – in the framework of source-specific recalculations (cf. Chapters 6.2.5, 6.3.2 and 6.5.5).

6.1.6.4 Verification

The national emissions results calculated with the GAS-EM inventory model cannot be compared with other pertinent data from Germany, since no such data are available. Instead, the implied emission factors (IEF) and other emissions-relevant figures are compared with the relevant IPCC default values and with relevant data of other countries. That process is discussed in the following, in the relevant sub-chapters.

6.1.6.5 Reviews and reports

In June 2007, the German inventory was reviewed in the framework of the "Initial Review under the Kyoto Protocol and Annual 2006 Review under the Convention".

In September 2009, a centralized review was carried out. Its most important result was that Germany's use of the new IPCC Guidelines 2006, in source category 4.D in the agriculture sector, was not accepted.

That problem was then considered by the In-Country Review for the Submission 2010. As a result of that review, the Resubmission 2010 was submitted. The changes implemented in it served as a basis for preparation of the following submissions.

The requirements resulting from the Centralized Review for the Submission 2011 (justification of national emission factors for N_2O emissions from manure management; correction of the overestimation of N excretions of dairy cattle; updating of the distribution of housing systems, manure-storage systems and manure-application techniques; consideration of biogas production from slurry) have been fulfilled through the present NIR 2013.

The ERT report of the Centralized Review for the Submission 2012 had not been completed at the time the NIR 2013 was prepared (September 2012). (Apart from a question relative to the crops taken into account in the inventory in the areas of N fixation and crop residues, the ERT raised no further questions regarding the Submission 2012 during the review.)

6.2 Enteric fermentation (4.A)

6.2.1 Source category description (4.A)

CRF 4.A	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Dairy cattle (CRF 4.A.1)	**CH_4**	**L**	**-/T2**	**16,002.7**	**(1.31%)**	**11,677.4**	**(1.26%)**	**-27.03%**
Non-dairy cattle (CRF 4.A.1)	**CH_4**	**L**	**-/T2**	**12,229.0**	**(1.00%)**	**7,996.3**	**(0.86%)**	**-34.61%**
Other animals (buffalo, sheep, goats, horses, swine, mules & asses) (CRF 4.A.2-9)	CH_4	-	-	1,329.7	(0.11%)	1,019.0	(0.11%)	-23.37%

Gas	Method used	Source for the activity data	Emission factors used
CH_4	CS/D/Tier1/Tier2	M/Q/AS/RS/NS	CS/D

The category *Dairy cattle* (4.A.1.a) is the most important emissions source within the source category *enteric fermentation*. It is a key category in terms of emissions level. The reasons for its status as a key category include the high animal weights involved, the high yields involved and – in keeping with the first two factors – the high gross energy intakes involved. The source category *Other cattle* (4.A.1.b) is a key category in terms of emissions level.

Microbial reactions in the animals' stomachs release CH_4. The quantities released per animal and unit of time depend on the animal species in question, individual-animal yield and feed composition.

Germany reports on emissions of methane (CH_4) from enteric fermentation in dairy cattle, other cattle (calves, heifers, male beef cattle, suckler cows and mature males > 2 years), swine (sows, including suckling piglets weighing up to 8 kg animal^{-1}, weaners, fattening pigs and boars), sheep, goats, horses, mules and asses and buffalo.

Table 180 in Chapter 6.2.2.3 shows all CH_4 emissions from the source category *enteric fermentation*, in the form of a time series. The CH_4-emissions trend is shaped by decreasing animal counts – for cattle especially, throughout the entire period, and for all animal categories since the early 1990s – and by improved feed digestibility, which is partly offset by increasing GE intake levels in connection with increases in milk yield and animal weights.

CH_4 emissions from enteric fermentation, as a percentage of total CH_4 emissions from the German agricultural sector, have decreased slightly over the years (1990: 81.5 %; 2011: 80.6 %). Overall, CH_4 emissions from enteric fermentation decreased 30.0 % between 1990 and 2011.

6.2.2 Methodological issues (4.A)

6.2.2.1 Methods

CH_4 emissions from enteric fermentation in dairy cattle are calculated using a national method (Tier 3); see below. For other cattle and swine, the calculations are carried out with a Tier-2 method (IPCC, 1996b, 4.15 ff; IPCC, 2006, 10.24 ff); see below. For sheep, goats, horses, mules and asses and buffalo, calculations are carried out with a Tier-1 that employs default emission factors (cf. Chapter 6.2.2.2).

In the national method for calculation of CH_4 emissions from enteric fermentation in dairy cattle (DÄMMGEN et al., 2012b), the emission factor is calculated, pursuant to KIRCHGESSNER et al. (1994), as a function of intake of raw fibre, N-free extracts, raw protein and fat:

Equation 8: Calculation of the CH_4 emission factor for dairy cattle (national method)

$$EF_{\mathrm{CH4,ent}} = a \cdot M_{\mathrm{XFi}} + b \cdot M_{\mathrm{NFE}} + c \cdot M_{\mathrm{XP}} + d \cdot M_{\mathrm{XF}} + e$$

where

$EF_{\mathrm{CH4, ent}}$	Emission factor for CH_4 from enteric fermentation (in kg place^{-1} a^{-1} CH_4)
a	Coefficient (a = 0.079 kg kg^{-1})
M_{XFi}	Raw-fibre intake (in kg place^{-1} a^{-1})
b	Coefficient (b = 0.010 kg kg^{-1})
M_{NFE}	Intake of N-free extracts (in kg place^{-1} a^{-1})
c	Coefficient (c = 0.026 kg kg^{-1})
M_{XP}	Intake of raw protein (in kg place^{-1} a^{-1})
d	Coefficient (d = - 0.212 kg kg^{-1})
M_{XF}	Intake of fat (in kg place^{-1} a^{-1})
e	Constant (e = 365 · 0.063 kg place^{-1} a^{-1})

The intake of raw fibre, N-free extracts, raw protein and fat is determined from the basic feed- composition data and from the pertinent quantities of ingested feed (cf. Chapter 6.1.3.3).

The methane conversion factor is calculated from those figures, with the help of the gross energy intake (GE) (cf. Chapter 6.1.3.3):

$$x_{\text{CH4,GE}} = \frac{\eta_{\text{CH4}} \cdot EF_{\text{CH4,ent}}}{GE}$$

where

$x_{\text{CH4, GE}}$	Methane conversion factor for dairy cattle (in MJ MJ^{-1})
η_{CH4}	Energy content of methane (η_{CH4} = 55.65 MJ (kg $CH_4)^{-1}$)
$EF_{\text{CH4, ent}}$	Emission factor for CH_4 from enteric fermentation (in kg $place^{-1}$ a^{-1} CH_4)
GE	Gross energy intake (in MJ $place^{-1}$ a^{-1} GE)

While the methane conversion factor for dairy cattle decreased from 0.071 MJ MJ^{-1} in 1990 to 0.063 MJ MJ^{-1} in 2011, the emission factor increased, as a result of continual increases in yield, from 119.9 kg CH_4 per animal place and year in 1990 to 132.7 kg CH_4 per animal place and year in 2011 (cf. Chapter 6.2.2.2).

The Tier-2 method that is used for other cattle and swine calculates the emission factor from the gross energy intake (GE) (cf. Chapter 6.1.3.3) and the methane conversion factor, in accordance with the following formula:

Equation 9: Calculation of the CH_4 emission factor (Tier-2 method, IPCC (1996b))

$$EF_{\text{CH4,ent}} = GE \cdot \frac{x_{\text{CH4,GE}}}{\eta_{\text{CH4}}}$$

where

$EF_{\text{CH4, ent}}$	Emission factor for CH_4 from enteric fermentation (in kg $place^{-1}$ a^{-1} CH_4)
GE	Gross energy intake (in MJ $place^{-1}$ a^{-1} GE)
$x_{\text{CH4, GE}}$	Methane conversion factor (in MJ MJ^{-1})
η_{CH4}	Energy content of methane (η_{CH4} = 55.65 MJ (kg $CH_4)^{-1}$)

For the other cattle category, the methane conversion factor fluctuates slightly from year to year, due to changes in the composition of the total population (mean: 0.0615 MJ MJ^{-1}; Minimum: 0.0614 MJ MJ^{-1}; Maximum: 0.0617 MJ MJ^{-1}. This mean methane conversion factor is composed as follows: For suckler cows, heifers, male beef cattle and mature males > 2 years, a methane conversion factor of 0.065 MJ MJ^{-1} is used in each case, pursuant to IPCC (2006), Table 10.12. While that value is higher than the standard value of 0.06 MJ MJ^{-1} pursuant to IPCC (1996b), it provides a better representation of the circumstances prevailing in Germany, with regard to fodder quality.

For calves, a conversion factor of 0.02 MJ MJ^{-1} is used, on the basis of a national expert assessment (Flachowsky, Institut für Tierernährung (Institute for animal nutrition) of the former FAL, Braunschweig) oriented to the fact that calves become ruminants only gradually; cf. KIRCHGESSNER (2008), p. 430 ff, for example, and PENN STATE COLLEGE OF AGRICULTURAL SCIENCES (2011). Neither IPCC (1996b), which uses a figure of 0.06 MJ MJ^{-1}, nor IPCC (2006), which uses 0 MJ MJ^{-1} , takes account of calves' gradual development into ruminants.

For swine, the standard methane conversion factor pursuant to IPCC (1996b), Table A-4, is used: 0.006 MJ MJ^{-1}.

With regard to the calculated emission factors, cf. Chapter 6.2.2.2.

A more detailed description of calculation of CH_4 emissions from enteric fermentation is provided by RÖSEMANN et al. (2013).

6.2.2.2 Emission factors (4.A)

Table 177 shows CH_4 emission factors calculated for enteric fermentation in dairy cattle, other cattle and swine.

Table 177: CH_4 emission factors for animal husbandry (enteric fermentation) (4.A.1.a)

[kg $^{-1}$ place^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	119.9	120.3	122.1	123.3	123.5	124.0	125.0	125.3	126.3	127.0
Other cattle	44.3	44.2	45.2	45.6	45.1	45.5	45.5	45.5	45.8	46.5
Swine	1.08	1.10	1.11	1.12	1.13	1.14	1.15	1.15	1.16	1.15
[kg $^{-1}$ place^{-1} a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	127.9	129.1	129.3	129.9	130.0	130.7	131.1	131.7	131.0	131.5
Other cattle	46.4	46.7	46.1	46.0	45.9	45.9	46.0	46.0	45.7	45.9
Swine	1.16	1.17	1.18	1.17	1.18	1.17	1.18	1.19	1.18	1.19
[kg $^{-1}$ place^{-1} a^{-1}]	**2010**	**2011**								
Dairy cattle	132.2	132.7								
Other cattle	45.9	45.7								
Swine	1.18	1.17								

Table 178 shows, by way of example for 2011, the emission factors for the sub-categories for other cattle:

Table 178: CH_4 emission factors (enteric fermentation) for "other cattle", for 2011, in comparison with the default values for western Europe pursuant to IPCC (1996b)-4.11, Table 4-4 and IPCC (2006)-10.29, Table 10.11

	[kg place^{-1} a^{-1} CH_4]
Calves	4.3
Heifers	40.5
Male beef cattle	56.8
Suckler cows	76.1
Mature males > 2 years	85.3
Total for other cattle	**45.7**
IPCC (1996) default	48
IPCC (2006) default	57

Table 179 shows the emission factors used for sheep, goats, heavy horses, light horses and ponies, mules and asses and buffalo. For these animal categories, the default emission factors pursuant to IPCC (1996b)-4.10, Table 4-3, are used. Calculations for light horses and ponies were carried out with an emission factor that was estimated as follows: Pursuant to DLG (2005), p. 54, the average daily metabolisable-energy requirements for a light horse or pony amount to 57.5 MJ d^{-1}, or about 65% of those for a large horse (89 MJ d^{-1}). That percentage is also used for the relationship between the relevant emission factors.

Table 179: The emission factors (enteric fermentation) used in the inventory for sheep, goats, heavy horses, light horses and ponies, mules and asses and buffalo

Animal category	*EF* [kg place^{-1} a^{-1} CH_4]
Sheep	8
Goats	5
Heavy horses	18
Light horses, ponies	12
Mules and asses	10
Buffalo	55

6.2.2.3 Emissions (4.A)

The calculated CH_4 emissions from enteric fermentation, for all German animal husbandry, are listed in Table 180.

Table 180: CH_4 emissions E_{CH4} from animal husbandry (enteric fermentation) (4s1.A)

[Gg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CH4}	1,408	1,245	1,204	1,196	1,191	1,191	1,189	1,152	1,133	1,132
[Gg a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
E_{CH4}	1,103	1,113	1,070	1,052	1,023	1,015	991	990	1,009	1,009
[Gg a^{-1} CH_4]	2010	2011								
E_{CH4}	1,000	985								

As Table 181 shows, almost all CH_4 emissions from enteric fermentation in Germany result from keeping of cattle. In addition, dairy cattle are the most important source category within the "cattle" group. The emissions contributions from animals that are not listed are very low.

Table 181: CH_4 emissions from enteric fermentation (4.A.1.a)

[Gg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	762	678	655	654	651	649	649	630	610	605
Other cattle	582	508	490	483	482	485	481	464	463	471
Swine	29	24	25	25	24	23	24	24	26	26
Sheep	26	26	24	24	23	24	24	23	23	22
[Gg a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	584	587	572	568	557	554	535	536	552	553
Other cattle	462	469	440	427	409	404	399	396	400	401
Swine	25	26	26	26	26	27	26	27	27	27
Sheep	22	22	22	22	22	21	20	20	19	19
[Gg a^{-1} CH_4]	2010	2011								
Dairy cattle	553	556								
Other cattle	396	381								
Swine	26	27								
Sheep	17	13								

The emissions trend since 1990 basic reflects the combined effects of trends in numbers of animals (sharp reduction in 1990/1991, and continuous reduction since then, in numbers of cattle and sheep; for swine, a sharp reduction in 1990/1991, followed by further decreases until the mid-1990s, and, since then, a slightly increasing trend) and of continuous increases in yield (milk yield, animal weight, weight gain). For example, the continuous increases in milk yield seen since 2007 have resulted in a slight re-increase in total emissions from dairy cattle husbandry, even though the numbers of animals involved continue to decrease.

6.2.3 Uncertainties and time-series consistency (4.A)

With regard to the uncertainties in the area of methane emissions from enteric fermentation, the reader's attention is called to Table 176 in Chapter 6.1.5 (total uncertainty of the German GG inventory).

All emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and all data gaps have been filled in.

6.2.4 Source-specific quality assurance / control and verification (4.A)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Chapter 6.1.6 provides an overview of measures implemented relative to source-specific QA/QC and verification.

As part of verification, for 2010 the data for German dairy cattle husbandry were compared with IPCC default values and with relevant data of neighbouring countries, including data of the UK (Table 182 and Table 183). Among the ten countries being so compared, Germany has the second-highest implied emission factor (IEF) with respect to animal place. As expected, the comparison shows a good linear correlation between IEF and GE intake (R^2=0.93). The correlation between IEF and milk yield, which, along with the maintenance energy requirement, influences GE intake, is not as close (R^2=0.62). At the same time, the German IEF with respect to milk yield is higher than average – for example, it is considerably higher than the Belgian value, a value tied to a comparable milk yield. The IEF shows no clear correlation with animal weight. The IEF for Germany is comparable to that for Denmark, although the Danish value is tied to a considerably higher GE intake and a higher milk yield. The discrepancy between the German IEF and the IPCC default values can be explained as a result of higher energy intake, tied to higher weight and higher milk yield, and of the higher methane conversion factor used in the national method for calculation of CH_4 emissions from enteric fermentation. Overall, it is likely that there are still considerable differences, at the European level, in the way CH_4 emissions from enteric fermentation in dairy cattle are modelled.

Table 182: Methane emissions from enteric fermentation in dairy cattle, in various countries – a comparison of Implied Emission Factors (*IEF*) for 2010

	***IEF**$_{CH_4}$* [kg place^{-1} a^{-1} CH_4]	**GE intake** [MJ place^{-1} d^{-1}]	**Milk yield** kg place^{-1} d^{-1}	**Animal weight** [kg animal^{-1}]
Austria	115.97	294.7	16.71	700
Belgium	126.03	321.0	19.65	600
Czech Republic	114.26	290.3	18.91	590
Denmark	134.35	344.8	23.29	570
France	118.72	k. A.	17.62	k. A.
Germany	**132.19**	**314.3**	**19.41**	**647**
Netherlands	128.70	333.20	k. A.	k. A.
Poland	97.36	247.4	12.67	500
Switzerland	122.29	310.76	22.46	650
UK	111.45	283.2	20.04	k. A.
IPCC(1996)-3-4.11, 4.31, 4.39 (Western Europe)	100	254.7	11.5	550
IPCC (2000)-4.13-4.20		Equation 4.1-4.11		
IPCC(2006)-10.15-10.21, 10.29, 10.72	109	Equation 10.3-10.16	16.44 [a]	600

[1)] calculated on the basis of 6,000 kg place^{-1} a^{-1}

Source: Germany: Submission 2013; other countries: UNFCCC 2012; k.A.: no data (keine Angabe)

The German IEF for other cattle lies in the midrange of the IEF figures given in Table 183, which show considerable variation. The GE intake values also show considerable variation, although that variation is not always consistent with that for the IEF figures. For example, the German GE-intake figure lies in the lower range, although the corresponding IEF is in the midrange. With respect to IEF and GE intake as a pair, Germany is comparable to Belgium, while other countries, such as the UK and the Czech Republic, have considerably higher GE-intake figures but IEF that are not far from the German value. Like Germany, Switzerland and the Netherlands have comparatively low GE-intake figures, although for those two countries the low GE are reflected in IEF that are noticeably lower than Germany's. From these results, it is clear that there are still considerable differences, at the European level, in the way CH_4

emissions from enteric fermentation in other cattle, and for the pertinent sub-categories of such cattle, are modelled.

In the swine category (Table 183), some countries calculate with the default IEF of IPCC (1996b) (1.50 kg place^{-1} a^{-1} CH_4), which is noticeably higher than the values given by those countries that explicitly calculate the IEF. Presumably, the default IEF of IPCC (1996b & 2006) cannot figure in any adequate description of the central European situation for swine. The IEF minimum is reported by France, followed by Denmark. Since Denmark's GE value is very high at the same time, it may be assumed that Denmark uses a comparatively low methane conversion factor for enteric fermentation in swine.

In connection with the 2013 report, national experts proposed that the possibility of using alternative input data and calculation methods for CH_4 emissions from enteric fermentation in dairy cattle and other cattle be reviewed (Piatkowski und Jentsch, 2012). A review carried out by the Thünen Institute's working group (TI-AK) substantiated the applicability of the German methods currently being used (Haenel et al., 2012a).

Table 183: Methane emissions from enteric fermentation in other cattle and swine, in various countries – a comparison of Implied Emission Factors (*IEF*) for 2010

	Other cattle		Swine	
	IEF$_{CH_4}$ [kg place^{-1} a^{-1} CH_4]	**GE intake** [MJ place^{-1} d^{-1}]	***IEF***$_{CH_4}$ [kg place^{-1} a^{-1} CH_4]	**GE intake** [MJ place^{-1} d^{-1}]
Austria	56.21	142.83	1.50	38.00
Belgium	45.24	112.08	1.50	k. A.
Czech Republic	47.91	121.74	1.50	k. A.
Denmark	39.82	130.27	1.05	40.27
France	50.28	k. A.	0.87	k. A.
Germany	**45.85**	**109.36**	**1.18**	**30.00**
Netherlands	35.73 [a]	90.56 [a]	1.50	k. A.
Poland	49.21	125.05	1.50	k. A.
Switzerland	39.28 [a]	103.11 [a]	1.34	34.04
UK	43.25	128.45	1.50	k. A.
IPCC (1996)-3-4.10, 4.11, 4.39, 4.42 developed countries, Western Europe	48.00	135.10	1.50	38.00
IPCC (2000)-4.13-4.20		Equation 4.1-4.11		
IPCC (2006)-10.15-10.21, 10.28, 10.29, Western Europe	57.00	Equation 10.3-10.16	1.50	Equation 10.3-10.16

[1)] calculated from reported original data

Source: Germany: Submission 2013; other countries: UNFCCC 2012; k.A.: no data (keine Angabe)

In connection with the 2013 report, national experts proposed that the possibility of using experimental input data, and of calculation methods – derived from such data – for CH4 emissions from enteric fermentation in dairy cattle and other cattle be reviewed (PIATKOWSKI & JENTSCH, 2012). A review carried out by the Thünen Institute's working group (TI-AK) substantiated the applicability of the German methods currently being used (HAENEL et al., 2012a).

6.2.5 Source-specific recalculations (4.A)

In comparison to the NIR 2012, the following main changes have resulted (cf. Table 184 through Table 186):

- The differences in GE intake between the NIR 2012 and the NIR 2013 are the result of changes in the relevant yield data (cf. Chapter 6.1.3.3) and of allocation of cows for fattening and for slaughter to the "suckler cows" category instead of to the "heifers" category (cf. Chapter 6.1.3.1).
- The new national calculation method in the dairy-cow model (cf. Chapter 6.2.2.1) yields a methane conversion factor that is higher than the value used for the NIR 2012. In all fairness, however, it must be noted that the pertinent difference is greater for the (reported) year 1990 than for the (reported) year 2011.
- The new allocation of cows for fattening and for slaughter to suckler cows, instead of to heifers (cf. Chapter 6.1.3.1), slightly increases CH_4 emissions from enteric fermentation, since suckler cows have higher energy requirements than heifers do. The effect diminishes over the years covered, and it is small overall, since cows for fattening and for slaughter account for only about 1 % of the "other cattle" figures.
- As a result of the above-described changes, total methane emissions from enteric fermentation, in the German agricultural sector, have increased by about 3.6% for the reported year 2010, with respect to the NIR 2012. At the same time, such emissions for the year 1990 have increased by 10.8 %. As a result, the decreasing trend in total enteric-fermentation emissions from the German animal husbandry sector is more pronounced in the NIR 2013 than it was in the NIR 2012. And this is true even though the contribution from dairy cattle is noticeably higher than as was reported in the Submission 2012.

Table 184: Comparison of mean daily GE intake as reported in 2013 and as reported in 2012 (4.A)

[MJ/animal]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2013	259.9	261.9	271.0	276.0	275.7	278.6	282.3	284.2	288.6	291.9
Dairy cattle, 2012	257.1	262.0	271.0	276.1	275.7	278.7	282.4	284.2	288.6	291.8
Other cattle, 2013	105.8	104.7	107.8	108.7	107.6	108.4	108.5	108.4	109.1	110.7
Other cattle, 2012	102.4	103.8	107.2	108.0	106.8	107.6	108.2	107.9	108.3	109.2
Swine, 2013	27.4	27.9	28.3	28.4	28.7	28.9	29.2	29.2	29.6	29.3
Swine, 2012	27.4	27.9	28.3	28.4	28.7	28.9	29.2	29.2	29.6	29.3
[MJ/animal]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2013	295.9	301.2	302.7	306.1	306.9	310.4	312.0	315.0	311.1	314.3
Dairy cattle, 2012	295.9	301.1	302.7	306.0	306.8	310.4	312.0	315.0	311.2	314.4
Other cattle, 2013	110.5	111.2	109.8	109.7	109.3	109.4	109.7	109.7	109.1	109.4
Other cattle, 2012	109.5	109.8	108.9	108.8	108.4	108.4	109.0	109.5	108.8	109.0
Swine, 2013	29.4	29.8	29.9	29.7	30.0	29.8	30.0	30.1	30.1	30.1
Swine, 2012	29.4	29.8	29.9	29.7	30.0	29.8	30.0	30.1	30.1	30.2
[MJ/animal]	**2010**	**2011**								
Dairy cattle, 2013	317.7	320.5								
Dairy cattle, 2012	315.3									
Other cattle, 2013	109.4	109.0								
Other cattle, 2012	109.2									
Swine, 2013	30.0	29.7								
Swine, 2012	30.1									

Table 185: Comparison of implied CH_4 emission factors (enteric fermentation) as reported in 2013 and in 2012 (4.A)

[kg place^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2013	119.9	120.3	122.1	123.3	123.5	124.0	125.0	125.3	126.3	127.0
Dairy cattle, 2012	101.2	103.6	106.7	108.6	108.5	109.7	111.1	111.8	113.6	114.8
Other cattle, 2013	44.3	44.2	45.2	45.6	45.1	45.5	45.5	45.5	45.8	46.5
Other cattle, 2012	42.9	43.8	45.0	45.3	44.8	45.1	45.4	45.3	45.5	45.8
Swine, 2013	1.08	1.10	1.11	1.12	1.13	1.14	1.15	1.15	1.16	1.15
Swine, 2012	1.08	1.10	1.11	1.12	1.13	1.14	1.15	1.15	1.16	1.15

[kg place^{-1} a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle, 2013	127.9	129.1	129.3	129.9	130.0	130.7	131.1	131.7	131.0	131.5
Dairy cattle, 2012	116.4	118.5	119.1	120.4	120.8	122.2	122.8	124.0	122.5	123.7
Other cattle, 2013	46.4	46.7	46.1	46.0	45.9	45.9	46.0	46.0	45.7	45.9
Other cattle, 2012	46.0	46.1	45.7	45.6	45.5	45.5	45.7	46.0	45.6	45.7
Swine, 2013	1.16	1.17	1.18	1.17	1.18	1.17	1.18	1.19	1.18	1.19
Swine, 2012	1.16	1.17	1.18	1.17	1.18	1.17	1.18	1.19	1.18	1.19

[kg place^{-1} a^{-1}]	2010	2011
Dairy cattle, 2013	132.2	132.7
Dairy cattle, 2012	124.1	
Other cattle, 2013	45.9	45.7
Other cattle, 2012	45.8	
Swine, 2013	1.18	1.17
Swine, 2012	1.18	

Table 186: Comparison of CH_4 emissions (enteric fermentation) as reported in 2013 and in 2012 (4.A)

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	**1408**	**1245**	**1204**	**1196**	**1191**	**1191**	**1189**	**1152**	**1133**	**1132**
Total, 2012	**1270**	**1147**	**1118**	**1115**	**1108**	**1113**	**1115**	**1082**	**1067**	**1067**
Dairy cattle, 2013	762	678	655	654	651	649	649	630	610	605
Dairy cattle, 2012	643	584	572	576	572	574	577	562	549	547
Other cattle, 2013	582	508	490	483	482	485	481	464	463	471
Other cattle, 2012	564	504	487	480	479	481	479	462	460	464
Swine, 2013	28.6	24.5	25.2	24.9	23.9	23.2	23.9	24.4	26.2	25.5
Swine, 2012	28.6	24.5	25.2	24.9	23.9	23.2	23.9	24.4	26.2	25.5
Other animals, 2013	34.7	34.9	33.3	33.8	33.5	34.8	35.0	33.6	32.6	30.6
Other animals, 2012	34.7	34.9	33.3	33.8	33.5	34.8	35.0	33.6	32.6	30.6
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	**1103**	**1113**	**1070**	**1052**	**1023**	**1015**	**991**	**990**	**1009**	**1009**
Total, 2012	**1046**	**1059**	**1021**	**1007**	**980**	**975**	**954**	**958**	**972**	**975**
Dairy cattle, 2013	584	587	572	568	557	554	535	536	552	553
Dairy cattle, 2012	532	539	527	526	518	518	501	505	517	520
Other cattle, 2013	462	469	440	427	409	404	399	396	400	401
Other cattle, 2012	458	463	437	423	405	400	396	396	399	400
Swine, 2013	25.2	25.5	26.0	26.1	25.7	26.7	26.5	27.3	26.8	27.3
Swine, 2012	25.2	25.5	26.0	26.1	25.7	26.7	26.5	27.2	27.0	27.0
Other animals, 2013	31.0	31.5	31.3	31.3	31.2	30.5	30.2	30.4	29.2	28.2
Other animals, 2012	31.0	31.5	31.3	31.3	31.2	30.5	30.2	30.4	29.2	28.2
[Gg a^{-1}]	**2010**	**2011**								
Total, 2013	**1000**	**985**								
Total, 2012	**966**									
Dairy cattle, 2013	553	556								
Dairy cattle, 2012	519									
Other cattle, 2013	396	381								
Other cattle, 2012	395									
Swine, 2013	26.3	26.6								
Swine, 2012	26.0									
Other animals, 2013	25.4	21.9								
Other animals, 2012	25.4									

6.2.6 Planned improvements (4.A)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

6.3 Manure management (4.B)

6.3.1 Source category description (4.B)

CRF 4.B	Natural gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Dairy cattle (CRF 4.A.1)	**CH_4**	**-**	**-/T2**	**2,320.1**	**(0.18%)**	**1771.9**	**(0.19%)**	**-20.54%**
Non-dairy cattle (CRF 4.A.1)	CH_4	-	-	2,285.5	(0.19%)	1,452.3	(0.16%)	-36.45%
Dairy cattle (CRF 4.B.1)	N_2O	-	-	1,621.3	(0.13%)	967.9	(0.10%)	-40.30%
Non-dairy cattle (CRF 4.B.1)	**N_2O**	**-**	**-/T2**	**1,455.1**	**(0.12%)**	**1,099.7**	**(0.12%)**	**-24.42%**
Other animals (buffalo, sheep, goats, horses, poultry, mules & asses) (CRF 4.B.2-7;9)	CH_4	-	-	119.1	(0.01%)	135.7	(0.01%)	13.96%
Other animals (buffalo, sheep, goats, horses, mules & asses) (CRF 4.B.2-7)	N_2O	-	-	234.3	(0.02%)	192.3	(0.02%)	-17.91%
Swine (CRF 4.B.8)	**CH_4**	**-**	**-/T2**	**2,063.4**	**(0.17%)**	**1,622.9**	**(0.18%)**	**-21.35%**
Swine (CRF 4.B.8)	N_2O	-	-	570.4	(0.05%)	502.6	(0.05%)	-11.88%
Poultry (CRF 4.B.9)	N_2O	-	-	37.6	(0.00%)	49.8	(0.01%)	32.44%

Gas	Method used	Source for the activity data	Emission factors used
CH_4	D/Tier 1/Tier 2	M/Q/AS/RS/NS	CS/D
N_2O	CS/Tier 1	M/Q/AS/RS/NS	CS
NO_X			CS

The source category *Manure management* is a key category, pursuant to Tier 2 analysis, for CH_4 and N_2O emissions from dairy cattle and for CH_4 emissions (only) from swine.

In sector 4.B, Germany reports on CH_4, N_2O and NO from manure management.

The greenhouse-gas emissions involved in the area of manure management include CH_4 and N_2O from storage of manure in stables and in storage facilities. CH_4 occurs when methanogenic bacteria break down organic substances in anaerobic environments. N_2O occurs in nitrification and denitrification processes during manure storage.

NO from manure management occurs via nitrification in surface layers of manure storage facilities.

Calculations of CH_4, N_2O and NO emissions from manure management must take account of a range of factors, including animal category; animal excretions (which, in turn, are a function of animal performance and of diet); the amounts of time spent by relevant animals in various defined areas (pastures, stables); the types of stables used; nitrogen inputs from straw used for bedding; and the type of manure storage involved.

In keeping with the IPCC Guidelines, VS contributions from bedding material are not taken into account. This does not result in underestimation of emissions, since the more VS are brought into a solid-manure system, via bedding material, the drier the system will be and thus the lower its CH_4 emissions will be.

Anaerobic digestion of slurry in biogas plants has been taken into account, for the first time, for CH_4, N_2O, NO and NH_3.

In 2011, a total of 19.4 % (1990: 18.5 %) of total CH_4 emissions from German agriculture were CH_4 emissions from manure management. From 1990 to 2011, such manure-management emissions decreased by about 25.6 %. That reduction is due largely to a decrease in animal populations in the period 1990 to 1992, as a result of German reunification. Emissions reductions as a result of slurry digestion are another reason. The reductions are somewhat offset by increases in VS excretions as a result of increases in yields per individual animal.

In 2011, manure management accounted for a 6.3 % share of total N_2O emissions from German agriculture. The corresponding share for 1990 was 7.6 %. From 1990 to 2011, N_2O emissions from manure management decreased by 28.2 %. As with the decrease in CH_4 emissions, that effect was due largely to a reduction in animal populations and to emissions savings via slurry digestion. It was partly offset by an increase in use of storage systems with higher emissions. Another offsetting effect consists of increases in animal performance (in this context, because of the related increases in N excretions).

6.3.2 Methane emissions from manure management (4.B, CH_4)

6.3.2.1 Source category description (4.B, CH_4)

Cf. Chapter 6.3.1.

6.3.2.2 Methodological issues (4.B, CH_4)

6.3.2.2.1 Methods (4.B, CH_4)

For all animal categories except for geese, CH_4 emissions are calculated in accordance with the Tier-2 method:

Equation 10: Calculation of total CH_4 emissions from manure management

$$E_{\mathrm{CH4,MM}} = \sum_{\mathrm{i,\,j,\,k}} n_{\mathrm{i}} \cdot EF_{\mathrm{i,\,j,\,k}} = \sum_{\mathrm{i,\,j,\,k}} n_{\mathrm{i}} \cdot \alpha \cdot \rho_{\mathrm{CH4}} \cdot VS_{\mathrm{i}} \cdot B_{\mathrm{o,i}} \cdot MS_{\mathrm{i,\,j}} \cdot MCF_{\mathrm{i,\,j,\,k}}$$

$E_{\mathrm{CH4,\,MM}}$	Total methane emissions from manure management (in kg a^{-1} CH_4)
n_{i}	Number of animal places in animal category i (in places)
$EF_{\mathrm{i,\,j,\,k}}$	Methane emission factor for animal category i in manure management system j and climate region k (in kg $place^{-1}$ a^{-1} CH_4)
α	Factor for conversion of time units (α = 365 d a^{-1})
ρ_{CH4}	Density of methane (ρ_{CH4} = 0.67 kg m^{-3})
VS_{i}	VS excretions for animal category i (in kg $place^{-1}$ d^{-1}); see chapter
$B_{\mathrm{o,\,i}}$	Maximum methane-producing capacity for animal category i (in m^3 kg^{-1} CH_4)
$MS_{\mathrm{i,\,j}}$	Relative proportion of housing places, for animal category i, whose excrement occurs in manure management system j (in place $place^{-1}$)
$MCF_{\mathrm{i,\,j,\,k}}$	Methane conversion factor for manure management system j and climate region k (in m^3 m^{-3}) [71]

With regard to the number of animal places n_{i}, the reader's attention is called to Chapter 6.1.3.2.3. The VS excretions are described in Chapter 6.1.3.5. With regard to the frequencies of systems for storage of solid manure and slurry, and to time allotted to grazing, cf. Chapters

[71] IPCC gives *MCF* in percent (of B_o), which is why the units m^3 m^{-3} are used in the German inventory.

6.1.3.6.1 and 19.4.1. The methane-formation rate B_o and the methane conversion factors *MCF* are discussed in Chapters 6.1.3.6.3 and 6.1.3.6.4.

For geese, the Tier-1 method is used, which calculates CH_4 emissions from manure management with the help of a common standard value for the emission factor $EF_{i, j, k}$. Since no such value is known for geese, the poultry emission factor pursuant to IPCC (1996b), Table B-7, is used: 0.78 kg place^{-1} a^{-1} CH_4.

6.3.2.2.2 Emission factors (4.B, CH_4)

Table 187 shows the mean emission factors for CH_4 emissions from manure management, for the relevant animal categories dairy cattle, other cattle and swine, and with respect to animal place. The emissions-reduction effect achieved via slurry digestion is included in the emission factors for dairy cattle and swine.

Table 187: CH_4 emission factors (IEF) for manure management (4.B(a)s1)

[kg place^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	16.7	17.2	17.6	17.7	21.3	21.4	21.6	21.7	22.3	22.4
Other cattle	8.3	8.4	8.7	8.7	8.4	8.4	8.3	8.3	8.4	8.5
Swine	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.1	4.2	4.1
[kg place^{-1} a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	22.6	23.0	23.2	23.4	23.5	23.3	22.9	22.4	22.0	21.5
Other cattle	8.5	8.6	8.4	8.6	8.5	8.5	8.5	8.5	8.4	8.4
Swine	4.1	4.1	4.1	4.1	4.1	4.0	3.9	3.8	3.7	3.7
[kg place^{-1} a^{-1}]	**2010**	**2011**								
Dairy cattle	21.0	20.1								
Other cattle	8.3	8.3								
Swine	3.5	3.4								

6.3.2.2.3 Emissions (4.B, CH_4)

Table 188 presents the time series for calculated total CH_4 emissions from manure management.

Table 188: Total CH_4 emissions from manure management (4s1)

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	318.96	283.24	280.66	278.25	291.92	289.34	291.04	285.85	291.60	290.20
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	283.35	287.11	280.29	279.34	271.42	269.80	261.21	259.00	257.77	254.64
[Gg a^{-1}]	**2010**	**2011**								
	244.18	237.28								

Table 188 shows an emissions decrease of about 40 Gg a^{-1} between 1990 and 1993, followed by relatively constant values until the 2001-2011 period, in which emissions decrease further by about 50 Gg a^{-1}. The decrease seen at the beginning of the 1990s is due to decreases in animal populations as a result of German reunification. It is also partly the result of the emissions reductions achieved via slurry digestion, which has a noticeable pertinent effect as of 2001. The reductions are somewhat offset by increases in VS excretions as a result of increases in animal performance.

All in all, emissions decreased by 25.6 % between 1990 and 2011.

As a comparison of Table 188 and Table 189 shows, nearly two-thirds of total emissions occur in cattle husbandry, while swine husbandry contributes about one-third of all emissions. The small remainder is divided up among the other animal categories.

Table 189: CH_4 emissions from manure management for dairy cattle, other cattle and swine (4.s1.)

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	106.2	96.8	94.3	94.1	112.2	112.0	112.3	108.9	107.6	106.9
Other cattle	108.8	96.9	94.3	92.5	89.6	89.4	88.0	84.8	84.4	86.3
Swine	98.3	83.9	86.6	86.2	84.5	82.2	84.9	86.5	93.9	91.5
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	103.3	104.7	102.5	102.3	100.5	98.5	93.4	91.4	92.9	90.6
Other cattle	84.8	86.1	80.6	79.6	75.7	74.8	73.5	73.0	73.4	73.3
Swine	89.5	90.3	91.3	91.3	88.9	90.3	87.9	88.1	85.0	84.3
[Gg a^{-1}]	**2010**	**2011**								
Dairy cattle	87.7	84.4								
Other cattle	71.9	69.2								
Swine	78.1	77.3								

Table 190 shows the CH_4-emissions reductions achieved via slurry digestion, as calculated for Germany with the GAS-EM inventory model. It also shows the reduction effects resulting for Germany by comparison to the emissions that would apply in a scenario with no slurry digestion.

Table 190: CH_4-emissions reductions in Germany via slurry digestion, and the percentage effects of such reductions with respect to the total CH_4 emissions from manure management, for all farm animals considered in the inventory, that would apply in a scenario with no slurry digestion

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
From cattle slurry	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.4
From swine slurry	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3
Total	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	11.0	0.5
Total, in %	**0.00**	**0.01**	**0.01**	**0.01**	**0.02**	**0.04**	**0.06**	**0.08**	**0.17**	**0.21**
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
From cattle slurry	0.6	0.9	1.3	1.5	2.0	4.2	6.4	9.6	11.6	14.7
From swine slurry	0.4	0.6	0.9	1.0	1.3	3.1	4.3	6.4	7.7	9.6
Total	1.0	1.5	2.1	2.5	3.3	7.3	10.8	16.0	19.2	24.3
Total, in %	**0.35**	**0.50**	**0.75**	**0.89**	**1.2**	**2.6**	**4.0**	**5.8**	**6.9**	**8.7**
[Gg a^{-1}]	**2010**	**2011**								
From cattle slurry	18.4	22.5								
From swine slurry	11.7	13.7								
Total	30.1	36.2								
Total, in %	**11.0**	**13.2**								

6.3.2.3 Uncertainties and time-series consistency (4.B, CH_4)

With regard to the uncertainties in the area of methane emissions from manure management, the reader's attention is called to Table 176 in Chapter 6.1.5 (total uncertainty of the German GG inventory).

All emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and all data gaps have been filled in.

6.3.2.4 Source-specific quality assurance / control and verification (4.B, CH_4)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Chapter 6.1.6 provides an overview of measures implemented relative to source-specific QA/QC and verification.

In the framework of verification, the results obtained for 2010 were compared with the 2010 values of neighbouring countries and of the UK (Submission 2012 for 2010, UNFCCC 2012).

Germany's CH_4-IEF for management of dairy cattle manure falls into the lower section of the overall range. In addition, its VS-excretions figure is at the lower end of the overall range (and is comparable to that of Belgium). France, the Netherlands, Denmark, the UK and Switzerland have higher CH_4-IEFs, while the Czech Republic, Poland and Austria have figures that are considerably lower than Germany's. That said, it must be noted that the CH_4-IEF values of the various European countries are only conditionally comparable, since they have been obtained from very different data for VS excretions, choices of slurry systems and methane conversion factors MCF. Significantly, the reason the German IEF is so low is that all cattle slurry digested in Germany has been categorised as slurry from dairy cattle, with the result that the CH_4 reductions achieved via slurry digestion have been allotted solely to the dairy cattle category.

In the "other cattle" category (cf. Table 192), Germany's emission factors lie within the middle of the range covered by the values for neighbouring countries.

In the "swine" category (cf. Table 193), Germany's IEF's fall into the lower part of the range, although it must be noted that those countries that calculate VS excretions (such as Germany) obtain excretion levels that are considerably below the pertinent default value of the IPCC (1996b). Such low-tending excretion figures correlate with the relevant IEF values.

The high emission factors France obtains for all animal categories are the result of simultaneously high VS excretions and *MCF* values; the effects of that combination are not offset by the somewhat lower use of slurry systems seen in France.

In the poultry category (cf. Table 194), the German IEF value is similar in level to the corresponding results for Belgium, Denmark and the Netherlands. The value obtained is considerably lower than the IEF default value in IPCC (1996b); the default value in IPCC (2006) provides a better description of the situation prevailing in central Europe. For nearly all poultry categories, the German VS-excretions figures are calculated on the basis of national input data. The mean VS value derived from those calculated figures for poultry is at the lower end of the default-value range in IPCC (2006) and, thus, is considerably lower than the IPCC-1996 default value for VS.

Table 191: CH_4 emissions from storage of manure from dairy cattle, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters for 2010

	***IEF*$_{CH4}$** [kg place^{-1} a^{-1} CH_4]	**VS excretions** [kg place^{-1} d^{-1}]	**Use of liquid-manure systems** [%]	**Mean *MCF* for liquid-manure systems** [%]
Austria	9.00	4.25	31.95	8.71
Belgium	16.66	3.96	11.67	19.00
Czech Republic	14.00	k. A.	27.00	k. A.
Denmark	33.23	6.23	87.43	0.10
France [a]	43.15	5.10	25.66	45.00
Germany	**20.98**	**3.99**	**73.57**	**14.35**
Netherlands	42.58	4.56	90.38	17.00
Poland	13.76	4.59	10.79	39.00
Switzerland	25.84	6.20	67.80	10.00
UK	26.88	0.01	30.60	39.00
IPCC (1996)-3-4.13, 4.43, Western Europe, cool region	14	5.1	40	10
IPCC(2000)-4.36				39.00
IPCC (2006)-10.38, 10.77, Western Europe, cool region	21 through 23 [b]	5.1	35.7	17 through 19 [b]

[a] France: Only temperate zone; frequency of slurry systems calculated from original data

[b] Range for the systems and/or temperatures occurring in Germany

Source: Germany: Submission 2013; other countries: UNFCCC 2012; k.A.: no data (keine Angabe)

Table 192: CH_4 emissions from storage of manure from other cattle, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters for the year 2010

	***IEF*$_{CH4}$** [kg place^{-1} a^{-1} CH_4]	**VS excretions** [kg place^{-1} d^{-1}]	**Use of liquid-manure systems** [%]	**Mean *MCF* for liquid-manure systems** [%]
Austria	4.13	1.95	22.90	8.44
Belgium	2.61	1.35	4.01	19.00
Czech Republic	6.00	k. A.	52.00	k. A.
Denmark	9.49	2.76	29.95	0.10
France [a]	14.64	2.70	24.79	45.00
Germany	**8.33**	**1.47**	**42.46**	**13.63**
Netherlands	7.49 [b]	1.15 [b]	74.57 [b]	15.97 [b]
Poland	2.56	2.17	48.35	39.00
Switzerland	5.09 [b]	2.03 [b]	46.75 [b]	10.00 [b]
UK	4.15	0.01	6.00	39.00
IPCC (1996)-3-4.13, 4.43, Western Europe, cool region	6	2.7	50	10
IPCC(2000)-4.36				39.00
IPCC (2006)-10.38, 10.77, Western Europe, cool region	6 through 7 [c]	2.6	25.2	17 through 19 [c]

[a] France: Only temperate zone; frequency of slurry systems calculated from original data

[b] Range for the systems and/or temperatures occurring in Germany

Source: Germany: Submission 2013; other countries: UNFCCC 2012; k.A.: no data (keine Angabe)

Table 193: CH_4 emissions from storage of manure from swine, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters for the year 2010

	IEF$_{CH4}$ [kg place^{-1} a^{-1} CH_4]	VS excretions [kg place^{-1} d^{-1}]	Use of liquid-manure systems [%]	Mean *MCF* for liquid-manure systems [%]
Austria	1.18	0.27	80.58	3.39
Belgium	9.69	0.49	6.20	19.00
Czech Republic	3.00	k. A.	76.00	k. A.
Denmark	2.20	0.20	96.64	0.10
France [a]	15.17	0.50	92.99	45.00
Germany	**3.51**	**0.26**	**91.91**	**21.65**
Netherlands	4.13	0.22	100.00	0.39
Poland	5.97	0.50	2.59	39.00
Switzerland	5.43	0.50	98.61	10.00
UK	5.50	0.50	24.27	k. A.
IPCC (1996)-3-4.13, 4.42, 4.46, Western Europe, cool region	3	0.5	“pit>1month”:73%	10
IPCC(2000)-4.36				39.00
IPCC (2006)-10.80, 10.81, Western Europe, cool region	Sows, boars: 9 through 10 [b] Other: 6	Sows, boars: 0.46 Other: 0.30	“pit>1month”: 70%	17 through 19 [b]

[a] France: Only temperate zone; frequency of slurry systems calculated from original data

[b] Range for the systems and/or temperatures occurring in Germany

Source: Germany: Submission 2013; other countries: UNFCCC 2012; k.A.: no data (keine Angabe)

Table 194: CH_4 emissions from storage of manure from poultry, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters for the year 2010

	IEF$_{CH4}$ [kg place^{-1} a^{-1} CH_4]	VS excretions [kg place^{-1}d^{-1}]	Mean animal weight [kg animal^{-1}]
Austria	0.07	0.10	1.10
Belgium	0.04	0.03	1.59
Czech Republic	0.08	k. A.	k. A.
Denmark	0.03	0.00	2.00
France	0.12	0.10	k. A.
Germany	**0.04**	**0.026** [a]	**1.96**
Netherlands	0.03	0.02	k. A.
Poland	0.08	0.10	1.10
Switzerland	0.12	0.10	k. A.
UK	0.08	0.10	k. A.
IPCC (1996)-3-4.47, cool region, developed countries	0.078	0.10	1.10
IPCC(2000)-4.36			
IPCC (2006)-10.82, We. Eur., cool reg., dev. countries	0.02 to 0.09	0.01 to 0.07	0.9 to 6.8

[a] without geese

Source: Germany: Submission 2013; other countries: UNFCCC 2012; k.A.: no data (keine Angabe)

6.3.2.5 Source-specific recalculations (4.B, CH_4)

Table 195 through Table 197 show the changes resulting for the time series for the relative shares of the three key categories of housing systems, in comparison to the corresponding figures reported in the NIR 2012. As called for in reporting in the CRF tables, the percentage figures refer to amounts of N excreted.

For the "dairy cattle" category, the percentage shares of the various housing systems changed only slightly from the NIR 2012 to the NIR 2013, with the only change affecting the year 1990. The relevant transfer between housing systems resulted from correction of errors in animal weights, for a number of German Länder (states) (cf. Chapter 6.1.3.3). That correction led to a change in energy requirements – and, thus, to changes in N intake via feed and in N excretions. As a result of these changes in the N excretions, and in the relative frequencies of the various housing systems in the relevant German Länder (states) (which deviate from the national averages), the nationally averaged relative frequencies of the various housing systems, with respect to N excretions, also changed.

For the "other cattle" category, the changes are to due to the change, in the transition from the NIR 2012 to the NIR 2013, in the allocation of cows for fattening and for slaughter; cf. Chapter 6.1.3.1 (in the NIR 2012, those cows were allocated to the "heifers" category; in the NIR 2013, they were added to "suckler cows"). The relative frequencies of the various housing systems for the "heifers" category differ from those for the "suckler cows" category. As a result, the two categories also differ in terms of their N-excretions levels.

Table 195: Comparison of the relative shares of slurry-based systems, as reported in the NIR 2013 and the NIR 2012, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2013	54.9	55.3	55.4	55.2	70.8	70.8	70.9	70.9	72.3	72.4
Dairy cattle, 2012	55.0	55.3	55.4	55.2	70.8	70.8	70.9	70.9	72.3	72.4
Other cattle, 2013	58.2	59.1	58.2	57.4	56.7	55.5	55.1	54.5	54.2	54.0
Other cattle, 2012	60.3	60.3	59.2	58.3	57.5	56.5	55.9	55.3	55.2	54.6
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2013	72.5	72.7	72.9	73.0	73.1	73.2	73.3	73.5	73.5	73.5
Dairy cattle, 2012	72.5	72.7	72.9	73.0	73.1	73.2	73.3	73.5	73.5	73.5
Other cattle, 2013	52.4	51.6	50.8	49.9	48.6	47.7	46.7	45.7	44.5	43.5
Other cattle, 2012	53.3	52.6	51.6	50.6	49.3	48.3	47.3	46.2	45.0	43.9
[%]	**2010**	**2011**								
Dairy cattle, 2013	73.6	73.5								
Dairy cattle, 2012	73.6									
Other cattle, 2013	42.5	42.5								
Other cattle, 2012	42.8									

Table 196: Comparison of the relative shares of straw-based systems, as reported in the NIR 2013 and the NIR 2012, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2013	26.9	26.2	26.2	26.4	15.5	15.5	15.4	15.4	14.4	14.3
Dairy cattle, 2012	26.7	26.2	26.2	26.4	15.5	15.5	15.4	15.4	14.4	14.3
Other cattle, 2013	26.3	25.3	25.6	26.1	26.6	27.1	27.2	27.5	27.4	27.5
Other cattle, 2012	25.1	24.7	25.1	25.6	26.1	26.5	26.7	27.0	26.8	27.2
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2013	14.6	14.7	14.9	15.0	15.2	15.4	15.6	15.7	15.8	15.9
Dairy cattle, 2012	14.6	14.7	14.9	15.0	15.2	15.4	15.6	15.7	15.8	15.9
Other cattle, 2013	28.8	29.7	30.6	31.6	32.5	33.4	34.3	35.2	36.3	37.3
Other cattle, 2012	28.3	29.1	30.1	31.1	32.1	33.1	34.0	35.0	36.2	37.2
[%]	**2010**	**2011**								
Dairy cattle, 2013	16.0	15.9								
Dairy cattle, 2012	16.0									
Other cattle, 2013	38.3	38.3								
Other cattle, 2012	38.1									

Table 197: Comparison of the relative shares for grazing, as reported in the NIR 2013 and the NIR 2012, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2013	18.3	18.5	18.4	18.5	13.8	13.8	13.8	13.8	13.5	13.4
Dairy cattle, 2012	18.4	18.5	18.4	18.5	13.8	13.8	13.8	13.8	13.5	13.5
Other cattle, 2013	15.5	15.5	16.1	16.5	16.8	17.4	17.7	18.0	18.5	18.5
Other cattle, 2012	14.6	15.0	15.7	16.1	16.4	17.0	17.4	17.7	18.1	18.2
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2013	13.0	12.7	12.3	12.1	11.8	11.5	11.2	10.9	10.7	10.6
Dairy cattle, 2012	13.0	12.7	12.3	12.1	11.8	11.5	11.2	10.9	10.7	10.6
Other cattle, 2013	18.8	18.7	18.7	18.6	18.9	18.9	19.0	19.1	19.1	19.2
Other cattle, 2012	18.4	18.3	18.3	18.3	18.6	18.6	18.6	18.8	18.9	18.9
[%]	**2010**	**2011**								
Dairy cattle, 2013	10.4	10.5								
Dairy cattle, 2012	10.4									
Other cattle, 2013	19.3	19.2								
Other cattle, 2012	19.0									

For dairy cattle, other cattle and swine, the NIR 2012 and the NIR 2013 differ with regard to VS excretions; cf. Table 198. In the "dairy cattle" category, the differences occur only with regard to the years 1990 and 2010. In both cases, the differences are due to updating of yield data (cf. Chapter 6.1.3.3: Corrections in animal weights for 1990 in several German Länder (states); updating of milk yields for 2010). With regard to other cattle, the changes are due to changes in allocation of cows for fattening and for slaughter (NIR 2012: with heifers; NIR 2013: with suckler cows; heifers and suckler cows have different VS excretions – cf. Chapter 6.1.3.1). With regard to swine, the changes are due to updating of the time series for the category "suckling piglets per sow" and of the time series for animal weights and growth rates for fattening pigs (cf. Chapter 6.1.3.3). In Table 198, these updates for the "swine" category are seen only in the year 2010, and only in two decimal places (since only two significant decimal places are shown).

Table 198: Comparison of daily VS excretions as reported in the NIR 2013 and as reported in the NIR 2012 (4.B)

[kg place^{-1} d^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2013	3.48	3.49	3.58	3.63	3.63	3.65	3.69	3.70	3.75	3.77
Dairy cattle, 2012	3.45	3.49	3.58	3.63	3.63	3.65	3.69	3.70	3.75	3.77
Other cattle, 2013	1.43	1.41	1.45	1.47	1.45	1.46	1.46	1.46	1.47	1.50
Other cattle, 2012	1.38	1.40	1.45	1.46	1.44	1.45	1.46	1.46	1.46	1.48
Swine, 2013	0.24	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.26	0.26
Swine, 2012	0.24	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.26	0.26
[kg place^{-1} d^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2013	3.81	3.86	3.87	3.90	3.90	3.93	3.94	3.97	3.94	3.96
Dairy cattle, 2012	3.81	3.86	3.87	3.90	3.90	3.93	3.94	3.97	3.94	3.96
Other cattle, 2013	1.50	1.51	1.48	1.48	1.47	1.47	1.47	1.47	1.46	1.47
Other cattle, 2012	1.48	1.49	1.47	1.47	1.46	1.46	1.47	1.47	1.46	1.46
Swine, 2013	0.26	0.26	0.27	0.26	0.27	0.26	0.27	0.27	0.27	0.27
Swine, 2012	0.26	0.26	0.27	0.26	0.27	0.26	0.27	0.27	0.27	0.27
[kg place^{-1} d^{-1}]	**2010**	**2011**								
Dairy cattle, 2013	3.99	4.01								
Dairy cattle, 2012	3.97									
Other cattle, 2013	1.47	1.46								
Other cattle, 2012	1.47									
Swine, 2013	0.26	0.26								
Swine, 2012	0.27									

Table 199 and Table 200 show, for the important animal categories dairy cattle, other cattle and swine, comparisons of implied emission factors (IEF) and CH_4 emissions as reported in the NIR 2012 and as reported in the current NIR 2013. The emission factors and emissions for dairy cattle husbandry are lower than they were in the NIR 2012. The opposite effect is seen in the "other cattle" category. In the "swine" category, the IEF and the emissions are lower than the values reported in the NIR 2012. These changes result partly from updating (as mentioned in connection with the above tables) of activity data and from changes in pertinent models (or the consequences of such changes – in VS excretions, for example). In the main, however, they are caused by changes, with respect to the NIR 2012, in values for animal-specific methane-producing capacity B_o and the storage-specific methane conversion factor *MCF* (cf. Chapters 6.1.3.6.3 and 6.1.3.6.4) and – in the case of dairy cattle and swine – by the inclusion, as described in Chapter 6.1.3.6.5, of slurry digestion.

Table 199: Comparison of mean CH_4 implied emission factors (IEF), as reported in the NIR 2013 and as reported in the NIR 2012, for manure management (4.B(a)s1)

[kg place^{-1} a^{-1}]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Dairy cattle, 2013	16.7	17.2	17.6	17.7	21.3	21.4	21.6	21.7	22.3	22.4
Dairy cattle, 2012	17.4	18.0	18.4	18.6	22.3	22.4	22.7	22.7	23.4	23.6
Other cattle, 2013	8.3	8.4	8.7	8.7	8.4	8.4	8.3	8.3	8.4	8.5
Other cattle, 2012	6.4	6.6	6.8	6.8	6.6	6.6	6.5	6.5	6.5	6.6
Swine, 2013	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.1	4.2	4.1
Swine, 2012	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.2	4.3	4.3
[kg place^{-1} a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2013	22.6	23.0	23.2	23.4	23.5	23.3	22.9	22.4	22.0	21.5
Dairy cattle, 2012	23.8	24.3	24.6	24.9	25.1	25.4	25.6	26.0	25.9	26.2
Other cattle, 2013	8.5	8.6	8.4	8.6	8.5	8.5	8.5	8.5	8.4	8.4
Other cattle, 2012	6.6	6.7	6.6	6.7	6.6	6.6	6.6	6.7	6.6	6.6
Swine, 2013	4.1	4.1	4.1	4.1	4.1	4.0	3.9	3.8	3.7	3.7
Swine, 2012	4.2	4.3	4.3	4.2	4.2	4.2	4.2	4.2	4.2	4.2
[kg place^{-1} a^{-1}]	**2010**	**2011**								
Dairy cattle, 2013	21.0	20.1								
Dairy cattle, 2012	26.4									
Other cattle, 2013	8.3	8.3								
Other cattle, 2012	6.5									
Swine, 2013	3.5	3.4								
Swine, 2012	4.1									

Table 200: Comparison of CH_4 emissions, as reported in the NIR 2013 and as reported in the NIR 2012, for manure management for dairy cattle, other cattle and swine (4.B)

[Gg a^{-1} CH_4]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Total, 2013	319.0	283.2	280.7	278.3	291.9	289.3	291.0	285.9	291.6	290.2
Total, 2012	301.2	269.0	267.2	265.1	280.0	277.5	279.8	275.1	281.3	278.9
Dairy cattle, 2013	106.2	96.8	94.3	94.1	112.2	112.0	112.3	108.9	107.6	106.9
Dairy cattle, 2012	110.5	101.5	98.9	98.6	117.5	117.4	117.8	114.3	113.0	112.4
Other cattle, 2013	108.8	96.9	94.3	92.5	89.6	89.4	88.0	84.8	84.4	86.3
Other cattle, 2012	84.2	75.7	73.9	72.5	70.1	69.9	69.1	66.4	66.0	66.9
Swine, 2013	98.3	83.9	86.6	86.2	84.5	82.2	84.9	86.5	93.9	91.5
Swine, 2012	100.9	86.2	89.0	88.5	86.7	84.4	87.1	88.8	96.7	94.1
[Gg a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	283.3	287.1	280.3	279.3	271.4	269.8	261.2	259.0	257.8	254.6
Total, 2012	272.9	276.6	271.9	271.5	265.1	267.8	262.9	266.4	268.4	270.4
Dairy cattle, 2013	103.3	104.7	102.5	102.3	100.5	98.5	93.4	91.4	92.9	90.6
Dairy cattle, 2012	108.8	110.6	108.7	108.8	107.4	107.5	104.6	105.7	109.4	110.2
Other cattle, 2013	84.8	86.1	80.6	79.6	75.7	74.8	73.5	73.0	73.4	73.3
Other cattle, 2012	66.1	66.9	62.9	62.1	59.1	58.3	57.5	57.3	57.6	57.5
Swine, 2013	89.5	90.3	91.3	91.3	88.9	90.3	87.9	88.1	85.0	84.3
Swine, 2012	92.2	93.2	94.4	94.5	92.4	95.7	94.4	96.7	94.9	96.2
[Gg a^{-1} CH_4]	**2010**	**2011**								
Total, 2013	244.2	237.3								
Total, 2012	265.4									
Dairy cattle, 2013	87.7	84.4								
Dairy cattle, 2012	110.6									
Other cattle, 2013	71.9	69.2								
Other cattle, 2012	56.5									
Swine, 2013	78.1	77.3								
Swine, 2012	92.1									

6.3.2.6 Planned improvements (4.B, CH_4)

The method used for calculation of GG emissions from slurry digestion was unable to take account of small amounts of slurry (cf. Chapter 6.1.3.6.5). The calculation method is to be revised to enable inclusion of such amounts of slurry.

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

6.3.3 NMVOC emissions from manure management (4.B, NMVOC)

The IPCC does not provide any method for calculating NMVOC emissions from manure-management. EMEP (2009)-4B-41 notes: "Data on NMVOC emissions from animal husbandry do not allow any direct estimation of emission factors …". In the framework of of the 2010 In-Country Review, the ERT found that the emission factors of HOBBS et al. (2004) that had been used were questionable, that they lead to considerable overestimation of NMVOC emissions and that therefore they had not been included in EMEP (2009). In keeping with the ERT's recommendation, Germany no longer reports NMVOC emissions from animal husbandry.

6.3.4 N_2O and emissions from manure management (4.B, N_2O & NO)

6.3.4.1 Source category description (4.B, N_2O & NO)

Cf. Chapter 6.3.1.

6.3.4.2 Methodological issues (4.B, N_2O & NO)

6.3.4.2.1 Methods (4.B, N_2O & NO)

N_2O emissions from manure management are calculated separately for all animal categories, taking account of the management systems in use (and including slurry digestion; cf. Chapter 6.1.3.6.5), in accordance with the following formula:

Equation 11: Calculation of N_2O emissions from manure management

$$E_{\mathrm{N2O\text{-}N}} = \sum_{\mathrm{i,j}} [(N_{\mathrm{excr,\,i}} + N_{\mathrm{straw,\,i,\,j}}) \cdot MS_{\mathrm{i,\,j}}] \cdot EF_{\mathrm{N2O\text{-}N,\,j}}$$

where:

$E_{\mathrm{N2O\text{-}N}}$	Total N_2O-N emissions from manure management (kg a^{-1} N_2O-N)
$N_{\mathrm{excr,\,i}}$	Total N excretions of animal category i (kg a^{-1} N)
$N_{\mathrm{straw,\,i,\,j}}$	N input via bedding material, for animal category i and manure-management system j (kg a^{-1} N), $N_{\mathrm{straw,\,i,\,j}} = 0$ for slurry systems and grazing
$MS_{\mathrm{i,\,j}}$	Relative proportion of manure management system j in animal category i (place place^{-1})
$EF_{\mathrm{N2O\text{-}N,\,j}}$	N_2O-N emission factor for manure management system j (kg kg^{-1} N_2O-N)

With regard to total N excretions and total N inputs via bedding material, cf. Chapters 6.1.3.4 and 6.1.3.6. The pertinent N_2O-N emission factors are given in Chapter 6.3.4.2.2. With regard to the relative frequencies of manure management systems, cf. Chapters 6.1.3.6.1 and 19.4.1.

NO emissions from manure management (not including manure application and grazing) are calculated using a method similar to that used to calculate the relevant N_2O emissions. The pertinent NO-N emission factors are given in Chapter 6.3.4.2.2.

N_2O and NO emissions resulting from manure application and N excretions in pastures are reported under 4.D.

6.3.4.2.2 Emission factors (4.B, N_2O & NO)

For slurry systems, Germany uses N_2O emission factors that are higher than those specified by the IPCC (1996b/2000) (IPCC, 2006); consequently, the pertinent emissions cannot be underestimated. In NIRs up to and including the NIR 2012, an N_2O emission factor of 0 kg kg^{-1} N was used for an artificial floating cover consisting of chaff. In keeping with a worst-case assumption, the emission factor used for a natural floating crust (0.005 kg kg^{-1} N) is now also being used for such artificial covers. Because use of artificial floating covers consisting of chaff is not widespread, this change has little impact on total N_2O emissions, however.

For N_2O emissions from slurry digestion, the default emission factor of the IPCC (2000) was used; it is 0.001kg N_2O-N (kg $N)^{-1}$.

Germany differentiates solid-manure systems according to whether they include solid-manure storage or use deep bedding material. For solid manure, the present NIR 2013 uses a new emission factor that was developed by VANDRÉ et al. (2012) and that was accepted, on 27 June 2012, by the KTBL working group "emission factors for animal husbandry" ("Emissionsfaktoren Tierhaltung"; KTBL = Association for Technology and Structures in Agriculture), as an emission factor receiving national consensus: 0.013 kg N_2O-N (kg $N)^{-1}$. For deep bedding material, the IPCC (1996b/2000) gives no emission factor. Since no national emission factor is available for this category, the default value of the IPCC (2006) was adopted: 0.01 kg N_2O-N (kg $N)^{-1}$. The situation with regard to poultry manure is similar, and thus the default emission factor of the IPCC (2006) was adopted here as well for purposes of inventory calculations. It is 0.001 kg N_2O-N (kg $N)^{-1}$. Results with manure-storage systems in Denmark (deep bedding material with cattle; Sommer, 2001) and in the UK (poultry manure; SNEATH et al., (1997)) have confirmed that use of the default emission factor of the IPCC (2006) for deep bedding material and poultry manure does not lead to underestimation of emissions.

Table 201 provides an overview of the N_2O emission factors used in the NIR 2013.

Table 201: Emission factors for emissions of N_2O-N from manure management (in relation to total excreted N and straw-bedding N) (4.B(b))

Manure		**Emission factor [kg kg^{-1} N]**
Slurry	Open tank, without natural crust[a]	0.000
	Solid cover [b]	0.005
	Natural crust[a]	0.005
	Floating cover (chaff) [b]	0.005
	Floating cover (plastic film) [c]	0.000
	Below slatted floor > 1 month [a]	0.002
	Storage of digested slurry [d]	0.001
Solid manure[a]	Heap	0.013
Deep bedding[a]		0.010
Poultry, solid manure or faeces[a]		0.001

[a] Source: See text.
[b] Worst-case assumption: Like natural crust, since no information is available.
[c] Assumption: Floating covers (plastic film) permit no N_2O formation.
[d] Source: IPCC (2000), p. 4.43.

As Table 201 shows, the emission factor for the slurry category "slurry and storage of digested slurry" is the lowest of the emission factors for slurry storage. This means that where digestion of slurry is carried out, instead of conventional storage of slurry, it generally leads to a reduction of N_2O emissions from manure management.

On average for all animal husbandry, the following N_2O-N emission factors result for Germany in 2010: slurry: 0.00321 kg kg^{-1} N; solid manure: 0.00935 kg kg^{-1} N.

The IPCC does not give any emission factors for NO. The Tier-1 emission factors given in EMEP (2009) refer to animal places and thus cannot be used in the GAS-EM inventory model, which, in the framework of the N-flow concept (cf. Chapter 6.1.2.4), requires emission factors that are related to N amounts. At the same time, comparative calculations show that the German total NO emissions from Sector 4.B as calculated with the Tier-1 method pursuant to EMEP (2009) can be reproduced with GAS-EM when the NO-N emission factor oriented to N is smaller than the N_2O-N emission factor by an order of magnitude. For this reason, in the inventory, the NO-N emission factor has been set at a level of 10 % of the N_2O-N emission factor. This approach yields NO emissions that are proportional to the relevant N_2O emissions.

Neither the IPCC nor EMEP gives emission factors for N_2 (which must also be taken into account in the N-flow concept; cf. Chapter 6.1.2.4). JARVIS & PAIN (1994) obtained 3:1 as the ratio of N_2 emissions to N_2O-N emissions. Therefore, for purposes of the inventory, it has been assumed that N_2 emission factor is three times as large as the N_2O-N emission factor.

Table 202 through Table 205 show the time series for the implied N_2O-N emission factors for the two manure-management-system categories, "slurry-based" and "straw-based", and for dairy cattle, other cattle, swine and all livestock overall. These emission factors are defined as the quotient of the total N_2O emissions from a management system (given in N) and the total N amount excreted by the animals in the system. For straw-based systems, the total N_2O emissions comprise both the emissions resulting from the animals' N excretions and the emissions from the N introduced via bedding material.

Table 202: Dairy cattle, mean N_2O-N emission factors

[kg kg^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Slurry-based	0.00375	0.00369	0.00369	0.00370	0.00389	0.00389	0.00389	0.00389	0.00388	0.00389
Straw-based	0.01235	0.01231	0.01226	0.01223	0.01219	0.01218	0.01217	0.01217	0.01215	0.01214
[kg kg^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Slurry-based	0.00388	0.00384	0.00381	0.00377	0.00373	0.00365	0.00353	0.00340	0.00330	0.00317
Straw-based	0.01227	0.01224	0.01223	0.01221	0.01220	0.01218	0.01217	0.01215	0.01217	0.01216
[kg kg^{-1}]	**2010**	**2011**								
Slurry-based	0.00302	0.00290								
Straw-based	0.01215	0.01213								

Table 203: Other cattle, mean N_2O-N emission factors

[kg kg^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Slurry-based	0.00372	0.00366	0.00363	0.00363	0.00380	0.00380	0.00379	0.00379	0.00378	0.00378
Straw-based	0.01247	0.01247	0.01242	0.01241	0.01240	0.01239	0.01240	0.01240	0.01238	0.01238
[kg kg^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Slurry-based	0.00375	0.00373	0.00371	0.00369	0.00367	0.00364	0.00362	0.00360	0.00357	0.00356
Straw-based	0.01234	0.01231	0.01229	0.01215	0.01214	0.01212	0.01210	0.01208	0.01206	0.01203
[kg kg^{-1}]	**2010**	**2011**								
Slurry-based	0.00354	0.00354								
Straw-based	0.01201	0.01202								

Table 204: Swine, mean N_2O-N emission factors

[kg kg^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Slurry-based	0.00170	0.00195	0.00198	0.00200	0.00242	0.00241	0.00243	0.00242	0.00240	0.00240
Straw-based	0.01189	0.01192	0.01192	0.01193	0.01200	0.01198	0.01199	0.01198	0.01198	0.01197
[kg kg^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Slurry-based	0.00252	0.00262	0.00273	0.00284	0.00295	0.00302	0.00309	0.00313	0.00318	0.00322
Straw-based	0.01198	0.01196	0.01197	0.01198	0.01197	0.01198	0.01199	0.01200	0.01201	0.01203
[kg kg^{-1}]	**2010**	**2011**								
Slurry-based	0.00325	0.00318								
Straw-based	0.01204	0.01206								

Table 205: All farm animals, mean N_2O-N emission factors (4.s2.B)

[kg kg^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Slurry-based	0.00317	0.00322	0.00320	0.00321	0.00349	0.00349	0.00348	0.00346	0.00343	0.00344
Straw-based	0.01068	0.01055	0.01058	0.01060	0.01023	0.01025	0.01027	0.01016	0.00999	0.01000
[kg kg^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Slurry-based	0.00345	0.00346	0.00345	0.00346	0.00347	0.00345	0.00341	0.00335	0.00332	0.00327
Straw-based	0.00989	0.00987	0.00984	0.00972	0.00956	0.00956	0.00956	0.00946	0.00949	0.00945
[kg kg^{-1}]	**2010**	**2011**								
Slurry-based	0.00321	0.00312								
Straw-based	0.00935	0.00921								

6.3.4.2.3 Emissions (4.B, N_2O & NO)

The following tables show the calculated N_2O emissions from manure management, broken down by animal categories and by management systems. N_2O and NO emissions have been decreasing considerably with regard to the base year. Cattle husbandry accounts for the major part of N_2O emissions (78.5 % in 1990, and a decrease to 73.5 % in 2011). Due to the proportionality in the emission factors involved (cf. Chapter 6.3.4.2.2), the same figures apply, in the same manner, for NO emissions.

Table 206: N_2O emissions from manure management, by animal categories (4.B)

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	5.230	4.625	4.550	4.601	3.938	3.930	3.942	3.833	3.674	3.655
Other cattle	4.694	4.026	3.879	3.849	3.964	4.009	3.986	3.865	3.836	3.890
Swine	1.840	1.688	1.744	1.695	1.517	1.466	1.508	1.532	1.566	1.519
Sheep	0.275	0.267	0.248	0.253	0.243	0.252	0.250	0.244	0.242	0.234
Goats	0.014	0.014	0.014	0.014	0.015	0.016	0.017	0.018	0.020	0.021
Horses	0.461	0.480	0.499	0.530	0.561	0.586	0.611	0.559	0.508	0.456
Mules/asses	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Buffalo [a]	NA	NA	NA	NA	NA	NA	0.0000	0.0002	0.0003	0.0004
Poultry	0.121	0.117	0.112	0.111	0.112	0.113	0.113	0.115	0.119	0.117
[Gg a^{-1} N_2O]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	3.587	3.630	3.541	3.516	3.453	3.427	3.275	3.242	3.252	3.211
Other cattle	3.885	3.978	3.782	3.692	3.578	3.575	3.556	3.562	3.648	3.689
Swine	1.524	1.576	1.629	1.658	1.655	1.719	1.708	1.749	1.714	1.725
Sheep	0.235	0.237	0.232	0.232	0.231	0.225	0.217	0.214	0.206	0.200
Goats	0.022	0.025	0.025	0.025	0.025	0.027	0.028	0.028	0.030	0.035
Horses	0.469	0.481	0.490	0.499	0.487	0.476	0.495	0.515	0.489	0.464
Mules/asses	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Buffalo	0.0006	0.0006	0.0007	0.0009	0.0010	0.0011	0.0013	0.0015	0.0017	0.0020
Poultry	0.126	0.129	0.128	0.132	0.140	0.140	0.140	0.148	0.147	0.150
[Gg a^{-1} N_2O]	**2010**	**2011**								
Dairy cattle	3.157	3.122								
Other cattle	3.678	3.547								
Swine	1.648	1.621								
Sheep	0.184	0.150								
Goats	0.024	0.024								
Horses	0.439	0.439								
Mules/asses	0.006	0.006								
Buffalo	0.0023	0.0026								
Poultry	0.154	0.160								

[a] Through 1995, the system included no buffalo

Table 207 shows N_2O emissions from manure management, in total and by system categories. For the period from 1990 to 2011, these data show a 28.2 % reduction of total N_2O emissions from manure management (slurry-based and straw-based). The reduction in straw-based systems, amounting to 34.1 % between 1990 and 2011, accounts for a greater share of the total reduction than does reduction in slurry-based systems, which amounts to only 17.7 %. This result reflects the development in the distribution of management systems (cf. Chapters 6.1.3.6.1 and 19.4.1). In part, that development has been modified by developments in animal populations and yield levels.

Table 207: N_2O emissions from manure management, total and by system categories (4.s2.B)

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	12.641	11.223	11.051	11.059	10.356	10.377	10.432	10.173	9.970	9.897
Slurry-based	4.537	4.075	4.000	3.973	4.758	4.710	4.734	4.617	4.658	4.638
Straw-based	8.104	7.148	7.052	7.087	5.598	5.666	5.698	5.556	5.311	5.259
[Gg a^{-1} N_2O]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total	9.854	10.062	9.833	9.762	9.575	9.595	9.426	9.465	9.493	9.481
Slurry-based	4.525	4.588	4.472	4.426	4.305	4.291	4.137	4.093	4.048	3.991
Straw-based	5.329	5.474	5.362	5.336	5.270	5.305	5.290	5.372	5.445	5.490
[Gg a^{-1} N_2O]	**2010**	**2011**								
Total	9.291	9.072								
Slurry-based	3.836	3.735								
Straw-based	5.455	5.337								

The NO emissions calculated for manure management overall are shown in Table 209.

Table 208 shows the N_2O-emissions reductions achieved via slurry digestion, as calculated for Germany with the GAS-EM inventory model. It also shows the reduction effects resulting for Germany by comparison to the emissions that would apply in a scenario with no slurry digestion.

Table 208: N_2O-emissions reductions in Germany via slurry digestion, and the percentage effects of such reductions with respect to the total N_2O emissions from manure management, for all farm animals considered in the inventory, that would apply in a scenario with no slurry digestion

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cattle slurry	0.0001	0.0003	0.0004	0.0005	0.001	0.002	0.003	0.003	0.01	0.01
Swine slurry	0.0000	0.0000	0.0000	0.0000	0.000	0.001	0.001	0.001	0.00	0.00
Total	0.0001	0.0003	0.0004	0.0006	0.001	0.002	0.004	0.005	0.01	0.01
Total, in %	0.0001	0.0003	0.0004	0.0005	0.001	0.002	0.003	0.003	0.01	0.01
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Cattle slurry	0.01	0.02	0.03	0.04	0.05	0.08	0.13	0.20	0.24	0.30
Swine slurry	0.01	0.01	0.01	0.02	0.02	0.05	0.08	0.12	0.15	0.19
Total	0.02	0.03	0.04	0.05	0.07	0.13	0.21	0.32	0.39	0.48
Total, in %	0.20	0.29	0.44	0.53	0.71	1.4	2.2	3.3	3.9	4.9
[Gg a^{-1}]	**2010**	**2011**								
Cattle slurry	0.36	0.43								
Swine slurry	0.24	0.28								
Total	0.60	0.71								
Total, in %	6.1	7.3								

Table 209 shows NO emissions from manure management. Because the emission factors of NO and N_2O are proportional to each other, the reduction rates for NO are identical to those for N_2O (cf. Table 208).

Table 209: NO emissions (E_{NO}) from manure management

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NO}	1.724	1.530	1.507	1.508	1.412	1.415	1.423	1.387	1.360	1.350
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
E_{NO}	1.344	1.372	1.341	1.331	1.306	1.308	1.285	1.291	1.295	1.293
[Gg a^{-1}]	**2010**	**2011**								
E_{NO}	1.267	1.237								

6.3.4.3 Uncertainties and time-series consistency (4.B, N_2O & NO)

With regard to the uncertainties in the area of N_2O emissions from enteric fermentation, the reader's attention is called to Table 176 in Chapter 6.1.5 (total uncertainty of the German GG inventory).

All emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and all data gaps have been filled in.

6.3.4.4 Source-specific quality assurance / control and verification (4.B, N_2O & NO)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Chapter 6.1.6 provides an overview of measures implemented relative to source-specific QA/QC and verification.

A comparison carried out in the framework of verification of "implied emission factors" for N_2O emissions from Germany (current report, for the year 2010) and neighbouring countries, including the UK (Submission 2012 for the year 2010, UNFCCC 2012), shows that half of all neighbouring countries use the N_2O-N default emission factors from IPCC (1996b), Table 4-22 (0.001 kg kg^{-1} N for slurry and 0.02 kg kg^{-1} N for solid manure; slight divergences are seen in the cases of Belgium, Denmark, France, the Netherlands and the UK). On average, for all animal husbandry, an N_2O-N-IEF for slurry of 0.00321 kg kg$_{-1}$ N, and an IEF for solid manure of 0.00935 kg kg$_{-1}$ N, result for Germany for the year 2010.

A comparison of Germany's N excretions (Table 210) with those of neighbouring countries shows that Germany's level is about in the middle of the overall range for dairy cattle. A similar result is obtained with regard to excretions of other cattle. The IPCC (1996b) default value for dairy cattle seems to be too low for central Europe, while the default value for other cattle fits better, on average, with the reported area.

The N excretions of swine as reported by Germany lie within the middle range of the corresponding data reported by neighbouring countries. The IPCC (1996b) default value is noticeably higher than the corresponding level prevailing in Germany and central Europe.

In the poultry category, German has the highest N excretions of all countries compared. Since the compositions of poultry populations in other countries are not reported, the comparability of the values is limited. The IPCC default values of 1996, 0.60 kg place^{-1} a^{-1}, and of 2006, 0.55 kg place^{-1} a^{-1} (for calculation cf. Table 210) underestimate the situation in Germany. The German value, on the other hand, lies well within the value range given by EMEP (2009), and it is nearly the same as the EMEP value for laying hens, 0.77 kg place^{-1} a^{-1}.

Table 210: N excretions per animal place, for dairy cattle, other cattle, swine and poultry of various countries, for the year 2010

	Dairy cattle [kg place^{-1} a^{-1}]	Other cattle [kg place^{-1} a^{-1}]	Swine [kg place^{-1} a^{-1}]	Poultry [kg place^{-1} a^{-1}]
Austria	97.40	46.67	9.50	0.55
Belgium	116.91	54.13	10.01	0.59
Czech Republic	132.59	68.76	20.00	0.60
Denmark	138.63	43.15	7.65	0.60
France	113.19	59.35	7.02	0.57
Germany	**115.27**	**44.48**	**11.90**	**0.76**
Netherlands	130.20	44.78 [a]	8.61	0.62
Poland	86.70	58.12	13.56	0.35
Switzerland	110.81	37.96 [a]	9.12	0.54
UK	121.10	53.85	10.39	0.58
Default IPCC (1996b, Table B-1)	100	70	20	0.6
IPCC (2006)-10.59, 10.72, 10.78,10.80, 10.81, 10.82	105.12 [b]	50.59 [b]	9.31 / 30.35 [b, d]	0.55 [b, c]
EMEP (2009)-4.B-26	105.00	41.00	12.1 / 34.5 [d]	0.36 to 1.64

Source: Germany: Submission 2013; other countries: UNFCCC 2012

[a] Calculated from reported original data

[b] Calculated pursuant to IPCC (2006), with the IPCC's standard values for weight and N excretions and, in the case of poultry, with the national animal counts in the various poultry sub-categories (Submission 2012)

[c] Assumptions for lacking values: Weight of geese = 1/2 standard weight of turkeys (IPCC 2006); N excretions of geese = standard N excretions of turkeys (IPCC 2006); weight of pullets = 1/2 standard weight of laying hens (IPCC 2006); N excretions of pullets = standard N excretions of laying hens (IPCC 2006)

[d] IPCC (2006): Sows and boars: 30.35, other: 9.31; EMEP (2009): Sows: 34.5, fattening pigs: 12.1

6.3.4.5 Source-specific recalculations (4.B, N_2O & NO)

Table 211 shows a comparison of N_2O emissions from manure management, as calculated for the present NIR 2013, and as reported in the NIR 2012. In general, the total emissions are noticeably higher in the NIR 2013; this is due primarily to the emissions contribution of straw-based systems. For the period until the reported year 2003, emissions from slurry-based systems are partly higher and partly lower in the present NIR than they were in the NIR 2012. For the period as of 2005, they are mostly lower, however, and the difference increases with the subsequent years covered by the report.

Table 211: Comparison of N_2O emissions from manure management, as reported in the NIR 2013 and as reported in the NIR 2012, as total emissions and by system categories (4.s2.)

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	12.641	11.223	11.051	11.059	10.356	10.377	10.432	10.173	9.970	9.897
Total, 2012	8.292	7.505	7.450	7.450	7.587	7.585	7.631	7.445	7.389	7.373
Slurry-based, 2013	4.537	4.075	4.000	3.973	4.758	4.710	4.734	4.617	4.658	4.638
Slurry-based, 2012	4.489	4.086	4.008	3.982	4.735	4.692	4.717	4.598	4.646	4.613
Straw-based, 2013	8.104	7.148	7.052	7.087	5.598	5.666	5.698	5.556	5.311	5.259
Straw-based, 2012	3.803	3.420	3.442	3.469	2.852	2.893	2.915	2.846	2.743	2.760
[Gg a^{-1} N_2O]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	9.854	10.062	9.833	9.762	9.575	9.595	9.426	9.465	9.493	9.481
Total, 2012	7.315	7.453	7.296	7.330	7.188	7.246	7.158	7.268	7.342	7.407
Slurry-based, 2013	4.525	4.588	4.472	4.426	4.305	4.291	4.137	4.093	4.048	3.991
Slurry-based, 2012	4.513	4.575	4.466	4.420	4.308	4.341	4.252	4.298	4.311	4.341
Straw-based, 2013	5.329	5.474	5.362	5.336	5.270	5.305	5.290	5.372	5.445	5.490
Straw-based, 2012	2.802	2.878	2.830	2.909	2.880	2.905	2.906	2.970	3.030	3.066
[Gg a^{-1} N_2O]	**2010**	**2011**								
Total, 2013	9.291	9.072								
Total, 2012	7.317									
Slurry-based, 2013	3.836	3.735								
Slurry-based, 2012	4.262									
Straw-based, 2013	5.455	5.337								
Straw-based, 2012	3.055									

The main reason that N_2O emissions from straw-based systems are about twice as high as was reported in the NIR 2012 is that the emission factor for solid manure has been increased (cf. Chapter 6.3.4.2.2). In the category of slurry-based systems, the emissions-reducing effects of slurry digestion become more and more pronounced with each successive year. Higher N excretions are also a factor for both straw-based and slurry-based systems; the higher excretions result from updating of yield data and from the change in allocation of cows for fattening and for slaughter (cf. Chapters 6.1.3.1 through 6.1.3.4). As the following table shows, the total N excretions for all animals are higher in the NIR 2013 than they were in the NIR 2012.

Table 212: Comparison of total N excretions of all animals, as calculated for the NIR 2013 and as calculated for the the NIR 2012

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N excretions, 2013	1,608.3	1,431.9	1,412.8	1,409.7	1,386.6	1,385.7	1,395.3	1,367.2	1,372.4	1,362.8
N excretions, 2012	1,574.8	1,421.5	1,404.5	1,401.4	1,378.3	1,377.3	1,388.5	1,359.7	1,364.2	1,353.4
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
N excretions, 2013	1,342.7	1,362.9	1,326.9	1,315.8	1,288.2	1,290.9	1,265.8	1,278.5	1,281.2	1,286.4
N excretions, 2012	1,334.6	1,352.7	1,319.1	1,307.8	1,280.8	1,283.1	1,259.2	1,273.9	1,277.7	1,283.3
[Gg a^{-1}]	**2010**	**2011**								
N excretions, 2013	1,270.9	1,264.9								
N excretions, 2012	1,261.3									

The NO emissions have changed, with respect to the NIR 2012, in the same manner that the N_2O emissions have changed, since both emissions types come from the same N pool and since the NO emission factors are directly proportional to the N_2O emission factors (cf. Chapter 6.3.4.2.2). The following table shows the relevant changes in the total NO emissions:

Table 213: Comparison of total NO emissions (E_{NO}) from manure management, as reported in the NIR 2013 and as reported in the NIR 2012

[Gg a⁻¹ NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NO} 2013	1.724	1.530	1.507	1.508	1.412	1.415	1.423	1.387	1.360	1.350
E_{NO} 2012	1.131	1.023	1.016	1.016	1.035	1.034	1.041	1.015	1.008	1.005
[Gg a⁻¹ NO]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
E_{NO} 2013	1.344	1.372	1.341	1.331	1.306	1.308	1.285	1.291	1.295	1.293
E_{NO} 2012	0.997	1.016	0.995	1.000	0.980	0.988	0.976	0.991	1.001	1.010
[Gg a⁻¹ NO]	**2010**	**2011**								
E_{NO} 2013	1.267	1.237								
E_{NO} 2012	0.998									

6.3.4.6 Planned improvements (4.B, N_2O & NO)

The method used for calculation of GG emissions from slurry digestion was unable to take account of small quantities of slurry (cf. Chapter 6.1.3.6.5). The calculation method is to be revised to enable inclusion of such quantities of slurry.

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

6.4 Rice cultivation (4.C)

No rice is cultivated in Germany (NO).

6.5 Agricultural soils (4.D)

6.5.1 Source category description (4.D)

CRF 4.D	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Direct soil emissions	**N_2O**	**L**	**T/T2**	**29,140.6**	**(2.39%)**	**26,360.9**	**(2.85%)**	**-9.54%**
Indirect emissions	**N_2O**	**L**	**T/T2**	**16,539.7**	**(1.36%)**	**14,195.7**	**(1.53%)**	**-14.17%**
Pasture, range and paddock manure	**N_2O**	**-**	**-/T2**	**2,104.2**	**(0.17%)**	**1,315.4**	**(0.14%)**	**-37.49%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2		IE	
N_2O	C/D/Tier 1/Tier 2	M/AS/RS/NS	D
NO_X			D

With regard to direct and indirect N_2O emissions, the source category *Agricultural soils* is a key category in terms of emissions level. With regard to direct emissions, it is also a key category in terms of trend. In addition, N_2O emissions from grazing are a key category pursuant to the results of Tier-2 key-category analysis.

Microbial transformations of N compounds (nitrification and denitrification) lead to emissions of N_2O. A distinction is made between direct and indirect N_2O emissions from soils. Direct emissions comprise N_2O emissions resulting from manure application, grazing, application of mineral fertiliser and sewage sludge, biological N-fixation, crop residues and management of organic soils. So-called "indirect N_2O emissions" result from deposition of reactive nitrogen and via leaching and surface runoff.

N_2O emissions from soils were 12.4 % lower in 2011 than they were in 1990. At 93.7 %, their share of total N_2O emissions from German agriculture was somewhat higher in 2011 than it was in 1990, when it was 92.4 %.

6.5.2 Methodological issues (4.D)

6.5.2.1 Methods and emission factors (4.D)

6.5.2.1.1 Direct N_2O emissions (4.Ds1.1, 4.Ds1.2)

Direct N_2O emissions from application of mineral fertilisers are calculated, via a Tier 1 method pursuant to IPCC (1996b)-4.92 ff, as a proportion of the N amount that remains from the N amount in applied fertiliser after deduction of N losses via NH_3 and NO emissions. In the German inventory, the remaining N amount is calculated not with the help of the value $Frac_{GASF}$ but with values for explicitly calculated NH_3 and NO emissions. (With regard to $Frac_{GASF}$, cf. Chapter 6.5.2.2.1.) The activity data used are the amounts of mineral fertiliser sold, as statistically recorded at the Länder level (cf. Chapter 6.1.4.1.1). Pursuant to IPCC(1996b)-4.89, Table 4-18, the emission factor is set as $EF_{fert,\ N2O}$ = 0.0125 kg kg^{-1} N_2O-N.

Calculation of direct N_2O emissions as a result of manure application is carried out analogously to calculation of such emissions from application of mineral fertiliser. Consequently, the emission factor is set to $EF_{man,\ N2O}$ = 0.0125 kg kg^{-1} N_2O-N. The activity data, i.e. the N amounts entering into the soil following application (cf. Chapter 6.1.4.1.1), are obtained from the amounts of N excreted, not including the shares from grazing (cf. Chapter 6.1.3.4), and via use of the N-flow concept (Chapter 6.1.2.4).

Since 2008, imports and exports of mineral fertilisers, pursuant to waste statistics, yield a net balance with a slight export surplus or of zero. In a conservative approach, they are thus not taken into account in the inventory.

Direct N_2O emissions from N excretions in pasture are calculated, in accordance with IPCC (1996b), in proportion to the N amount excreted in pasture (cf. Chapter 6.1.4.1.1). That amount is calculated as the product of relevant animals' total N excretions and the relative proportion of time the animals spend in pasture. The emission factor $EF_{graz,\ N2O}$ = 0.02 kg kg^{-1} N_2O-N is the same for all animal categories, and it is applied to the N amounts excreted.

IPCC (1996b), p. 4.89, recommends that emissions from use of sewage sludges not be calculated. IPCC (2000), on the other hand, proposes that sewage sludges be treated like mineral fertiliser and manure. For this reason, in the German inventory sewage sludges are taken into account in the area of direct N_2O emissions, in keeping with IPCC (2006)-11.7. For each Land (state) in Germany, the N amounts that enter into agricultural systems via sewage sludges are taken from data of the Federal Environment Agency and (since 2009) of the Federal Statistical Office. While other types of N emissions from use of mineral fertiliser are calculated, no other N emissions from sewage sludges are calculated; as a result, the N amounts tied to sewage sludges are used directly as activity data (cf. Chapter 6.1.4.1.1). Consequently, by analogy to the situation with application of mineral fertiliser, the emission factor is set to $EF_{sl,\ N2O}$ = 0.0125 kg kg^{-1} N_2O-N.

Direct N_2O emissions from cultivation of organic soils are calculated in proportion to the applicable area (cf. Chapter 6.1.4.1.2). Pursuant to IPCC (2000), Table 4.17, an emission factor of 8 kg ha^{-1} a^{-1} N_2O-N is used.

Direct N_2O emissions from biological N fixation are calculated in proportion to the amount of bound N (cf. Chapter 6.1.4.1.1). For each crop, that amount is determined as the product of the cultivated area and the specific fixation rate. The relevant data for the cultivated areas are provided by STATISTISCHES BUNDESAMT (Fachserie 3, Reihe 3), while the fixation data are obtained from FAUSTZAHLEN (1993), p. 477, and from Saxony's state institute for agriculture (Sächsische Landesanstalt für Landwirtschaft; LABER, 2005, p. 86). Consequently, by analogy to the situation with application of mineral fertiliser, the emission factor is set to $EF_{\text{fix, N2O}}$ = 0.0125 kg kg^{-1} N_2O-N.

Pursuant to IPCC (2006), 11.13, direct N_2O emissions from crop residues are calculated in proportion to the relevant available N amounts. Those amounts (cf. Chapter 6.1.4.1.1) result from the applicable figures for cultivated areas, yields and crop-specific N content. The data on areas under cultivation and yields are reported by the FEDERAL STATISTICAL OFFICE (STATISTISCHES BUNDESAMT; Fachserie 3, Reihe 3). The relative N amounts contained in residues are taken from the Fertiliser Ordinance (DüV, 2007) and from a list prepared by the Institute of Vegetable and Ornamental Crops (IGZ, 2007). The N amounts removed from relevant areas, for bedding material in animal husbandry, are deducted. Consequently, by analogy to the situation with application of mineral fertiliser, the emission factor is set to $EF_{\text{fix, N2O}}$ = 0.0125 kg kg^{-1} N_2O-N.

A detailed description of calculation of N_2O emissions from agricultural soils is provided by RÖSEMANN et al. (2013).

6.5.2.1.2 Indirect N_2O emissions as a result of deposition of reactive nitrogen (4.Ds1.3)

Indirect N_2O emissions from agricultural soils include a) N_2O emissions from deposition of previously emitted, reactive nitrogen and b) N_2O emissions from surface runoff and leaching.

The German procedure for calculating deposition-related N_2O emissions, as described below, accords with the meaning of the Tier 1 procedure given in IPCC (2006)-11.21. The equation for that procedure, 11.9 (IPCC, 2006: 11.21) is not used by Germany, however, since that equation does not take account of NH_3-N emissions from bedding material and legume cultivation and of NO-N emissions from bedding material. Since, furthermore, that equation is not consistent with the definition of $Frac_{GASM}$ in CRF Table 4.Ds2 (cf. Chapter 6.5.2.2.1), it can be used only as an approximation in checking of the German N_2O emissions reported in the inventory (cf. Chapter 6.5.3).

The German inventory calculates the deposition-related N_2O emissions as the product of the N_2O-N conversion factor, 44/28, the emission factor (0.01 kg kg-1 N, IPCC, 1996, Table 4-23) and the sum of the N content of the following NH_3 and NO emissions, which are described further below:

- NH_3 emissions from use of mineral fertilisers
- NO emissions from use of mineral fertilisers
- NH_3 emissions from manure management, including application

- NO emissions from manure management, including NO as a consequence of manure application
- NH_3 emissions from grazing
- NO emissions from grazing
- NH_3 emissions from legume cultivation

As of the present Submission 2010, NO emissions from legume cultivation and from crop residues are no longer reported, since neither the IPCC nor EMEP (2009) provide a pertinent method. This can be justified in that no free ammonium occurs in N fixation by legumes, and that crop residues, as an NO source, are implicitly included in the measurements for NO emission factors for fertilisers, since the relevant emission factors in STEHFEST & BOUWMAN (2006), which are used in the inventory, were calculated without deduction of "background emissions", i.e. were calculated as measured total emissions per amount of fertiliser.

NH_3 and NO emissions from use of mineral fertiliser are calculated as a proportion of the amount of N applied. The NH_3 emission factors for the various fertiliser types are calculated, pursuant to EMEP(2009)-4D-Table 3-2, as a function of spring temperatures. Such temperature data are obtained from the regionally differentiated statistics of the Deutscher Wetterdienst German meteorological service (cf. RÖSEMANN et al., 2013). The NO emission factor is given in Chapter 6.5.2.1.4.

NH_3 emissions from manure management are calculated separately for the areas of housing, storage and application, with the N amount at the beginning of the housing-storage-application chain including the nitrogen introduced with bedding material (cf. Chapters 6.1.2.4 and 6.1.3.6.2). Differentiated NH_3 emission factors are available for the housing systems, storage systems and application techniques commonly used in Germany (cf. RÖSEMANN et al., 2013).

NO emissions from manure management are a) calculated in combination for the housing and storage categories and b) calculated as a consequence of manure application. The NO emission factors for the housing-storage area are set at 10 % of the relevant N_2O emission factor (cf. Chapters 6.3.4.2.1 and 6.3.4.2.2). The emission factor for NO as a result of application is given in Chapter 6.5.2.1.4.

NH_3 and NO emissions from excretions during grazing are calculated in proportion to the amount of N excreted. The NH_3 emission factors are differentiated by type of animal; cf. EMEP (2009)-4B-26. The NO emission factor is given in Chapter 6.5.2.1.4.

NH_3 emissions from legume cultivation are calculated in proportion to the amount of N fixed by legumes (with regard to calculation of the amount of N fixed, cf. Chapter 6.5.2.1.1). Pursuant to EMEP (2007)-B1020-12, the NH_3 emission factor is set as $EF_{\text{fix, NH3}}$ = 0.01 kg kg^{-1} NH_3-N.

A detailed description of calculation of N_2O emissions from agricultural soils is provided by RÖSEMANN et al. (2013).

6.5.2.1.3 Indirect N_2O emissions resulting from leaching and surface runoff (4.Ds1.3)

In keeping with the Tier-1 method pursuant to IPCC (1996b), p. 4.109, indirect N_2O emissions resulting from leaching and surface runoff are calculated as the product of the

N_2O-N conversion factor 44/28, the amount of N leached (cf. Chapter 6.1.4.1.4) and the emission factor (0.025 kg kg^{-1} N, IPCC, 1996b, Table 4-23).

A detailed description of calculation of N_2O emissions from agricultural soils is provided by RÖSEMANN et al. (2013).

6.5.2.1.4 NO emissions

The procedure for calculating NO emissions is described in Chapter 6.5.2.1.2. The following table shows the emission factors used.

Table 214: Emission factors EF_{NO} for NO emissions from agricultural soils

	EF_{NO} kg kg^{-1} NO-N]	Remark
Application of mineral fertiliser	0.012	STEHFEST & BOUWMAN (2006)
Application of manure	0.012	STEHFEST & BOUWMAN (2006)
Grazing	0.007	EMEP (2007), B1020-12

6.5.2.1.5 NMVOC emissions

The IPCC does not provide any method for calculating NMVOC emissions from agricultural soils and crops. EMEP (2009) provides a method, but it provides no emission factors. Since no scientifically founded bases for calculation are available, NMVOC emissions will no longer be reported in Sector 4.D, just as they are no longer reported in Sector 4.B (cf. Chapter 6.3.3).

6.5.2.2 *Frac* values

6.5.2.2.1 $Frac_{GASF}$ and $Frac_{GASM}$

$Frac_{GASF}$ und $Frac_{GASM}$ were calculated with the help of input and output data, following the completion of emissions calculation. They are thus "diagnostic" entities; they were not used for emissions calculation.

$Frac_{GASF}$ (cf. Table 215) is the relative share of N that is emitted, as NH_3-N and NO-N, as a result of application of mineral fertilisers. $Frac_{GASF}$ is calculated in accordance with the definition in CRF-4.Ds2.

Table 215: $Frac_{GASF}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{GASF}$	0.034	0.034	0.033	0.036	0.037	0.037	0.038	0.038	0.039	0.039
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$Frac_{GASF}$	0.039	0.043	0.043	0.043	0.044	0.042	0.044	0.046	0.043	0.054
	2010	**2011**								
$Frac_{GASF}$	0.044	0.048								

The definition of $Frac_{GASM}$ given in CRF-4.Ds2 ("Fraction of livestock N excretion that volatilizes as NH_3 and NO_x") is in keeping with the definition implied by Equation 9 in IPCC (1996b)-4.112. This becomes apparent when Equation 9 in IPCC (1996b)-4.112 is reformulated in terms of $Frac_{GASM}$:

Equation 12: Derivation of $Frac_{GASM}$ from Equation 9 in IPCC (1996b)-4.112

$$Frac_{\mathrm{GASM,\,Eq.9}} = \frac{E_{\mathrm{N2O}} / EF_4 - N_{\mathrm{fert}} \cdot Frac_{\mathrm{GASF}}}{N_{\mathrm{ex}}}$$

where

$Frac_{\mathrm{GASM,\,Eq.\,9}}$	$Frac_{\mathrm{GASM}}$ value from Equation 9 in IPCC (1996b)-4.112 (in Gg Gg-1)
E_{N2O} / EF_4	Total emissions of N_2O-N from agricultural soils, via deposition of reactive nitrogen from emissions of NH_3-N and NO-N (in Gg a^{-1} N_2O-N)
$N_{\mathrm{fert}} \cdot Frac_{\mathrm{GASF}}$	Emissions of N_2O-N via deposition of reactive nitrogen from emissions of NH_3-N and NO-N from application of mineral fertiliser (in Gg a^{-1} N_2O-N)
N_{ex}	Total national N amount from animal excretions (in Gg a^{-1} N)

This definition does not take account of NH_3 and NO emissions from bedding material, while the German inventory does take account of bedding material. The N amount input via bedding material, and the resulting emissions, are covered by the N-flow concept used by Germany, however (cf. Chapter 6.1.2.4). To ensure the consistency of Germany's inventory results, they thus have to be taken into account in the definition of $Frac_{\mathrm{GASM}}$. These considerations lead to the definition of the value as reported by Germany, $Frac_{\mathrm{GASM,\,Germany}}$:

Equation 13: Definition of the value $Frac_{\mathrm{GASM,\,Germany}}$

$$Frac_{\mathrm{GASM,\,Germany}} = \frac{E_{\mathrm{NH3\text{-}N,\,MM}} + E_{\mathrm{NH3\text{-}N,\,grazing}} + E_{\mathrm{NO\text{-}N,\,storage}} + E_{\mathrm{NO\text{-}N,\,application}} + E_{\mathrm{NO\text{-}N,\,grazing}}}{m_{\mathrm{excr}} + m_{\mathrm{straw}}}$$

where

$Frac_{\mathrm{GASM,\,Germany}}$	Nitrogen fraction from animal excrement and bedding material (straw) that is emitted as NH_3-N and NO-N (in Gg Gg^{-1})
$E_{\mathrm{NH3\text{-}N,\,MM}}$	Emissions of NH_3-N from manure management (in Gg a^{-1} NH_3-N)
$E_{\mathrm{NH3\text{-}N,\,grazing}}$	Emissions of NH_3-N from grazing (in Gg a^{-1} NH_3-N)
$E_{\mathrm{NO\text{-}N,\,storage}}$	Emissions of NO-N manure storage (in Gg a^{-1} NO-N)
$E_{\mathrm{NO\text{-}N,\,application}}$	Emissions of NO-N as a result of manure application (in Gg a^{-1} NO-N)
$E_{\mathrm{NO\text{-}N,\,grazing}}$	Emissions of NO-N as a result of N excretions during grazing (in Gg a^{-1} NO-N)
m_{excr}	N amount excreted in animal husbandry (including grazing) (in Gg a^{-1} N)
m_{straw}	N amount introduced in animal husbandry via bedding material (straw) (in Gg a^{-1} N)

As a result of the aforementioned differences between the $Frac_{\mathrm{GASM}}$ definitions, it is not possible to confirm the indirect N_2O emissions (CRF-4.Ds1.3.1) as reported in the German inventory by inserting $Frac_{\mathrm{GASM,\,Germany}}$ into Equation 9 from IPCC (1996b)-4.112.

Because the relevant input data vary over time, $Frac_{\mathrm{GASM,\,Germany}}$ is not a constant (cf. Table 216).

Table 216: $Frac_{\mathrm{GASM,\,Germany}}$ (4.Ds2)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
$Frac_{\mathrm{GASM,\,Germany}}$	0.317	0.316	0.316	0.314	0.307	0.305	0.304	0.304	0.305	0.304
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$Frac_{\mathrm{GASM,\,Germany}}$	0.304	0.303	0.303	0.304	0.304	0.303	0.302	0.301	0.300	0.298
	2010	**2011**								
$Frac_{\mathrm{GASM,\,Germany}}$	0.296	0.296								

The values of $Frac_{\mathrm{GASM,\,Germany}}$ are slightly higher than they were in the NIR 2012. On the one hand, this results from an increase of NH_3 emissions as a result of updating of the N-flow concept and of inclusion of N_2O, NO and N_2 emissions from housing and storage (cf. Chapter 6.1.2.4), which inclusion has led to higher TAN levels for application. On the other hand, the higher $Frac_{\mathrm{GASM,\,Germany}}$ values are due to an increase of NO emissions from manure management. That increase has been indirectly caused by use of the new, higher N_2O emission factor, which, as a result of the prescribed proportionality (cf. Chapter 6.3.4.2.2), has required the NO emission factor to be higher as well.

6.5.2.2.2 The other Frac values

Except for $Frac_{LEACH}$, the Frac values described below are purely "diagnostic" entities that are not used for emissions calculation.

$Frac_{BURN}$ is not reported (NO), since field burning of crop residues is prohibited in Germany.

$Frac_{FUEL}$ is not reported (NO), since use of animal excrement as fuel is of no significance in Germany.

In keeping with the definition in CRF-4.Ds2, $Frac_{GRAZ}$ has been calculated as the ratio of N excreted during grazing to total N excretions. The $Frac_{GRAZ}$ values are somewhat higher than they were in the NIR 2012 because the allocation of cows for fattening and for slaughter has been changed (cf. Chapter 6.1.3.2); suckler cows spend greater amounts of time grazing than do heifers, to which cows for fattening and for slaughter were allocated through the NIR 2012.

Table 217: $Frac_{GRAZ}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{GRAZ}$	0.134	0.137	0.137	0.139	0.122	0.126	0.126	0.125	0.123	0.124
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$Frac_{GRAZ}$	0.123	0.121	0.118	0.116	0.115	0.113	0.112	0.110	0.110	0.109
	2010	**2011**								
$Frac_{GRAZ}$	0.109	0.107								

$Frac_{LEACH}$ shows the relative fraction of N soil inputs that is lost via leaching and surface run-off. For $Frac_{LEACH}$, a constant value of 0.30 kg kg^{-1} N has been used in the German inventory, in keeping with IPCC (1996b), p. 4.106.

$Frac_{NCRBF}$ describes the N fraction in dry matter of N-fixing plants. That fraction has been calculated as a weighted average of the contributions of field peas, broad beans, yellow lupins, clover, clover-containing mixtures, alfalfa, garden peas, bush beans and runner beans. In each case, the N content of the entire plant, included the parts harvested, has been used as a basis.

Table 218: $Frac_{NCRBF}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{NCRBF}$	0.0481	0.0490	0.0475	0.0473	0.0469	0.0450	0.0438	0.0430	0.0417	0.0406
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$Frac_{NCRBF}$	0.0417	0.0395	0.0402	0.0373	0.0395	0.0417	0.0424	0.0441	0.0437	0.0437
	2010	**2011**								
$Frac_{NCRBF}$	0.0434	0.0442								

$Frac_{NCR0}$ describes the N fraction in the dry matter of non-N-fixing plants (weighted mean from crop cultivation and horticulture). In each case, the N content of the entire plant, included the parts harvested, has been used as a basis.

Table 219: *Frac*$_{NCR0}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Frac$_{NCR0}$	0.0274	0.0265	0.0272	0.0272	0.0271	0.0264	0.0260	0.0253	0.0255	0.0248
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Frac$_{NCR0}$	0.0251	0.0241	0.0251	0.0234	0.0231	0.0240	0.0236	0.0245	0.0225	0.0224
	2010	**2011**								
Frac$_{NCR0}$	0.0232	0.0241								

In accordance with the definition in CRF-4.Ds2, *Frac*$_R$ / *Frac*$_{Remove}$ have been calculated as a fraction of the above-ground biomass that is removed as part of the harvest. That fraction can be usefully determined for those crops that form above-ground fruit. In the German inventory, it has been calculated for grain, rape, peas, beans, lupins and grasses. Root crops and vegetables have not been taken into account (the latter are not included for reasons of inadequate data). The quantities of straw that are used for bedding material (Chapter 6.1.3.6.5) have also not entered into calculation of *Frac*$_R$ and *Frac*$_{Remove}$.

Table 220: *Frac*$_R$ (*Frac*$_{Remove}$) (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Frac$_R$	0.65	0.64	0.64	0.64	0.63	0.63	0.64	0.63	0.63	0.62
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Frac$_R$	0.63	0.62	0.62	0.62	0.62	0.62	0.62	0.63	0.63	0.63
	2010	**2011**								
Frac$_R$	0.63	0.66								

6.5.2.3 Emissions (4.D)

The results of the relevant N_2O and NO emissions calculations are presented in Table 221. The time series for N_2O emissions from the various relevant sub-sources are shown in Table 225 in connection with recalculations.

Table 221: N_2O and NO emissions E_{N2O} and E_{NO} from agricultural soils (4s1, 4s2)

[Gg a^{-1} N_2O], [Gg a^{-1} NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{N2O}	154.1	142.6	136.8	135.7	127.1	134.1	134.8	135.1	136.3	139.5
E_{NO}	88.8	81.3	78.7	75.6	70.2	74.7	74.4	73.4	74.2	77.0
[Gg a^{-1} N_2O], [Gg a^{-1} NO]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
E_{N2O}	141.5	138.0	133.5	130.0	136.4	133.8	131.2	127.7	135.8	129.5
E_{NO}	79.5	75.6	73.4	73.0	73.5	72.2	71.9	67.4	72.8	66.3
[Gg a^{-1} N_2O], [Gg a^{-1} NO]	**2010**	**2011**								
E_{N2O}	126.9	135.1								
E_{NO}	66.5	72.0								

As Table 221 clearly shows, N_2O emissions decreased from 1990 to 1992. Thereafter, N_2O emissions fluctuate around a mean of 133.8 Gg a^{-1} N_2O. The pertinent emissions maximum, 154.1 Gg a^{-1} N_2O, occurred in 1990, while the minimum, 126.9 Gg a^{-1} N_2O, occurred in 2010. This trend is primarily reflects the year-to-year fluctuations in N_2O emissions from mineral-fertiliser application (cf. Table 224). Those fluctuations, in turn, result from the annual fluctuations in the quantities of mineral fertiliser applied (cf. Table 171).

For 2011, a share of 28.4 % of N_2O emissions from soils can be allocated to indirect emissions as a result of leaching and surface runoff; 24.7 % can be allocated to use of mineral fertilisers; 14.1 % can be allocated to crop residues; 11.6 %; 11.4 % can be allocated to cultivation of organic soils; and 11.1 % can be allocated to application of manure. The remainder, amounting to a total of 10 %, comprises emissions from pasture, range and paddock manure, sewage sludge and legumes, as well as indirect emissions resulting from deposition of reactive N species.

6.5.3 Source-specific QA/QC and verification (4.D)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Chapter 6.1.6 provides an overview of measures implemented relative to source-specific QA/QC and verification.

For purposes of verification, the following table compares the N_2O emission factors used for the present NIR 2013 with the corresponding figures, from last year, of neighbouring countries, including the UK (UNFCCC 2012). Apart from a few exceptions, all listed countries use the default emission factors of the IPCC (1996b).

Table 222: Comparison of the N_2O emission factors used in the German inventory with those of neighbouring countries

[kg kg^{-1} N_2O-N]	$EF_{N2O,}$ min_fert	$EF_{N2O,}$ manure	$EF_{N2O,}$ legumes	$EF_{N2O,}$ crop_residues	$EF_{N2O,}$ histosols *	$EF_{N2O,}$ grazing	$EF_{N2O,}$ deposition	$EF_{N2O,}$ leaching
Austria	0.0125	0.0125	0.0125	0.0125	NO	0.0200	0.010	0.0250
Belgium	0.0125	0.0125	0.0125	0.0125	8.00	0.0000	0.025	0.0000
Czech Republic	0.0125	0.0125	0.0125	0.0125	NO	0.0200	0.010	0.0250
Denmark	0.0125	0.0125	0.0125	0.0125	7.96	0.0125	0.000	0.0100
France	0.0125	0.0125	0.0125	0.0125	NO	0.0125	0.000	0.0100
Germany	**0.0125**	**0.0125**	**0.0125**	**0.0125**	**8.00**	**0.02**	**0.010**	**0.025**
Netherlands	0.0130	0.0087	0.0100	0.0100	4.70	0.0330	0.010	0.0250
Poland	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.010	0.0251
Switzerland	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.010	0.0250
UK	0.0112	0.0100	0.0125	0.0125	8.00	0.0200	0.016	0.0459
IPCC(1996)-3-4.89, 4.97, 4.105	0.0125	0.0125	0.0125	0.0125	5.00	0.0200	0.010	0.0250
IPCC (2000)-4.43, 4.60, 4.73	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.010	0.0250
IPCC(2006)-11.6, 11.11, 11.24	0.0100	0.0100	No method	0.0100	8.00	0.01 0.02	0.010	0.0075

* units: kg ha^{-1} N_2O-N

Source: Germany: Submission 2013; other countries: UNFCCC 2012

Table 223 compares the fractions $Frac_{GASF}$, $Frac_{GASM}$, $Frac_{GRAZ}$, $Frac_{LEACH}$, $Frac_{NCR0}$, $Frac_{NCRBF}$ and $Frac_{Remove}$, as determined for Germany, with the corresponding figures for countries that either are neighbours or have agricultural sectors that are comparable to that of Germany.

The spread seen in the case of $Frac_{GASF}$ can be explained as the result of differences in urea fractions. That possibility cannot be comprehensively assessed, however, since the different fertiliser types' shares of the total relevant fertiliser quantities is not known.

The spread seen in the case of $Frac_{GASM}$ is due to the differences, among neighbouring countries, in application techniques and time normally allotted to working fertiliser into the soil. The German $Frac_{GASM}$ value is the $Frac_{GASM, Germany}$ value defined in Chapter 6.5.2.2.1

With regard to $Frac_{LEACH}$, it is worthy of note that most neighbouring countries use the IPCC default value. Use of other $Frac_{LEACH}$ values cannot be understood without additional information. In principle, this also applies to *Frac*$_{NCR0}$, *Frac*$_{NCRBF}$ and *Frac*$_{R}$, although Germany calculates those values from the data used for emissions calculation.

Table 223: Comparison of the *Frac* values used in the German inventory with those of neighbouring countries

[kg kg^{-1}]	*Frac*$_{GASF}$	*Frac*$_{GASM}$	*Frac*$_{GRAZ}$	*Frac*$_{LEACH}$	*Frac*$_{NCR0}$	*Frac*$_{NCRBF}$	*Frac*$_{Remove}$
Austria	0.04	0.27	0.06	0.30	0.01	0.03	0.34
Belgium	0.04	0.21	0.31	0.12	0.02	0.03	0.50
Czech Republic	0.10	0.20	0.15	0.30	0.02	0.03	0.45
Denmark	0.02	0.19	0.08	0.33	0.02	0.04	0.86
France	0.10	0.20	0.41	0.30	0.01	0.03	NA
Germany	**0.04**	**0.30** [a]	**0.11**	**0.30**	**0.02**	**0.04**	**0.63**
Netherlands	0.05	0.09	0.16	0.12	NE	NE	NE
Poland	0.10	0.20	0.07	0.30	0.01	0.03	0.53
Switzerland	0.04	0.33	0.19	0.20	0.02	0.02	0.72
UK	0.10	0.20	0.52	0.30	0.02	0.03	0.45
IPCC(1996)-3-4.94, 4.106	0.100	0.200	Table 4-19	0.30	0.02	0.03	0.45
IPCC(2006)-11.13, 11.14, 11.24	0.100	0.200		0.30			

[1)] *Frac*$_{GASM, Germany}$ pursuant to Chapter 6.5.2.2.1

Source: Germany: Submission 2013; other countries: UNFCCC 2012

6.5.4 Uncertainties and time-series consistency (4.D)

With regard to the uncertainties in the area of N_2O emissions from agricultural soils, the reader's attention is called to Table 176 in Chapter 6.1.5 (total uncertainty of the German GG inventory).

For the NO emission factor for application of mineral fertiliser and manure, EMEP (2009)-4D-11, Table 3-1, gives an uncertainty range (95 % confidence interval) that corresponds approximately to a factor of 5. That factor is likely to be suitable for the NO emissions themselves (in light of the considerably lower uncertainty for the pertinent activity data).

According to EMEP (2007)-1020-15, the uncertainty factor for NO emissions from grazing could well be 5 or higher.

All emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and all data gaps have been filled in.

6.5.5 Source-specific recalculations (4.D)

In comparison to the NIR 2012, the following main changes have resulted (cf. Table 224 and Table 225):

- The N inputs from manure application are lower, throughout the entire time series. This is due primarily to the higher N losses from housing/storage resulting through use of the new, higher N_2O emission factor for solid manure (cf. Chapter 6.3.4.2.2). As a result of the required proportionality (cf. Chapter 6.3.4.2.2), use of that factor has also resulted in higher NO and N_2 emissions from housing and storage. These N losses are not offset by the other changes (animal performance; cf. Chapter 6.1.3.3; reallocation of cows for fattening and for slaughter, to suckler cows – cf. Chapter 6.1.3.1).

- The N inputs from grazing are slightly higher, throughout the entire time series, as a result of use of updated data in the area of animal performance (cf. Chapter 6.1.3.3) and of allocation of cows for fattening and for slaughter to suckler cows (cf. Chapter 6.1.3.1).
- The N inputs from crop residues are slightly lower, throughout the entire time series, as a result of increased straw removal from fields. The increase in straw removal results from allocation of cows for fattening and for slaughter to suckler cows, which require greater amounts of straw overall (cf. Chapters 6.1.3.1) and 6.1.3.6.2).
- The higher N inputs from deposition of reactive nitrogen are partly the result of an increase of animal N excretions, as well as of a related (to the increase of animal N excretions) increase in NH_3 and NO emissions from manure management (cf. Chapters 6.1.3.2 through 6.1.3.4). An additional increase of NH_3 emissions has resulted via updating of the N-flow concept and of inclusion of N_2O, NO and N_2 emissions from housing and storage (cf. Chapter 6.1.2.4), which inclusion has led to higher TAN levels for application. An additional increase of NO emissions from manure management has been indirectly caused by use of the new, higher N_2O emission factor, which, as a result of the prescribed proportionality (cf. Chapter 6.3.4.2.2), has required the NO emission factor to be higher as well.
- In the NIR 2013, the amount of N leached (including surface runoff) is higher for 1990 than it was in the NIR 2012, while for all other years it is lower than the figures reported in the NIR 2012. The difference for 1990 can be explained as a result of the higher weights for dairy cattle in the 4 largest eastern German Länder (cf. Chapter 6.1.3.3). The lower N amounts as of 1991 that are reported in the NIR 2013 are the result of higher N losses from solid-manure storage systems (via N_2O) and in application (via NH_3). The increase in N_2O emissions from manure management has been caused by use of the new, higher N_2O emission factor (cf. Chapter 6.3.4.2.2). The increase of NH_3 emissions has resulted via updating of the N-flow concept and via inclusion of N_2O, NO and N_2 emissions from housing and storage (cf. Chapter 6.1.2.4), which inclusion has led to higher TAN levels for application.
- The N input from sewage sludge has been updated for 2010 (cf. Chapter 6.1.4.1.1).
- The areas assigned to organic soils have been updated (cf. Chapter 6.1.4.1.2).
- In the area of N_2O emissions (cf. Table 225), the differences between the NIR 2012 and the NIR 2013 behave in keeping with the differences in the available N amounts (cf. Table 224) and – for organic soils – the differences in the relevant area values. This is due to the linearity in the emissions calculation (emissions = activity data * emission factor).

As a result of the above-described changes, the N_2O emissions from agricultural soils, as calculated for the NIR 2013, are always lower – with the exception of those for the year 1990 – than the corresponding figures reported in the NIR 2012.

Table 224: Comparison of N amounts, as reported in the NIR 2013 and as reported in the NIR 2012, used to calculate N_2O emissions from agricultural soils (4.D)

[Gg a^{-1} N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mineral fertilisers, 2013	2,089.3	1,943.3	1,863.1	1,744.9	1,552.9	1,720.8	1,702.7	1,689.9	1,718.2	1,827.7
Mineral fertilisers, 2012	2,089.3	1,943.3	1,863.1	1,744.9	1,552.9	1,720.8	1,702.7	1,689.9	1,718.2	1,827.7
Manure application, 2013	911.4	808.4	797.4	795.9	812.9	810.6	816.6	801.0	804.5	799.1
Manure application, 2012	913.6	821.0	810.5	808.6	823.1	821.0	827.8	811.1	814.2	807.8
Grazing, 2013	216.0	196.0	193.9	196.1	169.5	173.9	175.7	171.1	169.2	168.8
Grazing, 2012	206.4	191.7	190.7	192.9	166.7	170.8	173.3	168.6	166.2	166.1
Crop residues, 2013	840.3	801.6	727.0	801.4	739.4	784.5	813.4	855.2	857.5	867.3
Crop residues, 2012	841.4	802.4	727.6	802.1	740.0	785.2	813.9	855.8	858.2	867.7
N fixation, 2013	140.4	102.8	87.0	91.6	93.2	95.6	98.9	106.8	115.6	107.7
N fixation, 2012	140.4	102.8	87.0	91.6	93.2	95.6	98.9	106.8	115.6	107.7
Indirect, deposition 2013	600.3	535.5	524.6	522.5	496.4	501.7	503.6	495.5	499.8	500.3
Indirect, deposition 2012	587.7	529.0	518.6	516.5	491.0	496.1	498.5	490.5	494.3	494.5
Indirect, leaching, 2013	1,118.0	1,026.9	977.8	967.5	898.2	958.7	964.5	968.7	978.8	1,007.0
Indirect, leaching, 2012	1,116.7	1,029.6	980.8	970.5	900.4	961.0	967.1	971.0	980.9	1,008.8
Sewage sludge, 2013	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5
Sewage sludge, 2012	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5

[Gg a^{-1} N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mineral fertilisers, 2013	1,935.9	1,768.3	1,713.9	1,710.8	1,747.6	1,704.1	1,705.6	1,525.9	1,728.8	1,467.3
Mineral fertilisers, 2012	1,935.9	1,768.3	1,713.9	1,710.8	1,747.6	1,704.1	1,705.6	1,525.9	1,728.8	1,467.3
Manure application, 2013	790.6	805.1	788.1	783.2	768.4	773.6	761.0	772.2	775.9	781.9
Manure application, 2012	800.0	813.9	797.6	792.4	777.6	782.5	770.2	781.7	785.6	791.4
Grazing, 2013	165.0	165.4	156.4	152.6	148.1	145.4	141.3	140.3	140.8	140.4
Grazing, 2012	162.0	161.9	153.7	150.1	145.7	143.1	139.2	138.7	139.3	139.0
Crop residues, 2013	851.3	881.3	828.4	728.2	932.9	890.5	828.5	890.4	956.4	999.6
Crop residues, 2012	851.9	882.0	829.0	728.7	933.4	890.9	828.9	890.7	956.7	999.9
N fixation, 2013	95.6	102.3	97.5	95.5	91.7	94.7	92.7	83.2	76.4	78.3
N fixation, 2012	95.6	102.3	97.5	95.5	91.8	94.7	92.7	83.2	76.4	78.3
Indirect, deposition 2013	497.4	503.9	492.1	488.7	483.0	476.8	472.4	470.9	474.2	478.6
Indirect, deposition 2012	491.9	497.7	486.6	483.1	477.5	471.6	467.6	467.4	471.6	476.6
Indirect, leaching, 2013	1,025.6	993.7	956.8	926.8	984.8	963.1	942.0	911.1	982.0	926.0
Indirect, leaching, 2012	1,027.6	995.5	958.9	928.8	986.8	965.1	944.1	913.4	984.3	928.3
Sewage sludge, 2013	33.0	29.9	28.2	29.3	28.3	27.4	27.0	27.8	27.7	27.9
Sewage sludge, 2012	33.0	29.9	28.2	29.3	28.3	27.4	27.0	27.8	27.7	27.9

[Gg a^{-1} N]	2010	2011
Mineral fertilisers, 2013	1,499.3	1,701.6
Mineral fertilisers, 2012	1,499.3	
Manure application, 2013	775.8	775.5
Manure application, 2012	780.0	
Grazing, 2013	138.4	135.0
Grazing, 2012	136.6	
Crop residues, 2013	905.2	969.2
Crop residues, 2012	905.5	
N fixation, 2013	77.0	79.6
N fixation, 2012	77.0	
Indirect, deposition 2013	457.4	469.8
Indirect, deposition 2012	454.4	
Indirect, leaching, 2013	907.0	977.7
Indirect, leaching, 2012	907.7	
Sewage sludge, 2013	28.4	28.4
Sewage sludge, 2012	27.9	

Table 225: Comparison of N_2O emissions from agricultural soils as reported in the NIR 2013 and as reported in the NIR 2012 (4.D)

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{N2O} total, 2013	154.1	142.6	136.8	135.7	127.1	134.1	134.8	135.1	136.3	139.5
E_{N2O} total, 2012	153.7	142.7	137.0	135.9	127.2	134.2	135.0	135.2	136.4	139.6
Mineral fertilisers, 2013	41.0	38.2	36.6	34.3	30.5	33.8	33.4	33.2	33.7	35.9
Mineral fertilisers, 2012	41.0	38.2	36.6	34.3	30.5	33.8	33.4	33.2	33.7	35.9
Manure application, 2013	17.6	15.6	15.4	15.4	15.7	15.7	15.8	15.5	15.6	15.5
Manure application, 2012	17.7	15.9	15.7	15.6	15.9	15.9	16.0	15.7	15.8	15.6
Grazing, 2013	6.8	6.2	6.1	6.2	5.3	5.5	5.5	5.4	5.3	5.3
Grazing, 2012	6.5	6.0	6.0	6.1	5.3	5.4	5.5	5.3	5.2	5.2
Crop residues, 2013	16.5	15.7	14.3	15.7	14.5	15.4	16.0	16.8	16.8	17.0
Crop residues, 2012	16.5	15.8	14.3	15.8	14.5	15.4	16.0	16.8	16.9	17.0
Organic soils, 2013	15.5	15.5	15.5	15.6	15.6	15.6	15.6	15.6	15.6	15.6
Organic soils, 2012	15.5	15.5	15.5	15.6	15.6	15.6	15.6	15.6	15.6	15.6
N fixation, 2013	2.8	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.3	2.1
N fixation, 2012	2.8	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.3	2.1
Indirect, deposition 2013	9.4	8.4	8.2	8.2	7.8	7.9	7.9	7.8	7.9	7.9
Indirect, deposition 2012	9.2	8.3	8.1	8.1	7.7	7.8	7.8	7.7	7.8	7.8
Indirect, leaching, 2013	43.9	40.3	38.4	38.0	35.3	37.7	37.9	38.1	38.5	39.6
Indirect, leaching, 2012	43.9	40.4	38.5	38.1	35.4	37.8	38.0	38.1	38.5	39.6
Sewage sludge, 2013	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.6	0.6
Sewage sludge, 2012	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.6	0.6
[Gg a^{-1} N_2O]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
E_{N2O} total, 2013	141.5	138.0	133.5	130.0	136.4	133.8	131.2	127.7	135.8	129.5
E_{N2O} total, 2012	141.6	138.0	133.6	130.1	136.5	133.9	131.4	127.9	136.0	129.7
Mineral fertilisers, 2013	38.0	34.7	33.7	33.6	34.3	33.5	33.5	30.0	34.0	28.8
Mineral fertilisers, 2012	38.0	34.7	33.7	33.6	34.3	33.5	33.5	30.0	34.0	28.8
Manure application, 2013	15.3	15.6	15.3	15.2	14.9	15.0	14.7	14.9	15.0	15.1
Manure application, 2012	15.5	15.8	15.4	15.3	15.1	15.1	14.9	15.1	15.2	15.3
Grazing, 2013	5.2	5.2	4.9	4.8	4.7	4.6	4.4	4.4	4.4	4.4
Grazing, 2012	5.1	5.1	4.8	4.7	4.6	4.5	4.4	4.4	4.4	4.4
Crop residues, 2013	16.7	17.3	16.3	14.3	18.3	17.5	16.3	17.5	18.8	19.6
Crop residues, 2012	16.7	17.3	16.3	14.3	18.3	17.5	16.3	17.5	18.8	19.6
Organic soils, 2013	15.6	15.6	15.6	15.6	15.5	15.5	15.5	15.5	15.5	15.5
Organic soils, 2012	15.6	15.6	15.6	15.6	15.5	15.5	15.5	15.5	15.5	15.5
N fixation, 2013	1.9	2.0	1.9	1.9	1.8	1.9	1.8	1.6	1.5	1.5
N fixation, 2012	1.9	2.0	1.9	1.9	1.8	1.9	1.8	1.6	1.5	1.5
Indirect, deposition 2013	7.8	7.9	7.7	7.7	7.6	7.5	7.4	7.4	7.5	7.5
Indirect, deposition 2012	7.7	7.8	7.6	7.6	7.5	7.4	7.3	7.3	7.4	7.5
Indirect, leaching, 2013	40.3	39.0	37.6	36.4	38.7	37.8	37.0	35.8	38.6	36.4
Indirect, leaching, 2012	40.4	39.1	37.7	36.5	38.8	37.9	37.1	35.9	38.7	36.5
Sewage sludge, 2013	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
Sewage sludge, 2012	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
[Gg a^{-1} N_2O]	**2010**	**2011**								
E_{N2O} total, 2013	126.9	135.1								
E_{N2O} total, 2012	127.0									
Mineral fertilisers, 2013	29.5	33.4								
Mineral fertilisers, 2012	29.5									
Manure application, 2013	15.0	15.0								
Manure application, 2012	15.1									
Grazing, 2013	4.4	4.2								
Grazing, 2012	4.3									
Crop residues, 2013	17.8	19.0								
Crop residues, 2012	17.8									
Organic soils, 2013	15.5	15.4								
Organic soils, 2012	15.5									
N fixation, 2013	1.5	1.6								
N fixation, 2012	1.5									
Indirect, deposition 2013	7.2	7.4								
Indirect, deposition 2012	7.1									
Indirect, leaching, 2013	35.6	38.4								
Indirect, leaching, 2012	35.7									
Sewage sludge, 2013	0.6	0.6								
Sewage sludge, 2012	0.5									

6.5.6 Planned improvements (4.D)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

6.6 Prescribed burning of savannas (clearance of land by prescribed burning) (4.E)

Land clearance by prescribed burning is not practiced in Germany (NO).

6.7 Field burning of agricultural residues (4.F)

Burning of agricultural residues is prohibited in Germany. It is not possible to collect data on permitted exceptions. Such exceptions are considered to be irrelevant (NO).

7 LAND USE, LAND USE CHANGES AND FORESTRY (CRF SECTOR 5)

7.1 Overview (CRF Sector 5)

7.1.1 Source categories and total emissions and sinks, 1990 - 2011

In Germany, source category 5, Land Use, Land Use Changes and Forestry, includes CO_2 emissions and sinks of the carbon pools above-ground and below-ground biomass, dead wood, litter and soils from the categories Forest Land (5.A), Cropland (5.B), Grassland (5.C), Wetlands (5.D), Settlements (5.E) and the relevant land-use changes. In the category Other Land (5.F), no anthropogenic emissions and sinks occur, since the relevant land areas are not used. No land-use changes to Other Land occur, since, by definition, land in use cannot be returned to the category "unused land". CH_4 and N_2O from forest fires are taken into account in the land-use category Forest Land[72]. No nitrogen fertilisation in forests takes place in Germany. On the other hand, inventories are taken of N_2O emissions from: drained organic soils in the category Forest Land; humus mineralisation in mineral soils in connection with categories of conversion to Cropland; and CO_2 from liming. In wetlands, industrial peat extraction is taken into account. N_2O emissions from land-use changes on organic soils, leading to cropland and grassland, are reported in CRF Sector 4.D.

Figure 46, Figure 47 and Figure 48 provide an overview, for the present NIR 2013, of the development over time of greenhouse-gas emissions in categories 5.A, 5.B, 5.C, 5.D and 5.E, differentiated by sub-categories, pools and greenhouse gases.

The x axis consists of all the years covered by the report, while the y axis consists of a scale for emissions (positive values) and removals (negative values), expressed in Gg CO_2 equivalents.

[72] CO_2 emissions from forest fires are taken into account implicitly, via carbon-stock changes in Forest Land.

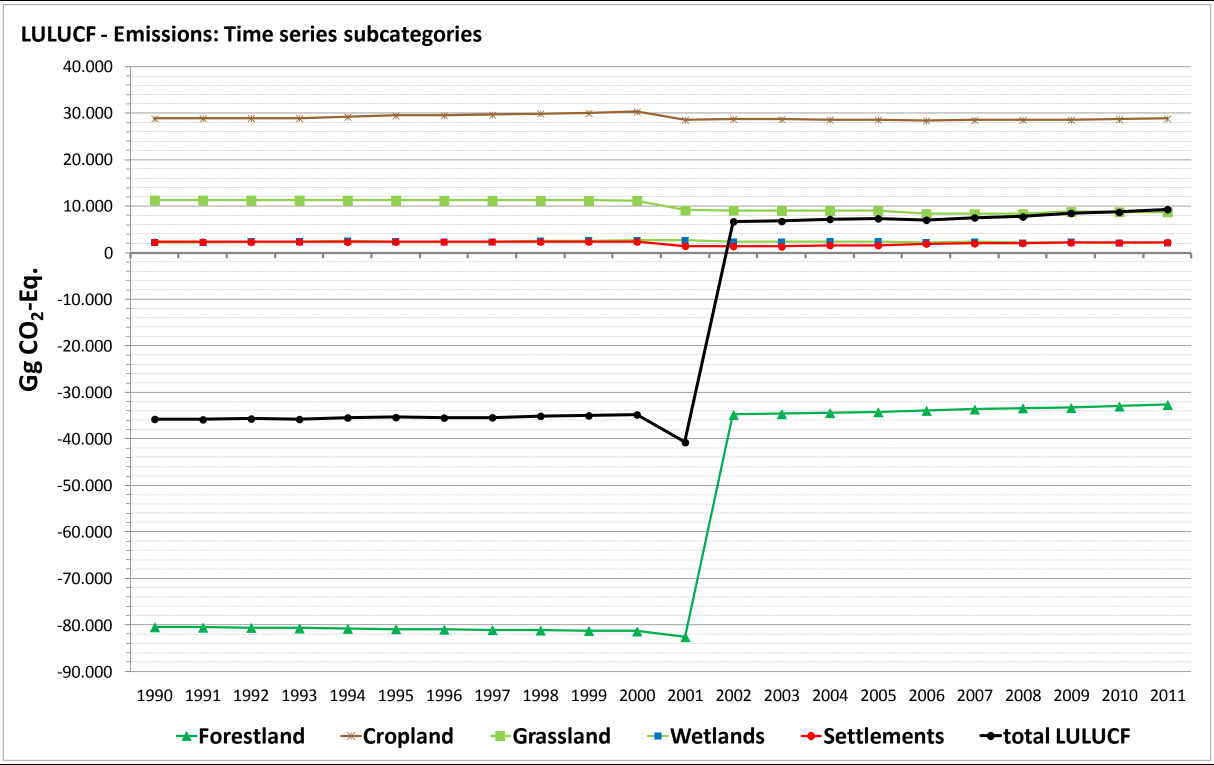


Figure 46: Time series for greenhouse-gas emissions and sinks [Gg CO_2 equivalents] in the LULUCF sector since 1990, differentiated by sub-categories

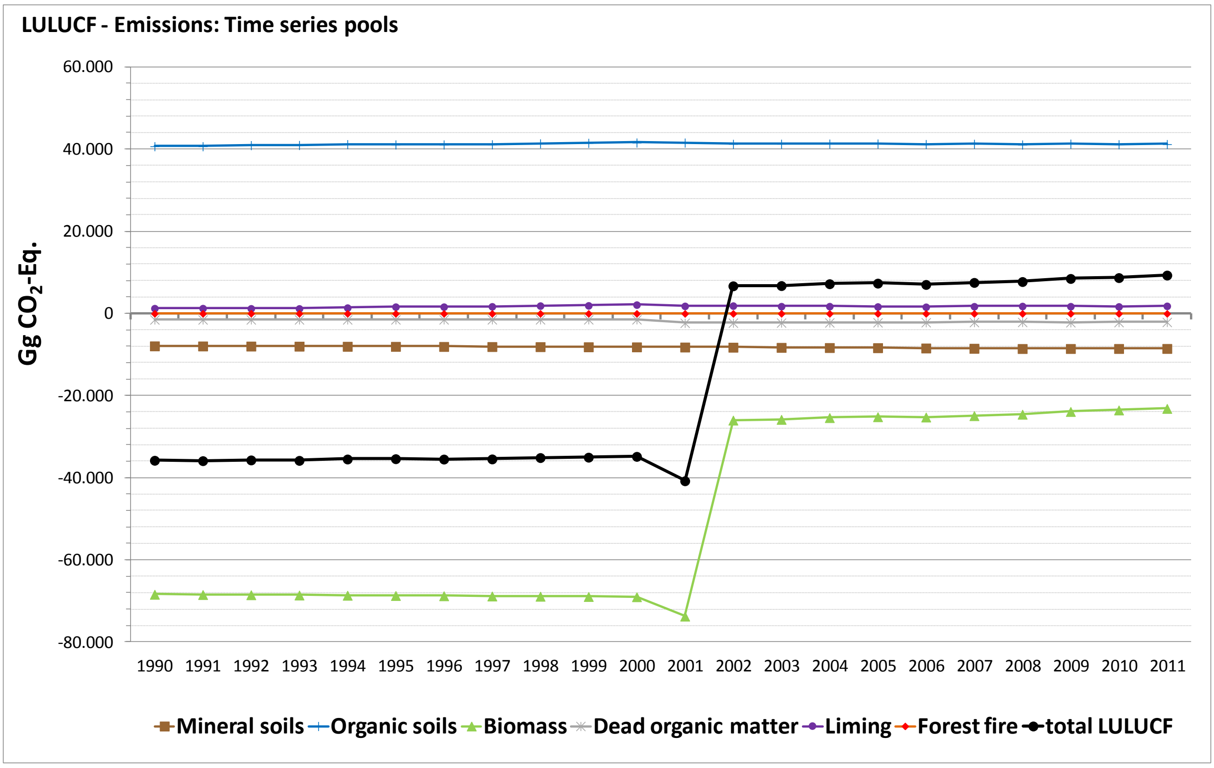


Figure 47: Time series for greenhouse-gas emissions and sinks [Gg CO_2 equivalents] in the LULUCF sector since 1990, differentiated by source categories

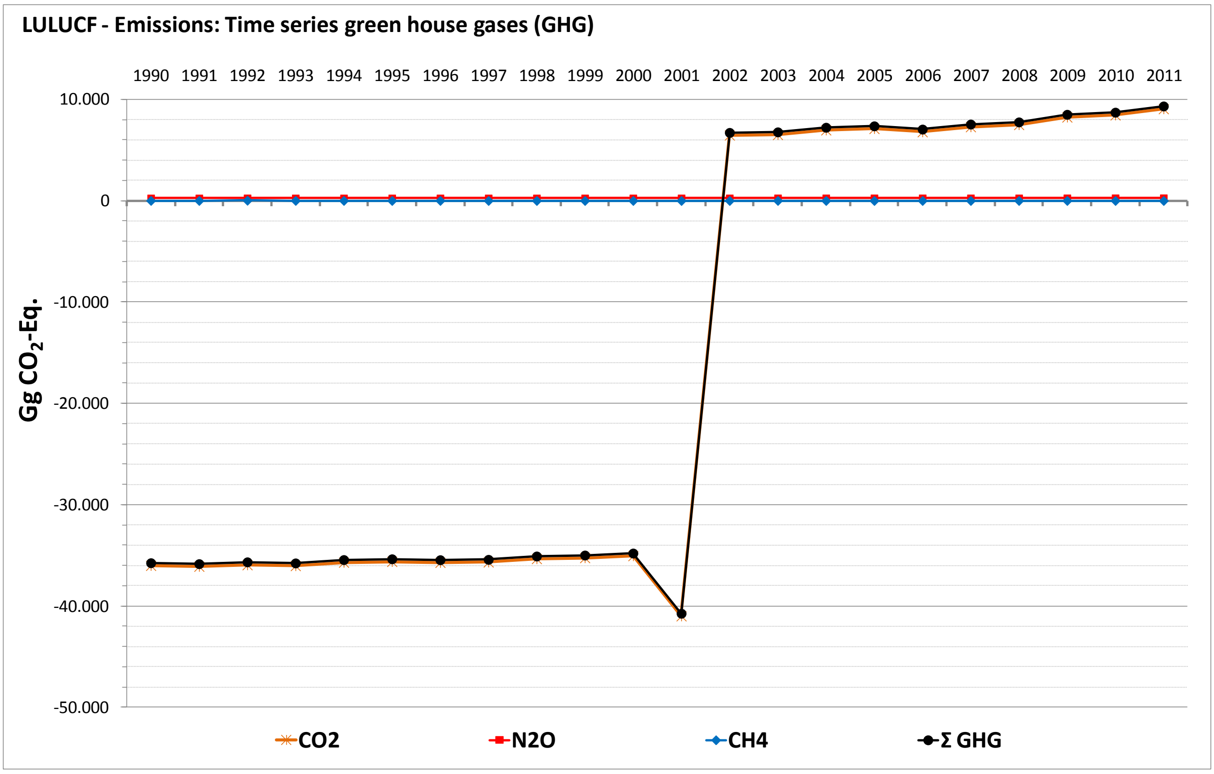


Figure 48: Time series for greenhouse-gas emissions and sinks [Gg CO_2 equivalents] in the LULUCF sector since 1990, differentiated by greenhouse gases

The total uncertainty for the German LULUCF inventory is 17.4 %, while that for the trend is 4.95 %. The relevant details are presented in the relevant chapters for the individual categories and in Chapter 19.5.4.

7.1.2 Methodological issues

The calculation methods used in CRF Sector 5 last year have been retained for the present Submission. Changes occurred only in the input data for emissions calculations. The following changes have been made relative to emission factors and activity data:

- New database for determination of activity data for the years 2009 – 2011
- In the present submission, the final results of the second National Forest Soil Inventory (BZE 2), have been used, for the first time. As a result, the provisional emission factors for carbon and nitrogen stocks of forest soils, and the figures for such stocks' changes over time, have been replaced with the BZE 2's analysis results. Similar action has been taken with regard to litter.
- Correction of the biomass emission factors for woodlands, perennial crops and annual crops

Germany reports in a total of eight LULUCF categories; relevant precise definitions and descriptions are provided in Chapter 7.1.4 (cf. also Chapter 7.1.3).

Table 226: Correlation of the German reporting categories with the IPCC land-use categories

IPCC category	German LULUCF categories	
Forest Land	Forest land	
Cropland	Cropland	
Grassland	Grassland (in a strict sense) (i.s.s.) Woody grassland	
Wetlands	Terrestrial wetlands	Terrestrial wetlands Peat extraction
	Waters	
Settlements	Settlements	
Other land	Other land	

Basic elements of the LULUCF inventory, and the steps required to prepare it

1. **Land-use matrix$_{\mathbf{annual}}$** *[Area_ann]*: Annual calculation of the total areas for the subcategories "final land use" and "land-use change", in each of the categories Forest land, Cropland, Grassland (in a strict sense), Woody grassland, Terrestrial wetlands, Waters, Settlements and Other land, and, for all time series, with differentiation by mineral and organic soils. The relevant land uses, and the specific areas assigned to them, were explicitly determined for the years 1990, 2000, 2005, 2008 and 2011. For the time periods between those years, the applicable areas were linearly interpolated (cf. Chapter 7.1.3).

2. **Emission factors for total carbon stocks in a year of a land-use change** *[EF_ann]*: The emission factors for the various pools have been differentiated by land-use categories. They are shown in Table 235 (mineral soils), Table 237 (biomass), Table 238 (forest biomass (deforestation), dead wood and litter) and Chapter 7.1.6.2 (organic soils). In most cases, the carbon stocks, i.e. their rates of increase or decrease per area unit, are constant over time. That means that the same conditions will apply to all parts of one and the same total time series.

3. **Carbon-stock changes for annual land-use changes** *[E_ann]* are calculated using the formula **E_ann [Gg C] = EF_ann [Mg C/ha]* Area_ann [kha]**, under the assumption that, in each case, the entire carbon-stock change occurs in the year of the land-use change.

4. **Introduction of a twenty-year transition period** *[Area_20y]*: The relevant areas are shown in the CRF tables Table 231 and Table 232. The land-use-matrix calculation is referenced to the fictitious reference year 1970, to make it possible to determine land-use-change areas for years prior to the period covered by the report (cf. Chapter 7.1.3.4). Identified areas on which conversion occurs are assigned to the relevant land-use-change category, in the year in which the land-use change takes place, and they remain in that category, a transition category, for 20 years. Consequently, the areas in the final-use categories are smaller, in each case, than the corresponding areas in the annual land-use matrix, while the areas in the transition categories are larger than those areas.

5. **Emission factors** *[EF]* **and implied emission factors** *[IEF]* **for the twenty-year transition period** *[IEF_20y]*: These factors are listed in the CRF tables. In a spreadsheet program, annual emission factors are converted into emission factors, and implied emission factors, that are suitable for the land-use matrix areas with 20-

year transition periods. The calculations can be checked, step-by-step, in the individual spreadsheet-program worksheets. Conversion of *EF_ann* to *IEF_20y*, following inclusion of the mineral-soil and organic-soil areas for emissions from pools that are taken account of completely in the year of the relevant land-use change, yields adjusted IEFs. Although the absolute emissions remain unchanged as this occurs, the IEFs are influenced by the annual net changes in the areas in the transition categories. The following formulae are used:

- **Mineral soils**: The entire carbon-stock change as a result of a land-use change is linearly distributed, using the formula *IEF_20y = EF_ann / 20*, over the 20-year transition period; i.e. only one twentieth of the total emissions are added annually.
- **Organic soils**: The same quantity of CO_2 is emitted each year; in the transition categories, that quantity is identical to the emissions for the final-use category for the new land use; *IEF_20y = EF_ann*.
- **Net carbon-stock change, carbon-stock increases and decreases in biomass and dead organic matter**: All emissions are taken account of completely in the year of the land-use change, in keeping with the formula *IEF_20y = E_ann / Area_20y*. The emissions that occur in a specific report year are thus adjusted in accordance with the larger area of the relevant transition category.
- **N_2O from loss of organic matter in mineral soils, as a result of land-use changes to cropland**: The method used for this is the same as is used for calculation of carbon-stock losses in mineral soils. The entire carbon-stock change as a result of a land-use change is linearly distributed over the 20-year transition period, in keeping with the formula *IEF_20y = E_ann / Area_20y*; i.e. only one twentieth of the total emissions are added each year.

6. **Total carbon-stock changes for areas with twenty-year transition periods** are also calculated, for purposes of the UN Framework Convention on Climate Change, using a spreadsheet program, and in accordance with the following formula: *E_20y [Gg C] = IEF_20y [Mg C/ha]* Area_20y [kha]*
7. **Calculation of CO_2 emissions** for the UNFCCC Inventory, via multiplication of carbon-stock changes by the factor -44/12.

7.1.3 Method for obtaining the land-use matrix

7.1.3.1 Introduction

In the 2012 Submission, a consistent, unified method was introduced for taking account of land-use changes in the LULUC sector and the forestry sector. This expands the existing sample-based system for determining forest land, and land-use changes to and from forest land, for all land-use categories and changes. The new system is based on the grid of the National Forest Inventory (BWI) 3.

7.1.3.2 Database and data processing

The flexible LULUCF survey system consists of all available geographically explicit data sets. For a data source to be usable in the system, its pertinent land-use classes, as obtained via interpretation or modelling, have to be transferable into the LULUCF system. At the same time, a data set does not have to cover all of the land-use classes; it simply has to include at least one of the six main land-use classes. Each sample point has a set of associated data distributed over time. Such data sets differ with regard to their numbers of data items, to their quality with respect to errors of position, preparation and interpretation and, in some cases, with regard to their underlying definitions.

The aims with this flexible LULUCF data-collection system thus do not include recording land-use changes as often as possible. Instead, they comprise the following:

- from the wealth of available information, to identify the most reliable land-use information,
- to filter out and detect land-use changes,
- to eliminate any possible uncertainties and sources of error.

An unambiguous hierarchy system has thus been introduced with those aims in mind. Within that system, data records have been arranged into a hierarchy of groups beginning with the most precise data (1st quality level) and leading to the least precise data (nth quality level), with precision in each case determined as of the relevant time of data collection. Within the hiearchical system, each entry refers to the state of land use in the year in which the relevant data source was collected, rather than to the pertinent change over one year or one period. If, for a given year and one given sample point, several different land-use data items are available, from different data sources, then the data record with the highest quality level (QL), pursuant to the hierarchy system, is used to define the pertinent land-use class. Where data sources with the same quality level show different land-use categories, additional rules for applicable decision-making have been defined and documented. Such rules can be oriented to references such as verification data – for example, trends shown in agricultural statistics – that are not available in georeferenced form.

7.1.3.2.1 Data sources

The following data sources / records have been used:

- Information relative to the forest-oriented LULUCF classes from the National Forest Inventory (Bundeswaldinventur) 1 and 2, for the period 1987 to 2002 for the old German Länder; and from the data of the National Forest Inventory 2 and the Inventory Study (Inventurstudie) 2008 (OEHMICHEN et al. 2011), for 2002 to 2008 for all Germany,
- The Basic Digital Landscape Model (Digitales Basis-Landschaftsmodell; Basis-DLM) for the years 2000, 2005, 2008 and 2011,
- CORINE 1990, 2000, 2006,
- GSE data for 1990, and for 2002 to 2006, for the new German Länder.

1st quality level: BWI data

Details relative to the National Forest Inventory (BWI) are described in Chapter 7.2.2.1. The BWI is a permanent, systematic cluster sample that is collected periodically. At present, BWI data are available referenced to 1987 and 2002 and, in a sub-sample, to 2008 (Inventory

Study 2008). The next BWI, which will be available as of the conclusion of the first commitment period in 2012, will provide new information. Land uses, and land-use changes leading to forest (afforestation) or away from forest (deforestation), are determined for each sample point, with the help of aerial photographs and country-specific map sets. The basis for relevant reporting, pursuant to the UN Framework Convention on Climate Change, consists of the definition of "forest" used by the National Forest Inventory (BMVEL, 2001); cf. Chapter 7.2.3.

The first German report under the Kyoto Protocol uses the following definition of "forest", which accords with the relevant FAO definition:

- Land with tree crown cover of more than 10% of the area;
- The minimum land area to be taken into consideration is 0.1 ha;
- The potential tree height is at least 5 meters.

Within the limits defined by the Marrakesh Accords, that definition is the one that comes closest to the definition used in the National Forest Inventory. Studies (TOMTER et al. 2010) comparing activity-data calculations using the aforementioned definitions have found that the resulting discrepancies are negligible. For that reason, the same area-estimation algorithms have been used for purposes of both the UN Framework Convention on Climate Change and the Kyoto Protocol. At the same time, in a departure from the BWI definition of "forest", areas that the BWI counts as forest, but places in the forest category non-woodland, i.e. because they are not permanently non-wooded, were not taken into account in the forestry sector in calculation of carbon stocks and carbon-stock changes.

For the new German Länder, no forest / non-forest information was available for the year 1987 at the relevant BWI points. In the interest of obtaining a maximally consistent database for the new German Länder, the individual-tree data of the BWI 2002 were used in the following manner: for 1987, the sample points were retroactively assigned to the land-use class Forest Land for those cases in which the BWI 2002, at the pertinent forest cluster points, listed trees that were more than 15 years old.

2nd quality level: Basis-DLM data

The Basic Digital Landscape Model (Basis–Digitale Landschaftsmodell; Basis-DLM) is the basis for Germany's Official Topographical-Cartographical Infomation System (Amtliches Topographisch-Kartographischen Informationssystem; ATKIS®), which is managed by the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV). The ATKIS® system describes Germany's topography in terms of digital landscape and terrain models. "The Basis-DLM uses a vector format to describe topographic objects of the landscapes and the relief of the earth's surface. Each object is assigned to a specific object type and defined in terms of its spatial position, geometric type, descriptive attributes and relations to other objects. Each object has an identification number (identifier) that is unique throughout all objects for Germany. In the Basis-DLM, spatial position is given true to scale, and independently of any representations, within the coordinate system used for land surveying. The object types contained in the DLM, and the manner in which the objects are to be formed, are defined in the ATKIS® object-type catalogue (ATKIS®-OK)" (AdV). The informational spectrum of the Basis-DLM is oriented to the contents of standard 1:25,000 topographic maps. At the same time, the Basis-DLM features greater precision of position (± 3m) for the most important point-shaped and line-shaped objects. Data of the

Basis-DLM systems of the Länder are adopted by the Federal Agency for Cartography and Geodesy (BKG) and then checked, harmonised, georeferenced and processed, without any overlapping, for use within a nationally standardised Basis-DLM. The BKG also manages the data, within a special database, for purposes of provision to federal authorities and other agencies.

The purpose of ATKIS® is to provide a landscape model (land cover) of Germany, with regularly updated and expanded geometries and content, that is maximally up-to-date and has the highest resolution possible. The surveying administrations of the Länder collect the pertinent data on an ongoing basis; they do not collect data as of a given key date, nor do they collect on a national basis. As a result, new surveying results are continuously transmitted to the Federal Agency for Cartography and Geodesy (BKG) and integrated within ATKIS®. The data are completely revised, at the Länder level, every five years or as otherwise necessary. For areas of central current interest, especially with regard to changes – for example, settlement and transport areas – efforts are normally made to transfer relevant data into the ATKIS® system within 3 – 12 months. The Basis-DLM version maintained and managed by the BKG is always the latest version. No pertinent history data are recorded, nor are old versions archived.

For the relevant Thünen institutes, this means:

- Basis-DLMs are obtained on an annual basis; the Basis-DLM for a given report year is obtained in September of that year;
- In each case, the version for the current year is archived.

Basis-DLM data sets have been available on an annual basis to the Thünen institutes only since 2005. One data set is available for the year 2000. No ATKIS® data exist for years prior to 2000.

Each data set in the Basis-DLM comprises some 800 individual layers of differing degrees of detail. For example, polygons with relatively low resolution (such as those showing settlement areas) are found on the lowest level, while polygons with very high resolution and rich detail (such as those showing residential areas) are found on the highest level. A single record thus will contain numerous superimposed polygons that, in terms of content, can be assigned to the same LULUCF categories. All such related content, with all overlays, is read into the system as a whole. As a result, data gaps occur only where the entire pertinent Basis-DLM data record contains no data. In a subsequent step, the areas so defined are merged with the points of the BWI network. Where a point touches several stacked areas, only a single value is chosen, with the help of a priority list. Where the same priorities overlap (for example, vegetation with vegetation), then that area with the lower ATKIS® identification value is used. The procedure has been carried out for the Basis-DLM records from the years 2000, 2005, 2008 and 2011. The Basis-DLM categories are assigned to the LULUCF classes with the help of a key table (cf. also Table 234).

3rd quality level: CORINE Land Cover (CLC) data

CORINE Land Cover (CLC) is a European remote-sensing project, initiated by the EU Commission, for standardising classification of land use and land-use changes. In a process underway since the 1980s, digital satellite images of 32 member states of the European

Environment Agency (EEA)[73] are being recorded in a standardised format and evaluated with regard to land use. Image data collected in three different years, 1990, 2000 and 2006, are available. CORINE data for the years 1990, 2000 and 2006 have been read into the database with the help of a script. The CORINE classes are allocated to LULUCF classes with the help of a translation table (cf. also Table 234).

4th quality level: GSE data

The GSE Forest Monitoring project is part of the Global Monitoring for Environment and Security (GMES) programme, which was established in 1998 by the European Commission and the European Space Agency (ESA). In the framework of the GSE Forest Monitoring project, the service "Forest Monitoring: Inputs for national greenhouse-gas reporting (GSE FM-INT; "Wald Monitoring: Inputs für die Nationale Treibhausgasberichterstattung") has been introduced for the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV). The products of that service have included maps of forest cover, land use and land-use changes, for 1990 and for pertinent changes through 2002 and 2005/06; area statistics; and error analyses for the new German Länder (GSE 2003, GSE 2006, GSE 2007, GSE 2009). Further information about the GSE FM-INT project is provided in OEHMICHEN et al. (2011b). For 1989 and 1990, Landsat satellite data were used. For 2001 to 2005, LISS data from the Indian IRS satellites were also used. Forest areas and their changes were classified with the help of Basis-DLM data, aerial photographs, topographic maps and elevation models. Following radiometric and geometric processing of the satellite data, the relevant structures were allocated to LULUCF classes via a monitored classification process. Subsequently, any obvious errors were corrected with the help of additional data sources, such as topographic maps, and any smaller artifacts were removed with filters or by manual retouching. Quality control was carried out on a random-sample basis, using orthophotos. According to the project specifications, all land areas and land-use changes entered into the system have to cover a minimum area of 0.5 hectares. The original data available to the Johann Heinrich von Thünen Institute (TI) include land areas and land-use changes smaller than 0.5ha, and down to a pixel size of 25m x 25m. Such smaller units may be considered similar to the "minimum mapping units" used in the National Forest Inventory (BWI). For purposes of the method used in the present context, the LULUCF categories were divided into land-use classes for the years 1990 and 2005. **The GSE data diffentiate solely according to the categories "forest land" and "non- forest land"**.

7.1.3.2.2 Derivation of LULUCF information

Each sample point is assigned the pertinent available information relative to land use for each year and data source. Then, classification in keeping with the LULUCF categories can begin. This is achieved via retrospective and prospective comparison – with reference to the year under consideration – to determine the time for each point at which land-use information on the highest available quality level is available (QL-MAX retrospective and QL-MAX prospective). This means, for example, that for a BWI point designated as forest to which a land-use class is to be assigned for 2001, data on the 1st quality level are available – the BWI information. Retrospectively, the last survey year for those data is 1987; prospectively,

[73] The 32 EEA member states include the 27 Member States of the European Union as well as Iceland, Liechtenstein, Norway, Switzerland and Turkey.

the next survey year is 2002. The LULUCF category is then derived from those two land-use classes, for the years 1987 and 2002.

Sampling points at which the BWI data show "forest" were validated via on-site inspections during the forest inventories and may be considered correct. The Basis-DLM data for 2011 are also considered current and quality-assured, since that project used a strictly hierarchical nomenclature (and was the first to do so). All other records have been reviewed for plausibility of the assigned land-use class, for a given year, on the basis of additional data, and in keeping with the following criteria:

- Can the classification into a specific LULUCF category be substantiated with pertinent data from a lower quality level?
- Is the time series for the land-use categories for the sample point consistent, i.e. is the land use free of multiple changes? In cases with inconsistencies, the land-use change was placed in the relevant valid category for 2011.
- Following placement in a LULUCF category, cases involving land-use changes were reviewed to determine whether data of lower quality levels could be used to narrow down the time period in which the change must have occurred.
- To provide an additional criterion, the national trend in land-use changes (except for those changes to and from forest land) was compared with the national net land-use-change rates obtained via the periodic land inventories and agricultural-structural inventories of the Federal Statistical Office. Those inventories use land-use-category definitions that differ – widely, in some cases – from those used in the present system.

In the following, an example is provided to illustrate the manner in which the time period in which a land-use change occurs is narrowed down. Let us assume that, on the basis of BWI data, a sample point was classified as forest land in 1987 and as settlements in 2002. If no additional data are available, the land-use change is linearly interpolated between those two years, meaning that 1/15 of the represented area would be converted each year from forest land to settlements. If Basis-DLM data are available for the point, and those data also show the category "forest land" for 2000 and also show the category "settlements" for 2005, then placement in the LULUCF class "forest land converted to settlements" would be logical and justified, and the change period could be narrowed down to 2 years (2000 = forest land in the Basis-DLM and 2002 = settlements pursuant to BWI) (cf. also Figure 49).

For each sample point and time, the process of selecting a land-use category – i.e. of carrying out relevant review and decision-making – has been carried out transparently, on the basis of a decision tree (cf. Chap. 7.1.3.4.1).

For conformity with GPG 2003, under the UN Framework Convention on Climate Change one must take account of land-use changes since 1970. The purpose of that requirement is to prevent land accumulation in the 20-year conversion classes from beginning in 1990, increasing continuously until 2009 and only then commencing to oscillate. At present, the earliest georeferenced data available for Germany date from the BWI 1987; and, in general, for the period prior to 1990, no complete and internally consistent (the latter aspect is even more important) national data sets are available. Consequently, the changes in all land-use categories in the period 1990 - 2000 were extrapolated retroactively to 1970. That approach is in keeping with that used, for example, by the Czech Republic and by Austria for the land-use matrix.

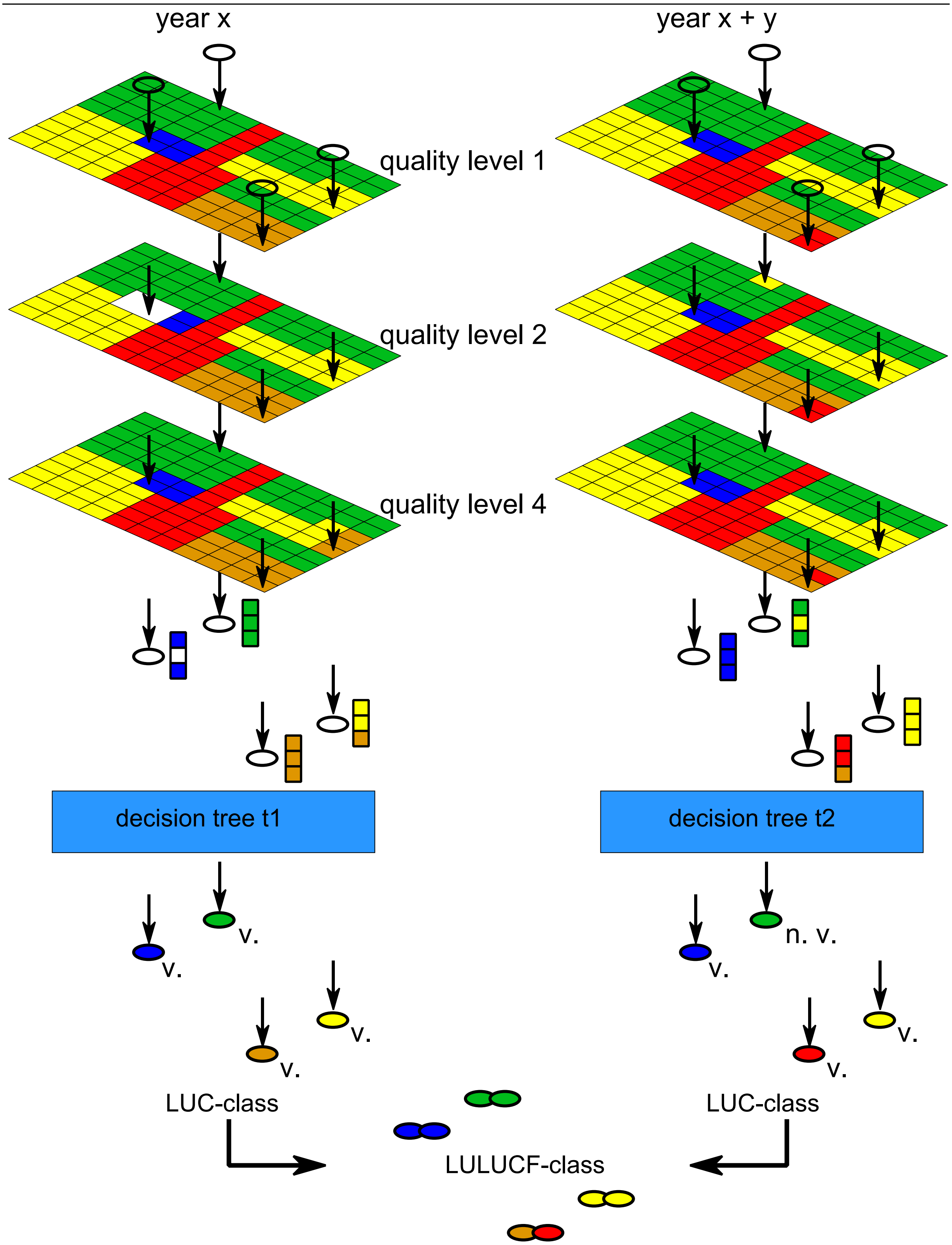


Figure 49: Schematic representation of allocation of sample points to a land-use category

7.1.3.3 Validation and error assessment

With the sampling method, various sources of error, such as

- additional sampling errors,
- differences in definitions, and
- discrepancies between Minimum Mapping Units,

can be quantified. On the other hand, error determination is hampered by the impossibility of achieving 100% accuracy in georeferencing of data sets.

Still, the three error sources mentioned immediately above can be eliminated, over time, via this flexible, sample-based system. The reason for this is as follows: Pursuant to the decision tree, placement within a LULUCF category is assumed correct only if such placement has been derived from suitably precise data sets on the 1st quality level, and data from a lower quality level confirm the placement. In every other case – i.e. whenever different data sources disagree about land use at a given time – the relevant sample point has to be evaluated with the help of aerial photos. Due to time limitations, such additional evaluation was not carried out for the current submission. It is planned for the future, however, as part of ongoing inventory improvement. If for some few points no decision can be taken even with the help of aerial photos, or if no aerial photos are available, the points will be assigned on-site. Once such additional validation has been carried out, inconsistencies in time series resulting from use of data sets with differing definitions, different Minimum Mapping Units or inconsistencies tied to imprecise geographic locations can no longer occur.

Table 227 shows how many of the points are already considered validated, as a result of agreement in LULUCF categories throughout different quality levels.

Table 227: Percentage shares for validated point data

Year	1990	2000	2005	2008	2011
Already validated, in %	55.07	96.08	98.70	98.95	98.97

The percentage of points in 1990 that have not yet been validated is still very high. The reasons for that are based in the system itself; for 1990, only CORINE data are available for all "non-forest" points in the BWI. Plans call for that percentage to be considerably improved via integration of new data sources (in particular, 1990 maps derived from ColorInfraRed data).

7.1.3.4 Step-by-step implementation

Complete implementation of this described new system for detecting land-use changes throughout Germany, over time, will necessitate extensive preliminary work and continuous supporting efforts. For example, the following have to be carried out:

- The various data materials, for different points in time, have to be acquired,
- Geometric corrections (of erroneous geometries, etc.) and checks have to be carried out,
- Conversion functions have to be written for converting the original classifications into LULUCF categories,
- The sample points have to be merged with the maps,
- The decision tree has to be programmed and adjusted as necessary, in keeping with data quality and availability, and
- The "transition-time" procedures have to be programmed and adjusted as necessary, in keeping with data quality and availability.

The decision to use this flexible, sample-based system was made in spring 2011, in consultation with the Single National Entity (Federal Environment Agency – UBA) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), which is responsible for forest inventories. In future, point information will continue to be gradually validated, with the help of additional regional data.

Programming of the decision trees for each classification year, and of the "transition-time" procedures, has been adapted in keeping with this current data structure.

7.1.3.4.1 Derivation of land use in the years 1990, 2000, 2005, 2008 and 2011

Each sample point can be assigned to a land-use category for the years in question (1990, 2000, 2005, 2008 or 2011), on the basis of the available data (cf. Chapter 7.1.3.2), and in keeping with the relevant quality levels. The basic table is structured as follows:

Table 228: Basis for derivation of land uses

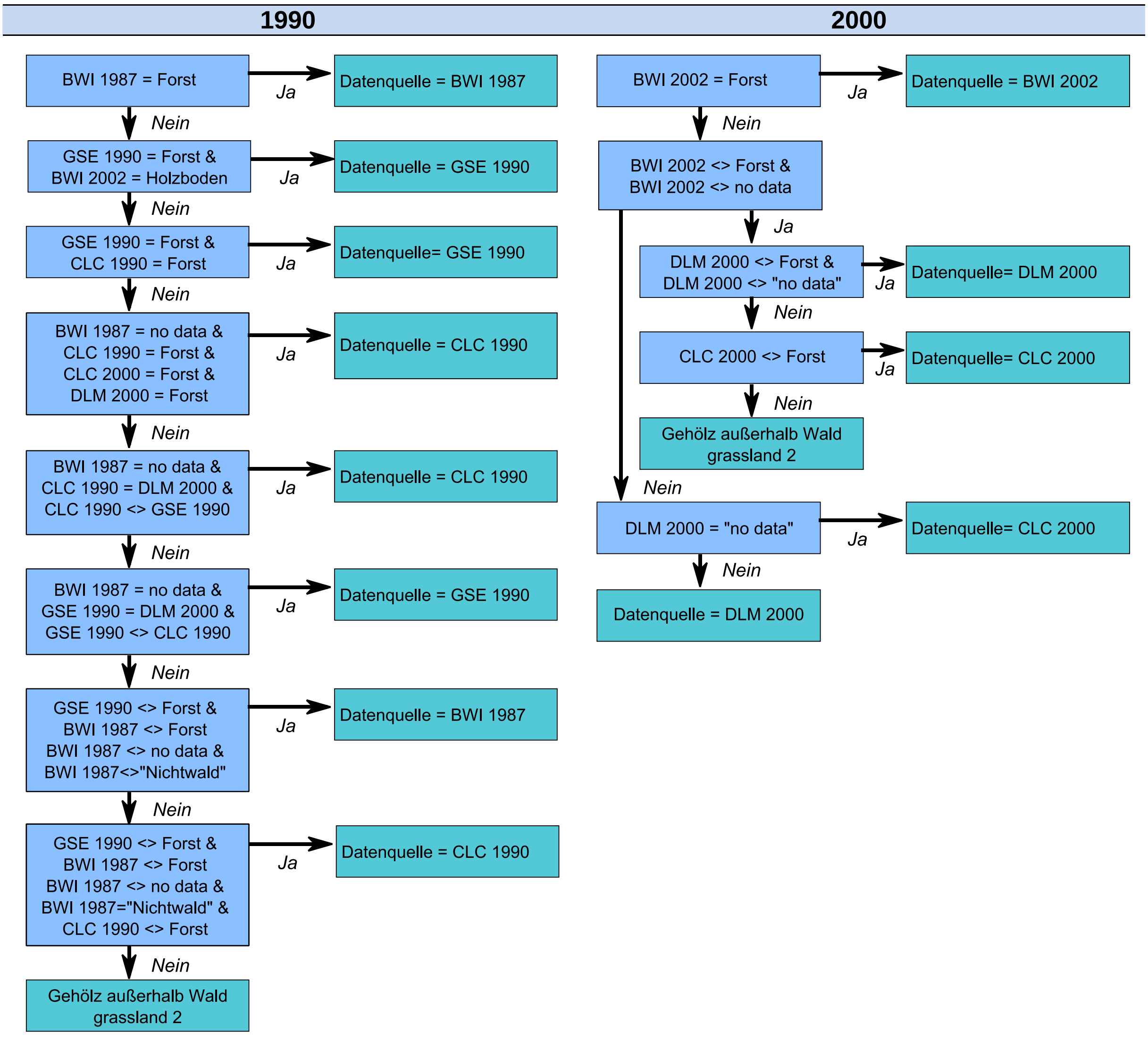
Cluster	Cluster point	BWI 1987	BWI 2002	BWI 2008	DLM 2000	DLM 2005	DLM 2008	DLM 2011	CORINE 1990	CORINE 2000	CORINE 2006	GSE 1990	GSE 2005
xya	1	forl	sett	sett	forl	sett	sett	sett	forl	gras	sett	gse0	gse0

The following codes were used for the land-use classes in the data records of the BWI, Basis-DLM, CORINE and GSE:

Table 229: Codes in the basic table

Code	Category	Sub-category
crop	Cropland	Cropland
gra1	Grassland	Grassland (in a strict sense)
gra2	Grassland	Woody grassland
forl	Forest land	Forest land
wetl	Wetland	Terrestrial wetland
gewa	Wetland	Waters
sett	Settlements	Settlements
othl	Other land	Other land
nofo	Non-forest land	The information is from BWI data, needs to be further specified with the help of other data sources and must be non-forest land.
bwi0	No information	No land-use information at this point in BWI data
dlm0	No information	No land-use information at this point in Basis-DLM data
clc0	No information	No land-use information at this point in CORINE data
gse0	No information	No land-use information at this point in GSE data

For the years 1990, 2000, 2005, 2008 and 2011, the following decision trees (cf. the following Figure 50) were applied to this basic table.


1990
2000
BWI 1987 = Forst
Ja
Datenquelle = BWI 1987
Nein
GSE 1990 = Forst & BWI 2002 = Holzboden
Ja
Datenquelle = GSE 1990
Nein
GSE 1990 = Forst & CLC 1990 = Forst
Ja
Datenquelle= GSE 1990
Nein
BWI 1987 = no data & CLC 1990 = Forst & CLC 2000 = Forst & DLM 2000 = Forst
Ja
Datenquelle = CLC 1990
Nein
BWI 1987 = no data & CLC 1990 = DLM 2000 & CLC 1990 <> GSE 1990
Ja
Datenquelle = CLC 1990
Nein
BWI 1987 = no data & GSE 1990 = DLM 2000 & GSE 1990 <> CLC 1990
Ja
Datenquelle = GSE 1990
Nein
GSE 1990 <> Forst & BWI 1987 <> Forst BWI 1987 <> no data & BWI 1987<>"Nichtwald"
Ja
Datenquelle = BWI 1987
Nein
GSE 1990 <> Forst & BWI 1987 <> Forst BWI 1987 <> no data & BWI 1987="Nichtwald" & CLC 1990 <> Forst
Ja
Datenquelle = CLC 1990
Nein
Gehölz außerhalb Wald grassland 2
BWI 2002 = Forst
Ja
Datenquelle = BWI 2002
Nein
BWI 2002 <> Forst & BWI 2002 <> no data
Ja
DLM 2000 <> Forst & DLM 2000 <> "no data"
Ja
Datenquelle= DLM 2000
Nein
CLC 2000 <> Forst
Ja
Datenquelle= CLC 2000
Nein
Gehölz außerhalb Wald grassland 2
Nein
DLM 2000 = "no data"
Ja
Datenquelle= CLC 2000
Nein
Datenquelle = DLM 2000

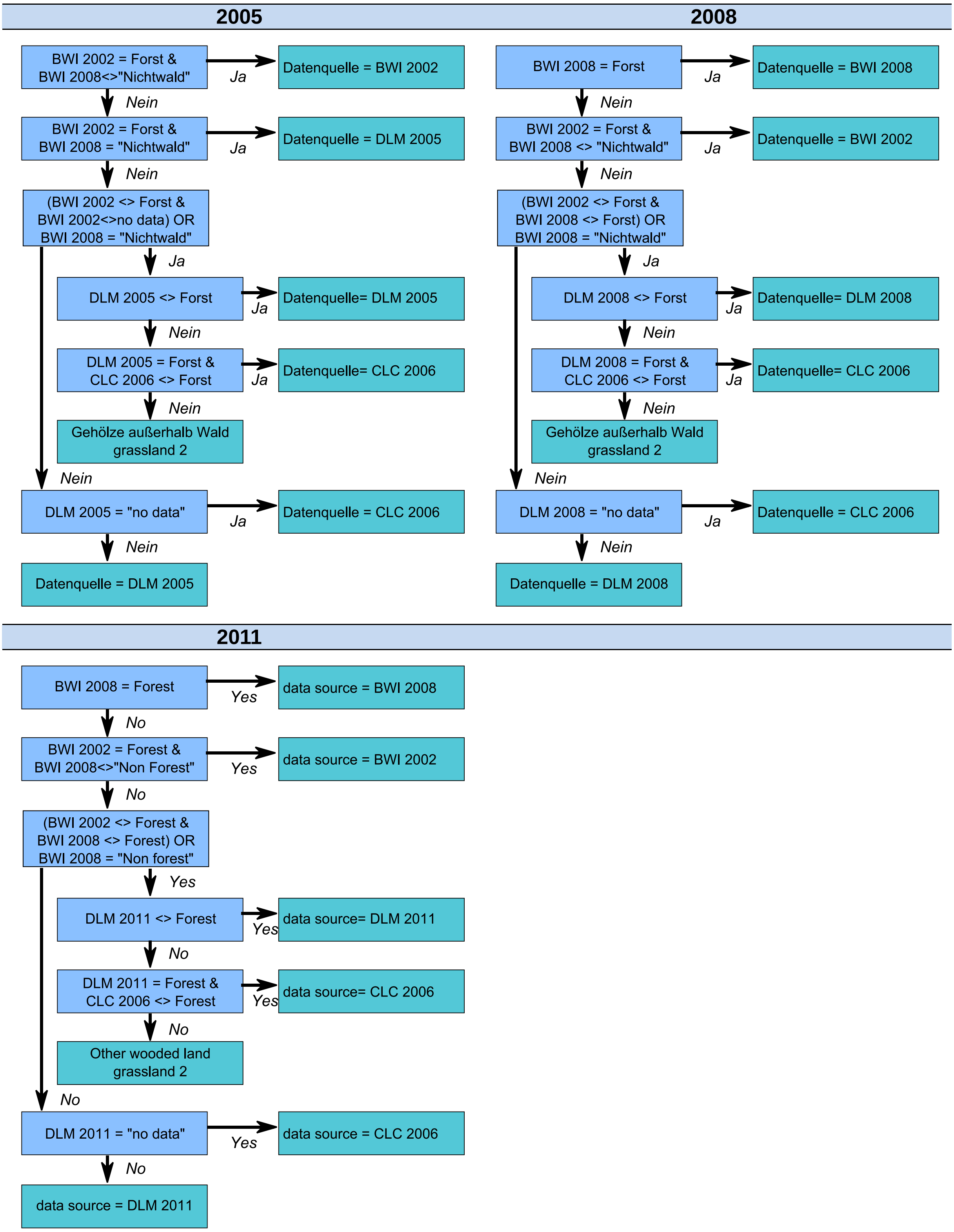


Figure 50: Decision trees for the years 1990, 2000, 2005, 2008, 2011

Use of the decision trees yields a further table, with the most probable land uses per sample point and year (1990, 2000, 2005, 2008 and 2011) and the best data source in each case. The BWI data are listed only for actual forest land, where the BWI returns the information "non-forest land", other data sources are used from then on to determine the land use:

Table 230: Most probable land use (LU) and pertinent data sources (DB)

Cluster	Cluster point	LU 1990	LU 2000	LU 2005	LU 2008	LU 2011	DB 1990	DB 2000	DB 2005	DB 2008	DB 2011
xya	1	forl	forl	sett	sett	sett	bwi	dlm	dlm	dlm	dlm

7.1.3.4.2 Derivation of annual land-use changes

Subsequently, the relevant land-use-change classes were derived for each change period (1990-2000, 2000-2005, 2005-2008, 2008-2011) and each sample point. To that end, an SQL script was programmed; it is documented in the inventory description.

The applicable transition times were implemented in several partial steps. For all land-use changes that occur within a period covered by the included observations (1990-2011), processing was carried out on a point-oriented basis. At the same time, the land-use changes have been spatially correlated with the individual observation points. Land-use changes that occurred prior to that period (1970-1990) are extrapolated retroactively from observations carried out during the first measurement period (1990-2000). In those cases, spatial correlation with the observation points is no longer required, nor is it even possible. As a result, for those cases a change is made from point-based processing to calculation on the basis of area sums.

No useful annual change data are available within the observation period, as is described in the methods section. The observation period is divided into change periods of differing lengths (1990-2000, 2000-2005, 2005-2008, 2008-2011), with the result that the annual changes in those periods have to be calculated on a proportional basis, via linear interpolation.

7.1.3.5 Land-use changes pursuant to the Convention and the KP

The method described here for determining land-use changes, and the resulting land-use matrix (cf. Table 231), including a 20-year transition time beginning in 1970, are compliant with reporting requirements pursuant to the UN Framework Convention on Climate Change, as set forth in IPCC GPG 2003. Table 232 shows the complete detailed land-use matrix for 2011 by way of example.

For determination of land-use changes pursuant to the Kyoto Protocol, the same set of annual data is used (cf. Table 233), but only land-use changes since 1990 are taken into account and, in the change categories of afforestation and deforestation, they are accumulated for more than 20 years (cf. Table 317 in Chapter 11.2.2).

Table 231: Land-use changes (LUC), including 20-year transition time, pursuant to reporting under the Convention

Source category	5.A.1 Forest land remaining forest land	5.A.2 … LUC to forest land	5.B.1 Cropland remaining cropland	5.A.2 … LUC to cropland	5.C.1 Grassland remaining grassland	5.A.2 … LUC to grassland	5.D.1 Wetlands remaining wetlands	5.A.2 … LUC to wetlands	5.E.1 Settlements remaining settlements	5.A.2 … LUC to settlements	5.F.1 Other land remaining other land	5.F.2 … LUC to other land
Units	**kha**	**kha**	**kha**	**kha**	**kha**	**kha**	**kha**	**kha**	**kha**	**kha**	**kha**	**kha**
1990	10,204.92	561.73	13,629.95	767.32	6,280.89	382.71	540.64	72.91	2,762.88	512.41	63.28	0.00
1991	10,217.86	561.73	13,638.28	767.32	6,254.62	382.71	540.49	72.91	2,769.55	512.41	61.75	0.00
1992	10,230.81	561.73	13,646.62	767.32	6,228.35	382.71	540.34	72.91	2,776.22	512.41	60.23	0.00
1993	10,243.75	561.73	13,654.95	767.32	6,202.09	382.71	540.19	72.91	2,782.89	512.41	58.70	0.00
1994	10,256.69	561.73	13,663.28	767.32	6,175.82	382.71	540.03	72.91	2,789.55	512.41	57.17	0.00
1995	10,269.64	561.73	13,671.61	767.32	6,149.55	382.71	539.88	72.91	2,796.22	512.41	55.65	0.00
1996	10,282.58	561.73	13,679.95	767.32	6,123.28	382.71	539.73	72.91	2,802.89	512.41	54.12	0.00
1997	10,295.53	561.73	13,688.28	767.32	6,097.02	382.71	539.58	72.91	2,809.55	512.41	52.60	0.00
1998	10,308.47	561.73	13,696.61	767.32	6,070.75	382.71	539.43	72.91	2,816.22	512.41	51.07	0.00
1999	10,321.42	561.73	13,704.94	767.32	6,044.48	382.71	539.28	72.91	2,822.89	512.41	49.55	0.00
2000	10,334.36	561.73	13,713.27	767.32	6,018.21	382.71	539.12	72.91	2,829.56	512.41	48.02	0.00
2001	10,358.84	543.32	13,687.62	760.52	5,995.00	387.38	540.85	75.76	2,837.01	546.67	46.65	0.00
2002	10,383.33	524.91	13,661.97	753.71	5,971.79	392.06	542.58	78.61	2,844.47	580.93	45.28	0.00
2003	10,407.81	506.51	13,636.32	746.91	5,948.58	396.74	544.30	81.46	2,851.93	615.18	43.90	0.00
2004	10,432.29	488.10	13,610.67	740.10	5,925.37	401.41	546.03	84.31	2,859.38	649.44	42.53	0.00
2005	10,456.77	469.69	13,585.02	733.30	5,902.16	406.09	547.76	87.16	2,866.84	683.69	41.16	0.00
2006	10,481.48	447.38	13,577.52	718.88	5,886.95	409.79	550.74	87.78	2,879.39	699.27	40.46	0.00
2007	10,506.18	425.06	13,570.03	704.47	5,871.74	413.50	553.72	88.39	2,891.93	714.84	39.76	0.00
2008	10,530.89	402.75	13,562.53	690.06	5,856.52	417.21	556.70	89.01	2,904.48	730.42	39.07	0.00
2009	10,557.19	376.02	13,560.17	688.30	5,828.04	411.78	559.51	89.36	2,920.92	749.68	38.67	0.00
2010	10,583.48	349.29	13,557.81	686.53	5,799.56	406.36	562.32	89.72	2,937.37	768.94	38.27	0.00

2011	10,609.78	322.56	13,555.44	684.76	5,771.07	400.93	565.14	90.07	2,953.81	788.19	37.87	0.00

Table 232: Land-use matrix for 2011. In each case, the boldface number on the diagonal shows the area remaining in the same category for the column in question. The other table cells show the relevant land-use changes from 2009 to 2010 (including 20-year transition periods).

							Land-use matrix for 2011: Areas [kha]				
Initial*Final*	*Forest land*	*Cropland*	*Grassland (in a strict sense)*	*Woody grassland*	*Wetlands (terr.)*	*Waters*	*Peat extraction*	*Settlements*	*Other land*	**Σ reductions**	**Σ additions - Σ reductions**
Forest land	**10,609.78**	42.08	47.39	40.69	1.75	5.43	0	32.46	0	**169.81**	**152.75**
Cropland	112.73	**13,555.44**	0	115.51	1.60	28.21	0	592.10	0	**850.16**	**-165.40**
Grassland (in a strict sense)	97.12	486.34	**5,278.96**	50.69	8.87	16.13	0	125.29	0	**784.43**	**-506.72**
Woody grassland	51.68	52.49	64.62	**376.80**	0.75	4.12	0	23.47	0	**197.13**	**41.40**
Wetlands (terr.)	13.37	2.27	8.03	0.37	**53.45**	1.07	0	8.33	0	**33.43**	**-19.83**
Waters	1.01	1.62	9.39	0.86	0.27	**510.35**	0	3.02	0	**16.17**	**61.64**
Peat extraction	0	0	0	0	0	0	**19.86**	0	0	**0**	**0**
Settlements	43.32	99.07	135.08	28.04	0	22.65	0	**2,933.95**	0	**328.15**	**460.04**
Other land	3.33	0.90	13.21	2.36	0.36	0.20	0	3.52	**37.87**	**23.88**	**-23.88**
Σ additions	**322.56**	**684.76**	**277.72**	**238.53**	**13.60**	**77.81**	**0**	**788.19**	**0**		
Σ Land-use category	**10,932.35**	**14,240.21**	**5,556.68**	**615.33**	**67.05**	**588.16**	**19.86**	**3,722.15**	**37.87**		
Total area of Germany				**35,779.63**							

Table 233: Annual areas for land-use changes on which calculations for the UNFCCC inventory (20-year transition period) and KP (cumulative area change) are based [hectares per year]

Land-use change [hectares per year]	**1990-2000**	**2001-2005**	**2006-2008**	**2009-2011**
… to forest land				
Cropland to forest land	8,947	4,793	2,319	430
Grassland (in a strict sense) to forest land	8,664	2,656	1,456	498
Woody grassland to forest land	5,187	139	1,301	133
Wetlands Wetlands (terrestrial) to forest land	1,396	160	0	0
Wetlands to forest land	90	20	33	0
Settlements to forest land	3,653	1,532	629	298
Other land to forest land	149	378	33	0
… to cropland				
Forest land to cropland	4,366	398	99	166
Grassland (in a strict sense) to cropland	20,910	26,386	21,296	34,108
Woody grassland to cropland	5,077	860	333	498
Wetlands (terr.) to cropland	230	40	0	0
Waters to cropland	80	120	0	100
Settlements to cropland	7,603	3,757	2,226	1,727
Other land to cropland	100	0	0	0
… to grassland (in a strict sense)				
Forest land to grassland (in a strict sense)	3,871	1,534	1,327	298
Cropland to grassland (in a strict sense)	0	0	0	0
Woody grassland to grassland (in a strict sense)	4,193	4,058	1,298	901
Wetlands (terr.) to grassland (in a strict sense)	670	360	0	67
Waters to grassland (in a strict sense)	300	840	566	266
Settlements to grassland (in a strict sense)	5,788	8,926	7,395	5,389
Other land to grassland (in a strict sense)	837	657	597	200
… to woody grassland				
Forest land to woody grassland	3,936	338	663	529
Cropland to woody grassland	2,444	8,724	10,568	6,063
Grassland (in a strict sense) to woody grassland	898	4,152	3,588	3,694
Wetlands (terr.) to woody grassland	30	0	0	33
Waters to woody grassland	40	0	33	133
Settlements to woody grassland	1,089	2,194	1,692	732
Other land to woody grassland	130	239	0	0
… to terrestrial wetlands				
Forest land to wetlands (terr.)	140	0	166	0
Cropland to wetlands (terr.)	100	140	0	0
Grassland (in a strict sense) to wetlands (terr.)	140	881	534	535
Woody grassland to wetlands (terr.)	50	60	0	0
Waters to wetlands (terr.)	30	0	0	0
Settlements to wetlands (terr.)	0	0	0	0
Other land to wetlands (terr.)	40	0	0	0
… to waters				
Forest land to waters	360	299	232	0
Cropland to waters	1,269	2,138	1,234	800
Grassland (in a strict sense) to waters	548	860	832	1,466
Woody grassland to waters	180	340	100	167
Wetlands (terr.) to waters	119	0	0	0
Settlements to waters	830	1,756	1,131	1,032
Other land to waters	0	20	33	0
… to settlements				
Forest land to settlements	2,469	1,034	896	796
Cropland to settlements	17,274	48,222	31,740	33,436
Grassland (in a strict sense) to settlements	3,919	8,815	7,364	7,951
Woody grassland to settlements	728	1,347	1,130	2,264
Wetlands (terr.) to settlements	748	279	0	66
Waters to settlements	213	100	33	167
Other land to settlements	270	79	33	200

7.1.3.6 Planned improvements

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

7.1.4 *Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories*

With the introduction of the sample-point grid system, the land-use definitions from the underlying data sources (Basis-DLM of ATKIS® and CORINE Land Cover; cf. Chapter 7.1.3.2) had to be correlated with the LULUCF reporting categories. The existing system was adapted for that purpose.

In a first step, the object numbers from the Basis-DLM of ATKIS® were assigned to the above-listed IPCC categories. To that end, the previous year's system was adopted, with slight changes (Table 234).

In a next step, in the framework of expansion of the land-use-identification system, the land-cover classes in the CORINE Land Cover nomenclature were assigned to object types within the ATKIS®-Basis-DLM – and, thus, to the relevant IPCC categories (Table 234). In preparation of the land-use matrix, grid-point allocation is computerized; it is carried out fully automatically via dedicated programmes. In support of that purpose, the allocation key for this classification system is included in digital form, with the result that any given grid point can always be unambiguously allocated to an object-type-key number and, thus, to a specific land-use type and IPCC category, regardless of the data source being used.

Table 234: Allocation of main object-type index numbers and attributes in ATKIS® to IPCC land-use categories

ATKIS Object-type catalog			CORINE LAND COVER
Object number	**Object type**	**Description / attributes pursuant to ATKIS object-type catalog**	**Nomenclature code**
IPCC category: Forest land			
4107	Forest land	Deciduous, coniferous and mixed forest	311; 312; 313; 324
IPCC category: Cropland			
4101	Cropland	Area for cultivation of field crops (such as grain, legumes, root crops) and berries (such as strawberries)	211; 212
4103	Horticultural land	Area for cultivation of vegetables, fruit and flowers, and for nurturing of young crop plants	242
4109	Specialised cultivation	Area for cultivation of certain plants (such as hops, grapes, orchards).	222
IPCC category: Grassland			
4102	Grassland – Grassland (in a strict sense)	Meadows, pastures, greenery along transport infrastructure	231; 321
4104	Heath - Grassland (in a strict sense)		322; 421
4106	Swamp, reeds - Grassland (in a strict sense)	Water-saturated area that is intermittently inundated (wet grassland).	411
4108	Woody grassland	Area covered with individual trees, groups of trees, bushes, hedges and shrubs.	243
IPCC category: (terr.)			
4105	Peat bogs, moss – Terrestrial wetlands	Uncultivated area whose top layer consists of peaty or decomposed plant remains.	412
2301	Peat extraction - Terrestrial wetlands		
5100	Waters	Such as dammed lakes, reservoirs, movable banks	511; 512; 423; 521; 522; 523
IPCC category: Settlements			
2100-2135	Structurally modified areas	Contiguously built-up areas with sizes of at least 10 ha or with at least 10 properties.	111; 112; 121; 131; 132
2201	Sports facilities	Area with structures and facilities intended to be used for (competitive) sports and by spectators. Sports facilities include "stadiums", "sports areas" – such as football pitches, tennis courts, ice-skating rinks – "shooting ranges", "swimming pools", "outdoor swimming pools" and "golf courses".	142
2202	Recreational facilities	Area with structures and facilities intended for recreational purposes. Recreational facilities include "open-air theaters", "open-air museum", "swimming pools, outdoor swimming pools", "zoos", "amusement parks" "safari parks", "game enclosures" and "drive-in movie theatres" and "outdoor movie theatres".	142
2213	Cemeteries		141
2227	Greenswards, parks	Large areas with trees, shrubs, grass areas, flower beds and/or paths, and that are intended primarily for recreation and as a means of urban beautification.	141
2228	Camping areas	142	
2300-2352	Buildings and other facilities		131; 133
3100-3205	Roads and railways		122
3301	Airports		124
3302	Airfields		No allocation
3400-3543	Ship-transport and related facilities	For example, ports, transmission masts, bridges, tunnels, piers	123
4110	Fallow land	Areas that for some time have not been used in accordance with their original purpose.	No allocation
4198	Glades		No allocation
IPCC category: Other land			
4120	Areas without vegetation	Areas without significant vegetation cover, as a result of special soil characteristics such as unprotruding rocks, sand or ice areas.	331; 332; 333; 334; 335
4199	Area currently undefined	Areas whose characteristics cannot currently be determined, in terms of allocation to object types.	No allocation

7.1.5 Soil carbon in mineral soils (5.A to 5.F)

The area of the mineral soils in the transition categories was calculated as the difference between the relevant total areas and the areas covered by organic soils (Chapter 7.1.6).

In the framework of the Forest Soil Inventory, an annual carbon-stock change of 0.27 ± 0.18 Mg C ha^{-1} a^{-1} was determined for category 5.A.1, Forest Land remaining Forest Land (cf. Chapter 7.2.2.2 and Chapter 19.5.2.1). On an annual basis, that quantity is added to the previous year's stocks and reported as a removal.

Changes in carbon and nitrogen stocks in mineral soils are calculated as the difference between the relevant stocks prior to, and after, relevant land-use changes.

Pursuant to the IPCC Tier 1 method, for mineral soils with no use change, in land-use sub-categories 5.B, 5.C, 5.D, 5.E and 5.F, it is assumed that the pertinent carbon inputs into the soil and carbon extractions from the soil are equal in size, so that the systems are in balance. The reasons for this assumption are described in Chapter 7.3.4.3 and Chapter 7.4.4.3.

The category Grassland (5.C 1) has two sub-categories: grassland (in a strict sense), and grassland areas with woods that do not fall within the Forest land category as it is defined. The transition areas between those two sub-categories are treated like land-use changes.

The category Wetlands (5.D.1) has three sub-categories: terrestrial wetlands; peat-extraction areas (which, in the pertinent "remaining" category, are subsumed within the terrestrial wetlands category); and waters. The transition areas between these sub-categories are treated like land-use changes. Mineral soils occur only in the two sub-categories "terrestrial wetlands" and "waters". No carbon-stock changes are applied in connection with land-use changes from and to waters. As a result, no carbon-stock changes in mineral soils occur in connection with land-use changes between the relevant sub-categories (NO).

The carbon stocks in mineral soils, to depths of 30 cm, in land-use categories 5.B - 5.F (Cropland, Grassland (in a strict sense), Woody grassland, Wetlands, Settlements and Other land), are determined as representative carbon stocks for mineral soils with depths to 30 cm, weighted by area in accordance with parent substrate, soil type and climate region (only topsoils), on the basis of the usage-differentiated profile data for soils in Germany. The manner in which the relevant values, and their uncertainties, are derived is described in Chapter 19.5.2.

For each land-use-change category, the carbon-stock changes in mineral soils as a result of land-use changes are calculated as the difference between the carbon stocks of the final-use category and the carbon stocks of the original category. **Since the carbon stocks in forest soils (5.A) change annually, the relevant inventory calculations are based on the valid annual values for all years in question.** Pursuant to IPCC Default (IPCC 1996b, 2003, 2006), the total changes are linearly distributed over a period of 20 years. The sum of all carbon-stock changes resulting from land-use changes in Germany's mineral soils is calculated, for a 20-year period, as follows:

$$\Delta C = \sum_{n=1}^{7} \left(C_{final} - C_{initial}\right)$$

ΔC: Change in carbon stocks as a result of land-use changes in mineral soils of an IPCC land-use category [Mg C $(20*a)^{-1}$]

C_{final}: Final soil-carbon stocks [Mg C]

$C_{initial}$: Initial soil-carbon stocks [Mg C]
n Transition categories

The carbon stocks of mineral soils in the various land-use categories, and the carbon-stock changes derived from those stocks and used as emission factors, are shown for 2011 in Table 235; the pertinent derivations are described in Chapter 19.5.2.

Table 235: Mean carbon stocks in Germany's mineral soils, by land use [Mg C ha^{-1}], and derived (e.g. therefrom) carbon-stock changes, as a result of land-use changes, **for 2011**

	Mean carbon stocks in Germany's mineral soils in 2011							
	Forest land	**Cropland**	**Grassland**	**Woody grassland**	**Terrestrial wetlands**	**Waters**	**Settlements**	**Other land**
[Mg C ha^{-1}]	*62.45*	60.03	77.43	73.18	74.00		58.67	55.60
	Carbon-stock change in 20 years [Mg C ha^{-1} (20 a)$^{-1}$]							
Initial\final	**Forest land**	**Crop-land**	**Grassland (in a strict sense)**	**Woody grassland**	**Terrestrial wetlands**	**Waters**	**Settlements**	**Other land**
Forest land		*-2.42*	*14.98*	*10.73*	*11.55*	0	*-3.78*	NO
Cropland	*2.42*		17.40	13.15	13.97	0	-1.35	NO
Grassland (in a strict sense)	*-14.98*	-17.40		-4.25	-3.43	0	-18.76	NO
Woody grassland	*-10.73*	-13.15	4.25		0.82	0	-14.51	NO
Terrestrial wetlands	*-11.55*	-13.97	3.43	-0.82		0	-15.32	NO
Waters	0	0	0	0	0		0	NO
Settlements	*3.78*	1.35	18.76	14.51	15.32	0		NO
Other land	*6.85*	4.42	21.83	17.58	18.39	0	3.07	

Values in italics: Changing from year to year

To take account of the 20-year transition period, the total stock change for each transition category in question (EF_ann, cf. Table 235) is divided by 20 (cf. also Chapter 7.1.2). This yields the implied emission factors for the transition categories (IEF_20y; cf. Table 236). In the case of land-use changes to and from Forest Land, and because carbon stocks in mineral forest soils change from year to year, an implied emission factor has to be derived for each transition category. Such IEF, which vary from year to year, are obtained in each case from the contributions of the land-use changes of the 20 previous years, weighted by emissions. The emissions are calculated as the product of IEF_20y and the areas of the 20-year transition categories (cf. Chapter 7.1.2).

Table 236: Emission factors [Mg C ha^{-1} a^{-1}] for determination of annual carbon-stock changes in Germany's mineral soils, following land-use changes, for the year 2011

	Emission factors$_{mineral\ soils}$ [Mg C ha^{-1} a^{-1}] for the year 2011							
Initial\final	**Forest land**	**Cropland**	**Grassland (in a strict sense)**	**Woody grassland**	**Terrestrial wetlands**	**Waters**	**Settlements**	**Other land**
Forest land		*0.074*	*0.920*	*0.720*	*0.738*	0	*-0.028*	NO
Cropland	*-0.050*		0.870	0.658	0.699	0	-0.068	NO
Grassland (in a strict sense)	*-0.929*	-0.870		-0.213	-0.172	0	-0.938	NO
Woody grassland	*-0.725*	-0.658	0.213		0.041	0	-0.725	NO
Terrestrial wetlands	*-0.774*	-0.699	0.172	-0.041		0	-0.766	NO
Waters	0	0	0	0	0		0	NO
Settlements	*0.013*	0.068	0.938	0.725	0.766	0		NO
Other land	*0.198*	0.221	1.091	0.879	0.920	0	0.154	

Values in italics: Changing from year to year
Negative: carbon losses; positive: carbon sequestration; NO: not occurring

The area of the mineral soils in the transition categories was calculated as the difference between the relevant total areas and the areas covered by organic soils (Chapter 7.1.6).

7.1.6 Greenhouse gas emissions from drained organic soils (5.A to 5.F)

In Germany, nearly all organic soils are drained. Greenhouse emissions resulting from peat depletion are reported in the land-use categories Forest land, Cropland, Grassland (in a strict sense), Woody grassland, terrestrial wetlands (industrial peat extraction) and Settlements (N_2O from drained organic soils is reported under Cropland and Grassland in CRF Sector 4.D). The few organic soils in Germany that are still in a "natural" state, and whose emissions do not have to be reported, are included in the land-use categories Other land and Terrestrial wetlands. The undrained areas also include 16,786 ha of grassland that, in the nomenclature of the Basis-DLM, are listed as object type 4106 "swamp, reeds" (cf. Chapter 7.1.4).

The emissions are calculated by multiplying the moor areas per sub-category by pertinent use-specific emission factors. For land-use changes, the emission factor for the final category is used right away:

$$EC_{orgsoil} = \sum_{n=1}^{7} (A_n * EF_n)$$

$EC_{orgsoil}$: Carbon emissions from organic soils in a land-use category [Gg C]
A_n: Moor area subject to a certain land use [kha]
EF_n: Land-use-specific emission factor [Mg C ha^{-1} a^{-1}]
n: Transition or no-change categories

7.1.6.1 Activity data: Determination of area sizes

The areas and distribution of organic soils have been documented via the 1:1,000,000-scale soil-survey map (BUEK 1000), with georeferencing. To that end, the following dominant soil associations have been surveyed:

LBA 6: primarily fens, often in association with fen gley soils, gleyed muck humus soils and gley soils; in part, transitional fens and podzolic gley soils (BGR 1995)

LBA 7: primarily raised-bog soils, with scattered pockets of gleyed muck humus soils, gley soils, fens and podzolic gley soils (BGR 1995)

Land use on bog areas is determined via a GIS. With such a system, the geometries of the LBA 6 and LBA 7 areas as shown in the BUEK 1000 (BGR 1997) are intersected with the ATKIS® data records from the year 2010. With that procedure, the organic-soil areas for each of the 8 land-use categories, in their final uses, were determined in a georeferenced format.

The land-use changes areas on organic soils were determined by intersecting the soil map with the ATKIS® data records from the years 2009 and 2010. For each transition category, the area percentage covered by organic soils, relative to the total area of the transition category in 2009/2010, was calculated. For all years since 1990, and for each transition category, these organic-soil area percentages were applied constantly to the total area of the transition category, as determined by the sampling-grid procedure. The area of the mineral soils in the transition categories was calculated as the difference between the relevant total areas and the areas covered by organic soils.

The areas of organic soils in the categories with no use changes were determined, beginning with the values for 2010, by adding the sums of the final areas for the relevant transition categories.

7.1.6.2 National emission factors

MUNDEL (1976), GENSIOR & ZEITZ (1999), MEYER (1999) und AUGUSTIN (2001) report C losses from German bogs in grassland areas of 2.46 – 7.63 Mg C ha^{-1} a^{-1}, while HÖPER (2002) reports 4.6 – 16.5 Mg C ha^{-1} a^{-1}, with bogs under cropland listed at 10.6 – 16.5 Mg C ha^{-1} a^{-1}.

On the basis of those studies, in 2004 the following emission factors were determined for fens and raised bogs alike, via estimation by experts:

- Cropland: -11 Mg CO_2-C ha^{-1} a^{-1} [± 50 %]
- Cultivated grassland and settlements: -5 Mg CO_2-C ha^{-1} a^{-1}[± 50 %]

The most recent findings of the BMBF research project "Climate protection via bog protection" ("Klimaschutz durch Moorschutz") (DROESLER et al. 2011) indicate, for German bog areas under agricultural use, that while the pertinent emissions vary widely, the two types "raised bog" and "fen" differ virtually not at all when under the same use.

For example, CO_2-C emissions from bogs under cropland were measured at ca. 4 - 13 Mg CO_2-C ha^{-1} a^{-1}, with a mean of about 9 Mg CO_2-C ha^{-1} a^{-1}± 50 %. For grassland, a range of about 2 – 12 CO_2-C ha^{-1} a^{-1} was substantiated, with an arithmetic mean, over all variants and usage intensities (not weighted by area), of about 5 Mg CO_2-C ha^{-1} a^{-1} ± 50 % (DROESLER et al. 2011). These results largely confirm the factors on which the inventory has been based to date.

For organic soils under forest, and for woodlands not falling within the definition of "forest" (grassland woodlands), the IPCC default value was used:

- Forest / woodland: -0.68 Mg CO_2-C ha^{-1} a^{-1} [- 39.7 %; + 180.8 %]

7.1.7 Biomass (5.B to 5.F)

In the framework of German inventory preparation, the LULUCF categories 5.B – 5.F include only carbon dioxide (CO_2) removals and emissions resulting from land-use changes between the eight reported land-use categories. In the process, removals and emissions of CO_2 are determined via the relevant carbon-stock changes, on the basis of national data, and separately for above-ground and below-ground biomass. In each case, a carbon-stock change takes place completely in the year of the relevant land-use change (cf. also Chapter 7.1.2). For the "remaining as" categories of cropland, grassland, woody grassland, wetlands and settlements, no carbon-stock changes are listed, since the carbon flows in those categories are assumed to be in balance with the relevant biomass. The reasons for this assumption are described in Chapters 7.3.4 and 7.4.4.

The carbon-stock changes in biomass are estimated by subtracting the biomass carbon stock before the land-use conversion from the stock after the conversion, with reference to the area affected by the change:

$$\Delta C_{Bio} = \sum_{n=1}^{7} \left(A_n * EF_{final} - A_n * EF_{initial} \right)$$

ΔC_{Bio}: Change in the biomass carbon stock for a given land-use category [Mg]
A_n: Area on which the land-use change has occurred [ha]
EF_{final}: Plant-specific biomass carbon stock in final land-use category [Mg ha^{-1}]
$EF_{initial}$: Plant-specific biomass carbon stock in initial land-use category [Mg ha^{-1}]
n: Transition categories

Biomass carbon stocks were calculated pursuant to GPG-LULUCF (IPCC, 2003). Chapter 7.1.3 provides a description of the relevant activity-data identification, while derivation of emission factors and their uncertainties is described in Chapter 19.5.3 and in the chapters for the individual land-use categories.

The biomass carbon stocks on cropland vary annually and are calculated for each year on the basis of harvest statistics. Therefore, the same data sources and algorithms are used as are used for calculating crop residues in CRF Sector 4.D. The emission factors in Table 237 are obtained, in each case, as the difference between the biomass stocks under the new use and the stocks under the old use. The resulting values differ from the corresponding values of the past year, since recalculation of the representative stocks for woody grassland and for perennial crops, along with a correction of the applicable annual stocks, led to changes in the representative carbon in all land-use categories (cf. Chapter 19.5.3).

Table 237: Emission factors [Mg C ha^{-1} a^{-1}] for determination of carbon-stock changes in the year of the conversion, in above-ground and below-ground biomass, by type of land-use change, for the year 2011

Mean carbon stocks in above-ground and below-ground biomass								
	Forest[1]	**Cropland**	**Grassland (in a strict sense)**	**Woody grassland**	**Terrestrial wetlands**	**Waters**	**Settlements**	**Other land**
[Mg C ha-1]	32.63	7.07	6.69	46.93	20.10	0	13.40	0
Emission factors for 2010, biomass [Mg C ha-1 a-1]								
Initial\final	**Forest[2]**	**Cropland[3]**	**Grassland (in a strict sense)[3]**	**Woody grassland[3]**	**Terrestrial wetlands (terr.)[3]**	**Waters[3]**	**Settlements[3]**	**Other land[3]**
Forest land		*-25.09*	*-25.95*	*14.30*	*-12.53*	*-32.63*	*-19.23*	NO
Cropland	*4.12*		*-0.86*	*39.39*	*12.56*	*-7.54*	*5.86*	NO
Grassland (in a strict sense)	*4.11*	*0.86*		40.25	13.42	-6.69	6.72	NO
Woody grassland	*4.03*	*-39.39*	-40.25		-26.83	-46.93	-33.53	NO
Terrestrial wetlands	*4.15*	*-12.56*	-13.42	26.83		-20.10	-6.70	NO
Waters	*4.15*	*7.54*	6.69	46.93	20.10		13.40	NO
Settlements	*4.06*	*-5.86*	-6.72	33.53	6.70	-13.40		NO
Other land	*4.15*	*7.54*	6.69	46.93	20.10	0	13.40	

Remark: The carbon stocks for forest land and cropland are chronologically variable (values in italics), while those for the other land-use categories are constant

1) Carbon stocks, deforestation areas
2) Annual carbon-stock change over 20 years
3) One-time carbon-stock change

For calculation relative to conversion of forest land into other land uses (deforestation), the average value determined for deforestation areas in Germany, in the National Forest Inventory, was used as a basis for the relevant reporting year. For the relevant methods and value derivation, cf. Chapter 7.2.4.1. **Now that the second Forest Soil Inventory has been completed, new values for litter can be used.**

Table 238: Time series for mean carbon stocks in phytomass of deforestation areas [Mg ha^{-1}]

Year	Phytomass – carbon [Mg ha^{-1}] (EF 1)					
	Bio_{total}	Bio_{above}	Bio_{below}	Litter	Dead wood	Σ deforestation
1990	34.86	26.89	7.97	18.58	1.56	55.00
1991	34.86	26.89	7.97	18.53	1.65	55.04
1992	34.86	26.89	7.97	18.48	1.75	55.09
1993	34.86	26.89	7.97	18.43	1.84	55.13
1994	34.86	26.89	7.97	18.38	1.93	55.17
1995	34.86	26.89	7.97	18.33	2.03	55.22
1996	34.86	26.89	7.97	18.28	2.12	55.26
1997	34.86	26.89	7.97	18.23	2.21	55.30
1998	34.86	26.89	7.97	18.18	2.31	55.35
1999	34.86	26.89	7.97	18.13	2.40	55.39
2000	34.86	26.89	7.97	18.08	2.50	55.44
2001	34.86	26.89	7.97	18.03	2.59	55.48
2002	32.63	23.85	8.78	17.98	2.68	53.29
2003	32.63	23.85	8.78	17.93	2.78	53.34
2004	32.63	23.85	8.78	17.88	2.87	53.38
2005	32.63	23.85	8.78	17.83	2.96	53.42
2006	32.63	23.85	8.78	17.78	3.06	53.47
2007	32.63	23.85	8.78	17.73	3.15	53.51
2008	32.63	23.85	8.78	17.68	3.25	53.56
2009	32.63	23.85	8.78	17.63	3.34	53.60
2010	32.63	23.85	8.78	17.58	3.43	53.64
2011	32.63	23.85	8.78	17.53	3.53	53.69

The uncertainty for the tree biomass is 36.6 % (half of the 95 % confidence interval). The distribution is normal. This also applies for the values for the dead organic matter; for dead wood, half of the 95 % confidence interval is 6.1 %, while for litter it is 3.6 %. The uncertainties for the emission factors listed in Table 237 are set forth in the chapters for the relevant land-use categories (Chapter 7.2.5, Chapter 7.3.5, Chapter 7.4.5, Chapter 7.5.5, Chapter 7.6.5 and Chapter 19.5.3).

On-site burning of biomass is prohibited by law in Germany and thus is not reported. In the CRF tables, NO (not occurring) is entered for that category.

7.1.8 Quality assurance

In keeping with the requirements of the QSE manual and its co-applicable documents, quality control and quality assurance have been carried out. For the first time, detailed checklists were used, and individual checks carried out, for review and documentation of the results in keeping with the quality management guidelines of the Thünen institute (2012). The TI checklists, along with other documents of importance for quality control, are added to the inventory description that is archived by the Single National Entity.

7.2 Forest land (5.A)

7.2.1 *Source category description (5.A)*

CRF 5.A	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Forest land	**CO_2**	**L**	**T/T2**	**-80,640.9**	**(6.62%)**	**-32,789.1**	**(3.54%)**	**-59.34%**
Forest land	N_2O	-	-	60.4	(0.00%)	66.3	(0.01%)	9.80%
Forest land	CH_4	-	-	9.1	(0.00%)	1.3	(0.00%)	-85.52%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS/Tier 2[74]	RS	CS
CH_4	Tier 1	RS	D
N_2O	Tier 1 / Tier 2	RS	D

The source categories Forest Land remaining Forest Land (5.A.1) und *Land converted to Forest Land* (5.A.2) are key sources for CO_2 emissions pursuant to GPG-LULUCF (IPCC, 2003).

Reporting in the category *Forest Land* covers CO_2 emissions / removals from/in mineral and organic soils, above-ground and below-ground biomass, litter, dead wood, forest fires and liming; in addition, it covers nitrous oxide emissions from forest fires, and from drainage of organic soils, and methane emissions from forest fires.

In 2011, the total emissions from forests amounted to -32,657 Gg CO_2 equivalents. Of those emissions, a total of -21,378 Gg CO_2 occurred via removals via phytomass growth, while -9,800 Gg CO_2 resulted from removals in mineral soils and -3,647 Gg CO_2 resulted from removals in dead wood. Emissions totalling 1,427 Gg CO_2 were released from litter. Drainage of organic soils resulted in emissions of 676 Gg CO_2 equivalents. Liming produced additional emissions of 64 Gg CO_2, while emissions from forest fires amounted to 1.6 Gg CO_2 equivalents.

The time series for emissions from forests (cf. Figure 51 and Figure 52) highlight the fact that the sum of all greenhouse-gas binding in forests decreased abruptly in 2002. The reason for the jump is that relevant surveys in the BWI framework are carried out periodically. Additional details about this aspect are provided in Chapter 7.2.4.1.1.

In the category Forest Land, the most important factors for CO_2 removals are the pools phytomass (61.39 %), mineral soils (28.14 %) and dead wood (10.47 %). Sources occur via litter, drainage, liming and forest fires. Such sources account for only a very small share – 5.69 % – of the greenhouse-gas balance for forests, however.

[74] The entry "CS/T2" refers to determination of changes in carbon stocks in biomass, dead wood and litter. Under Tier 1, changes in dead wood, litter and soil were estimated to be 0.

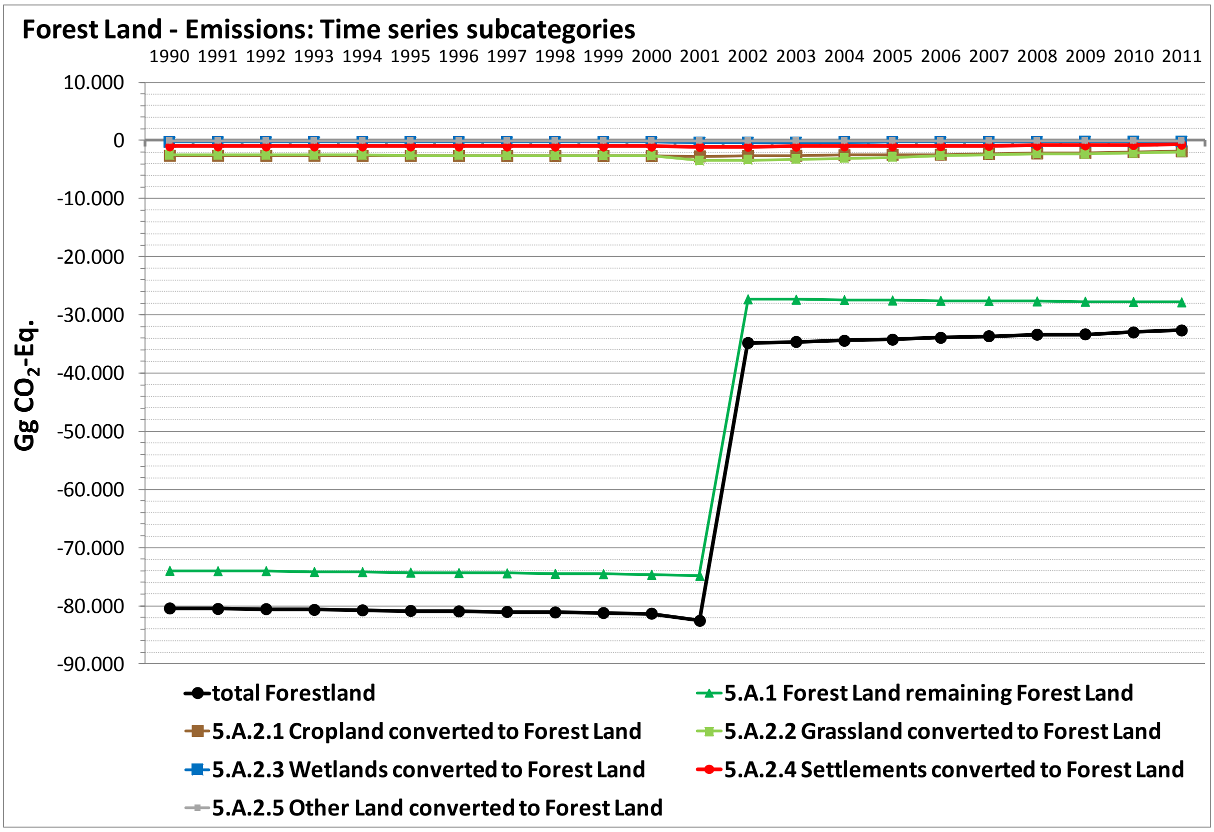


Figure 51: Greenhouse gas emissions [Gg CO_2-eqs.] from forest land, as a result of land use and land-use changes, 1990 – 2011, by sub-categories

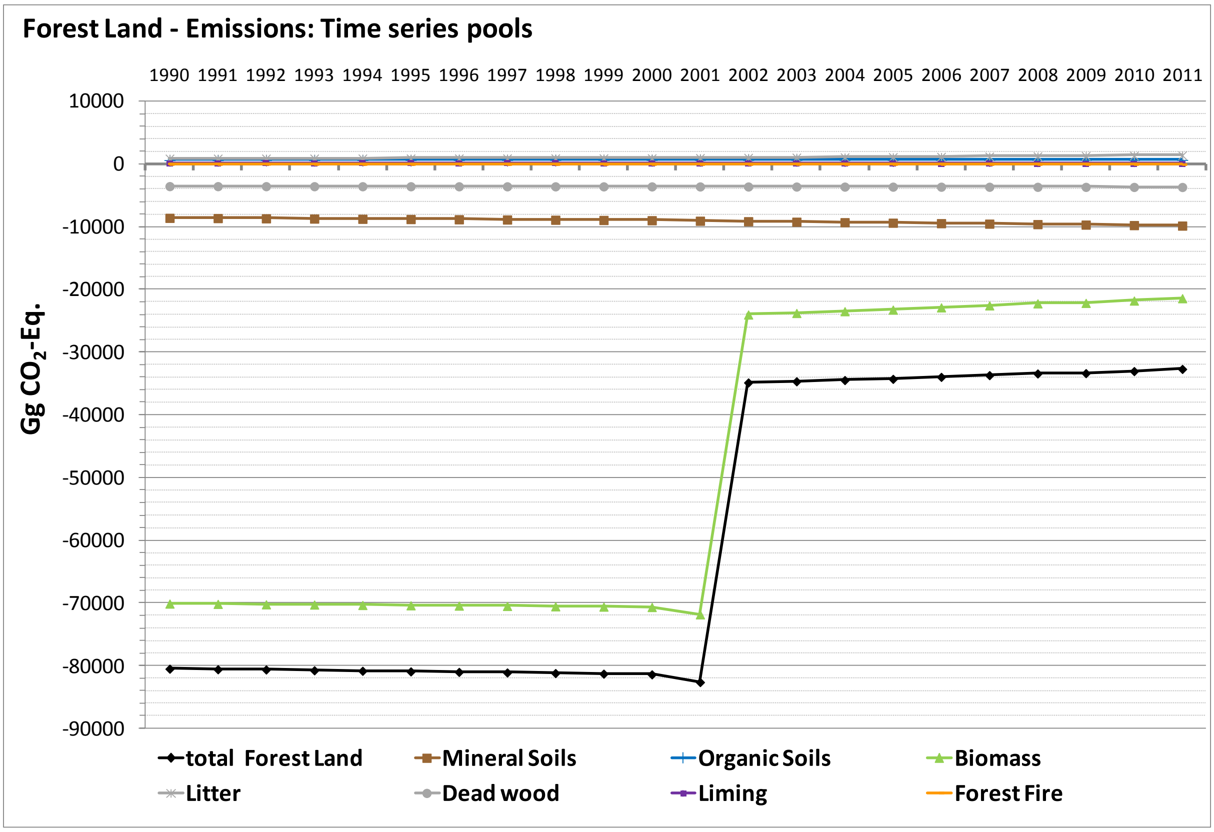


Figure 52: Greenhouse gas emissions [Gg CO_2-eqs.] from forest land, as a result of land use and land-use changes, 1990 – 2011, by pools

In the Good Practice Guidance for Land use, Land-use Change and Forestry (GPG-LULUCF, IPCC, 2003), and in the official reporting tables, in the "Common Reporting Format" (CRF), for the greenhouse-gas inventories sent to the Climate Secretariat, the category "Forest Land" is divided into "Forest Land remaining Forest Land" (forest that remains forest during the period covered by the report) and "Land converted to Forest Land" (new forest established, via afforestation or natural succession, on areas previously used for other land-use classes). It is important to note that relevant calculations are carried out on the basis of a 20-year transition period, and with a database beginning as of the year 1970 (cf. Chapter 7.1.3).

7.2.1.1 Forest Land remaining Forest Land (5.A.1)

Forest Land remaining Forest Land refers to the forest area that remains forest in the report year. It also includes areas that, after a 20-year period, are shifted from the category "Land converted to Forest Land" into the category "Forest Land remaining Forest Land". The category Forest Land remaining Forest Land differs from the total forest area in that it does not include Land converted to Forest Land, which is considered in a separate category (see Chapter 7.2.1.2).

7.2.1.2 Land converted to Forest Land (5.A.2)

Forest is established through succession, afforestation and reforestation; afforested areas start to accumulate carbon as soon as they are converted. Pursuant to IPCC GPG-LULUCF (2003), Land converted to Forest Land remains for the duration of the transition period of 20 years in the conversion category and is subsequently transferred into the "Forest Land remaining Forest Land" category.

It must be remembered that the C stocks of previous land uses are deducted following the conversion. Relevant information is provided in Chapters 7.3 through 7.7.

7.2.2 Information on approaches used for representing forest areas and on land-use databases used for inventory preparation (5.A)

The following data sources were used for determination of forest areas; determination of land-use changes that have occurred; estimation of the relevant emission factors for soil, biomass, litter and dead wood; for calculation of carbon stocks and stock changes at various times and over various periods; and for calculation of emissions from forest fires, fertilisation and drainage:

- National Forest Inventory 1 (Bundeswaldinventur; BWI 1)
- National Forest Inventory 2 (Bundeswaldinventur; BWI 2)
- Inventory Study 2008 (Inventurstudie; IS08)
- Datenspeicher Waldfonds (DSW)
- Forest Soil Inventory I (Bodenzustandserhebung im Wald I; BZE I)
- Forest Soil Inventory II (Bodenzustandserhebung im Wald II; BZE II)
- Soil-inventory data from the project BioSoil (BioSoil)
- GSE Forest Monitoring[75]: Inputs for national greenhouse-gas reporting (GSE FM-INT)

[75] GSE =GMES Services Elements
GMES = Global Monitoring for Environment and Security

- Official topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem; ATKIS®)
- CORINE Land Cover (CLC)
- Soil map for the Federal Republic of Germany 1:1,000,000 (Bodenübersichtskarte der Bundesrepublik Deutschland; BÜK 1000)
- Forest-fire statistics of the Federal Republic of Germany
- Fertiliser statistics of the Federal Statistical Office

7.2.2.1 National Forest Inventory, Inventory Study 2008 and Datenspeicher Waldfonds

The National Forest Inventory surveys the state of forests, and of forest production potential, on a large scale throughout Germany, using a standardised sampling procedure. The National Forest Inventory is a terrestrial sampling inventory that uses permanently marked sample points in a 4 km x 4 km basic grid whose resolution, at the request of the Länder, has been increased on a regional basis[76]. The first National Forest Inventory (BWI I) covered only the territory of the Federal Republic of Germany, in its pre-1990 borders, and West Berlin. It was carried out in the period 1986 to 1989 (referenced to 1987). The second National Forest Inventory (BWI II) was carried out in the period 2001 to 2003 (referenced to 2002), as a repeat inventory in the old German Länder and as a first inventory in the new German Länder (BMVEL, 2001; BMELV, 2005).

In 2008, data on the state of forests as of the beginning of the Kyoto-Protocol commitment period were collected on a sub-sample area of the National Forest Inventory that consisted of an 8 km x 8 km grid. In the main, the methods used for that so-called "2008 Inventory Study" (Inventurstudie 2008; IS08) are the same as those used for the National Forest Inventory (SCHWITZGEBEL et al. 2009, BMELV 2010).

The Datenspeicher Waldfonds (DSWF) database contains complete-coverage forestry-management data for the territory of the former GDR through 1993. Those data were collected at periodic intervals, annually revised in connection with growth models and updated in keeping with completion and change reports of that country's forest operations (BMELF, 1994).

7.2.2.2 Forest Soil Inventory (BZE and BioSoil)

Carbon emissions from forest soils have been estimated via the stock-changes method (IPCC 2003), through use of data from three soil surveys, BZE I, BioSoil and BZE II. The Forest Soil Inventory I (BZE I) was carried out from 1987 to 1992, BioSoil was carried out from 2006 to 2007 and the Forest Soil Inventory II (BZE II) was carried out from 2006 to 2008. In all three inventories, samples were taken of both the total organic surface layer, referred to in the following as "litter", pursuant to IPCC (2003), and of mineral soils. The data for the three inventories were collected by the Länder.

In the BZE I (WOLFF & RIEK 1996) and BZE II (WELLBROCK et al. 2006), forest soils throughout Germany were sampled within an 8 km x 8 km grid. In the sampling procedure, at each grid point, eight satellite samples were taken, within a 10 m radius around a central excavation with an exposed soil profile. For the BZE I, there were 1800 grid points; for the BZE II, there were 2000. The primary reason for the increase in the number of grid sample

[76] Further information: http://www.bundeswaldinventur.de

points, from one inventory to the next, is that for the second it became possible to access areas which had been closed for the first (for which no access permits were available; for example, various former military exercise grounds were opened up).

In the period during which the BZE II was carried out, the BioSoil survey (UN-ECE 2006), covering 425 points in a 16 km x 16 km grid, was also carried out. The sampling and analysis methods for that survey were similar to those used in the BZE II. For the most part, corresponding grid points for the three inventories all lay, in each case, within a 30 m radius. For some 400 points, a systematic grid shift with respect to the BZE I occurred.

For the BZE I, a database is now available with some 1800 points for which carbon stocks for litter and the mineral soil (0 – 30 cm) have been calculated (WOLFF & RIEK 1996), and the Länder have nearly completed transmitting BZE II survey data to a joint national database. For the BZE II, data from some 1,800 grid points are available for calculation of carbon stocks. Relevant analyses, and assessment in co-operation with Länder experts, have not yet been completed.

7.2.2.3 Additional activity data

Additional relevant activity data include

- GSE Forest Monitoring: Inputs for national greenhouse-gas reporting for the new German Länder
- Amtliches Official topographic-cartographic information system (Topographisch-Kartographisches Informationssystem; ATKIS®)
- CORINE Land Cover (CLC)

Details relative to these data are described in Chapter 7.1.3.2.1.

7.2.3 Land-use definitions and the classification systems used, and their correspondence to the LULUCF categories (5.A)

7.2.3.1 The definition of forest under the National Forest Inventory

The basis for reporting consists of the definition of forest used by the National Forest Inventory (Bundeswaldinventur (BWI); BMVEL, 2001):

"Forest" within the meaning of the BWI is any area of ground covered by forest vegetation, irrespective of the information in the relevant cadastral survey or similar records. The term "forest" also refers to cutover or thinned areas, forest tracks, firebreaks, openings and clearings, forest glades, feeding grounds for game, timber yards / lumberyards, forest aisles for conduction, further areas linked to and serving the forest including areas with recreation facilities, overgrown heaths and moorland, overgrown former pastures, alpine pastures and rough pastures, as well as areas with dwarf pines and green alders. Heaths, moorland, pastures, alpine pastures and rough pastures are considered to be overgrown if the natural forest cover has reached an average age of five years and if at least 50 % of the area is covered by forest. Forested areas of less than 1,000 m^2 located in farmland or in developed regions, narrow thickets less than 10 m wide, Christmas tree and decorative brushwood cultivations and parkland belonging to residential areas do not constitute forest within the meaning of the BWI. Watercourses up to 5 m wide do not break the continuity of a forest area.

At the same time, in a departure from the BWI definition of "forest", areas that the BWI counts as forest, but places in the forest category "non-forest ground", i.e. because they are not wooded, were not taken into account in calculation of carbon stocks and carbon-stock changes. While short-rotation coppices are recorded as "forest" in the BWI, they are not forest within the meaning of the Forest Inventory, the Federal Forest Act and the present inventory.

Pursuant to IPCC GPG-LULUCF (2003), Land converted to Forest Land remains in the conversion category for at least 20 years and is subsequently included in Forest Land remaining Forest Land. For afforestation areas, data for the period as of 1970 are taken into account.

7.2.3.2 Determination of forest area and of relevant changes

Activity data for the LULUCF sector are derived with a sampling system that is used consistently for all land-use categories. In this system, land uses, as obtained from various data sources, are assigned to sample points, for certain time periods. For the present purpose, that technique was used to prepare a land-use matrix for the period 1990 to 2011. A detailed description of the procedure is provided in Chapter 7.1.3. The activity data for the forest categories Forest Land remaining Forest Land and Land converted to Forest Land are summarised in Table 239.

Table 239: Forest area, forest land remaining forest land and conversions from other land-use categories to forest land, from 1990 through 2011

Year	Forest area [ha]	Forest Land remaining Forest Land (5.A.1) [ha]	Cropland converted to Forest Land (5.A.2.1) [ha]	Grassland (in a strict sense) converted to Forest Land (5.A.2.2) [ha]	Woody Grassland converted to Forest Land (5.A.2.2) [ha]	Wetlands (terr.) converted to Forest Land (5.A.2.3) [ha]	Waters converted to Forest Land (5.A.2.3) [ha]	Settlements converted to Forest Land (5.A.2.4) [ha]	Other land converted to Forest Land (5.A.2.5) [ha]
1990	10,766,646	10,204,916	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1991	10,779,590	10,217,861	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1992	10,792,535	10,230,806	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1993	10,805,479	10,243,750	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1994	10,818,424	10,256,695	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1995	10,831,368	10,269,639	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1996	10,844,313	10,282,584	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1997	10,857,257	10,295,528	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1998	10,870,202	10,308,473	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1999	10,883,146	10,321,417	178,940	173,280	103,734	27,924	1,799	73,067	2,985
2000	10,896,091	10,334,362	178,940	173,280	103,734	27,924	1,799	73,067	2,985
2001	10,902,166	10,358,844	174,786	167,273	98,687	26,688	1,729	70,945	3,214
2002	10,908,241	10,383,327	170,631	161,265	93,640	25,452	1,659	68,824	3,442
2003	10,914,316	10,407,809	166,477	155,258	88,593	24,217	1,589	66,702	3,671
2004	10,920,391	10,432,292	162,323	149,250	83,545	22,981	1,519	64,580	3,900
2005	10,926,466	10,456,775	158,169	143,243	78,498	21,745	1,449	62,459	4,129
2006	10,928,856	10,481,479	151,541	136,035	74,612	20,349	1,393	59,435	4,012
2007	10,931,245	10,506,183	144,912	128,828	70,727	18,953	1,336	56,410	3,896
2008	10,933,634	10,530,887	138,284	121,620	66,841	17,556	1,279	53,386	3,780
2009	10,933,204	10,557,185	129,767	113,454	61,787	16,160	1,189	50,031	3,631
2010	10,932,775	10,583,483	121,250	105,288	56,733	14,764	1,099	46,676	3,482
2011	10,932,345	10,609,781	112,733	97,123	51,679	13,368	1,009	43,321	3,332

7.2.4 Methodological issues (5.A)

7.2.4.1 Biomass

7.2.4.1.1 Forest land remaining forest land

For the old German Länder, and for the period until 2002, relevant data are available from two national forest inventories (referenced to the dates 1 October 1987 and 1 October 2002). Between BWI I and II, C stocks increased by 1.35 MgC ha^{-1} a^{-1} in the forests of the old German Länder. The increase in stocks is a result of low use, in comparison to growth. For the new German Länder, data from the National Forest Inventory II (BWI II) were compared with data from the Datenspeicher Waldfonds (DSWF) database, given the lack of an initial inventory comparable to BWI I. The comparison showed a marked net C-stock increase of 2.52 MgC ha^{-1} a^{-1}. As of 2002, data for stock-change calculations throughout Germany are available from the BWI II and the Inventory Study 2008 (IS08). On the basis of that data, a C-stock increase of 0.44 MgC ha^{-1} a^{-1} was calculated for Germany.

Nonetheless, managed forests' sink effect has decreased significantly as a result of forest management. The relevant reasons include a near doubling of the annual cut. In the first inventory period (1987 – 2002), for example, an average of about 47.9 million m³ (cubic meters of standing timber) were harvested per year in the old German Länder, while some 89.0 million m³ were harvested in the 2002 – 2008 inventory period. Despite the increase in the annual cut, and the resulting CO_2 emissions, the sum total of such emissions is still more than offset by the relevant CO_2 removals.

Logging statistics for Germany as a whole show a similar trend – although they differ from forest-inventory values (cf. DIETER & ENGLERT 2005) – with an average of 39 million m³ (Efm = cubic metre of harvested timber, i.e. with bark and cutting losses deducted)[77] in the period 1991 – 2001 and an average of 56 million m³ (Efm) in the period 2002 – 2010 (cf. Figure 54). The quality of logging-statistics data is poor however, since many subsets of the data are based on experts' assessment. "In light of the results of the National Forest Inventory, and of other estimates presented above, the figures in the official logging statistics can no longer be credibly defended. This applies both to statistics on quantities of timber cut and to various aggregated subsets of the statistics" (DIETER & ENGLERT 2005, p. 7). For this reason, the logging statistics are unsuitable as a data source for the national inventory.

Figure 53 shows the carbon stocks for the three inventory dates. The data for 1987 and 1993 have been derived from the BWI I or the DSWF; data for 2002 have been taken from the BWI II; and data for 2008 have been derived from the IS08. These figures, which take account of both forest land remaining forest land and land converted to forest land, also highlight the increase in forest carbon stocks.

Overall, the forests of the Federal Republic of Germany are thus a net sink for carbon.

[77] The wood mass in standing trees is given in cubic metres of standing timber. A cubic metre of harvested timber is equivalent to a cubic metre of standing timber less the losses incurred in wood harvesting and grading.

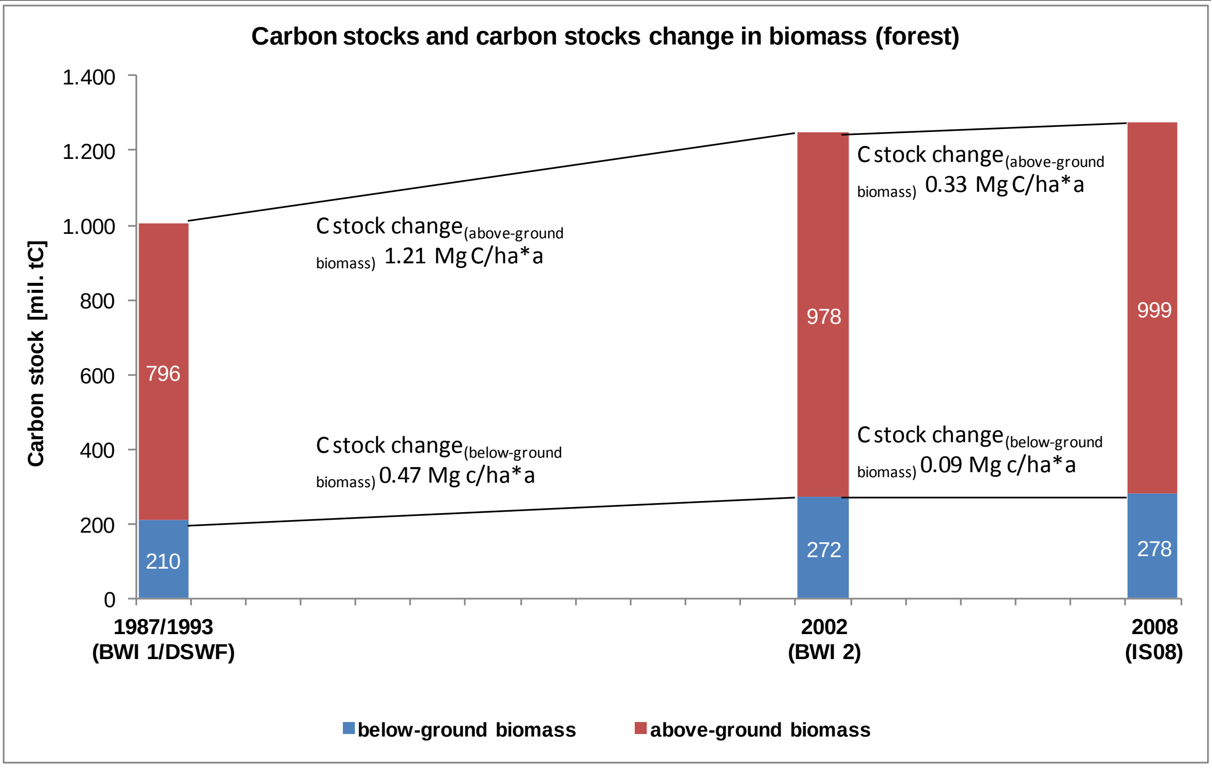


Figure 53: Carbon stocks and stock change in below-ground and above-ground biomass, in forests, in the years 1987/1993, 2002 and 2008

Changes in biomass carbon stocks are calculated via the "stock-change method" (IPCC 2003, p. 3.24). With that method, one obtains an average country-specific emission factor (Tier 2) for the time periods between different relevant years for which data sources are available. One thus obtains an IEF for the period prior to 2002 that reflects the average biomass change between a) BWI I (1989) and BWI II (2002) in the old German Länder and b) DWSF and BWI II (2002) in the new German Länder; and an IEF for the period as of 2002 that reflects the average biomass change between BWI II (2002) and IS08 (2008) for all Germany. As a result, the relevant biomass changes are adjusted between the years 2001 and 2002, in a manner leading to the "jump" referred to (cf. Chapter 7.2.1 Figure 51).

The reasons for the change include increased wood use in the 2002-2008 inventory period. Figure 54 shows the relationship between wood use and biomass changes.

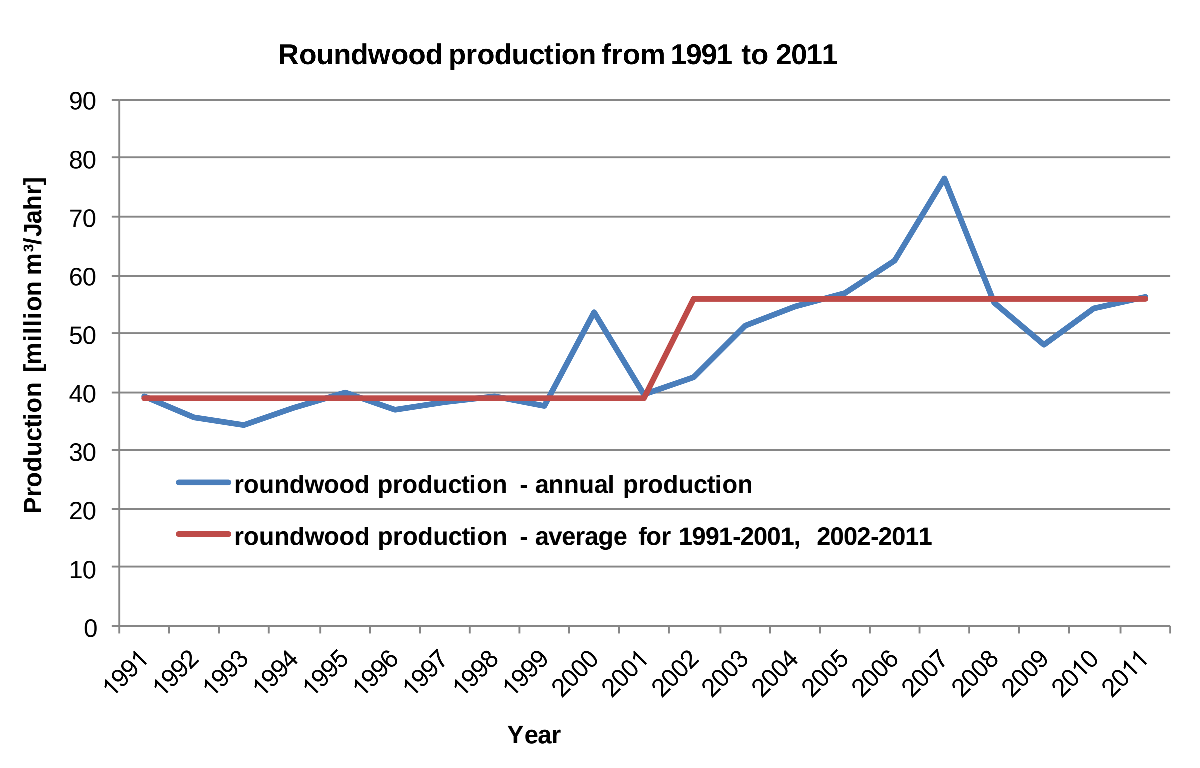


Figure 54: Raw-wood production in forests, pursuant to logging statistics of the Federal Statistical Office, annually and for the periods 1991 to 2001 and 2002 to 2011

A second reason for the change is that gross growth of forests has changed as a result of changes in forests' age structures (cf. Figure 55). German forests are aging, and thus additions through growth are expected to slow. That effect cannot be quantified, however, due to a lack of data for all of Germany for the period prior to 2002. This situation will change when the results of BWI III (2012) become available.

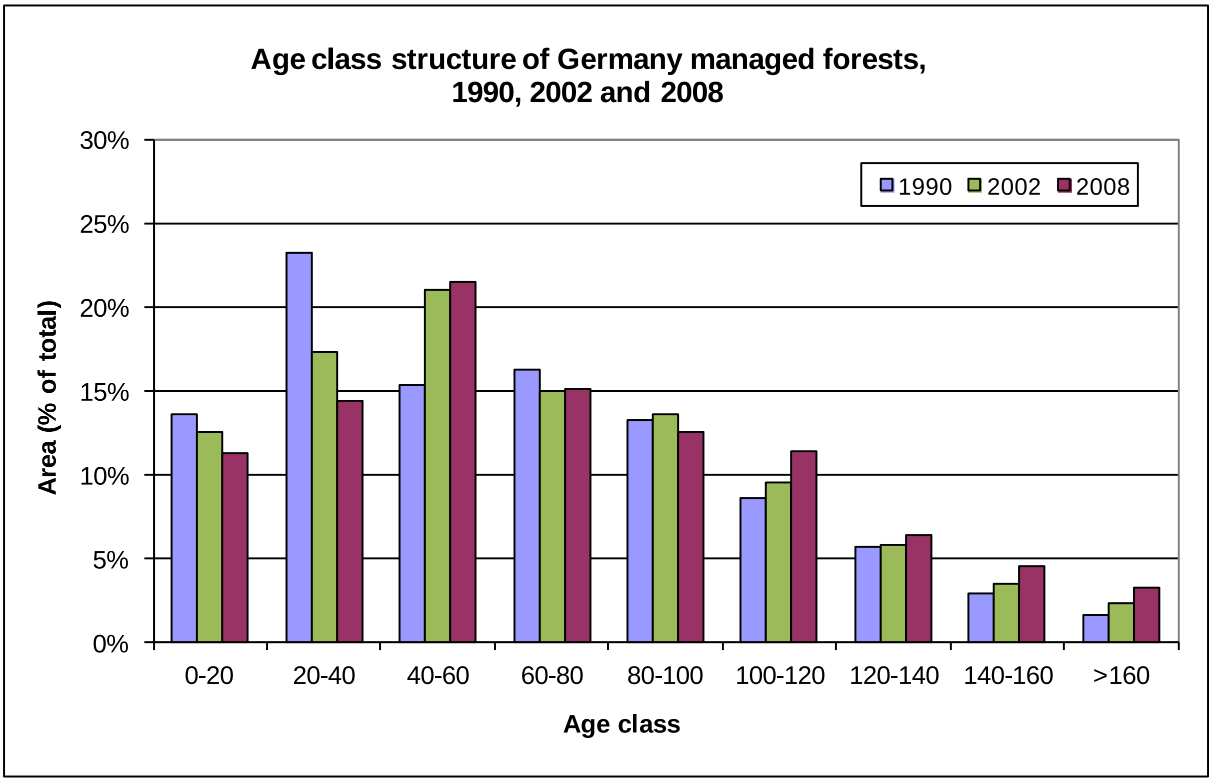


Figure 55: Age-class structure of forests in Germany as of the years 1990, 2002 and 2008

7.2.4.1.2 Land converted to Forest Land

To obtain emission factors for Land converted to Forest Land, an individual-tree calculation was carried out on the basis of the BWI I and BWI II inventories. Only trees in the old German Länder were taken into account, since the BWI I inventory was carried out only there. The carbon stocks were calculated for each area on which conversion from a given land use to forest land took place, and then all the resulting stocks were combined within the "Land converted to Forest Land" category. The stocks of earlier-use categories were deducted – and thus taken into account.

Since for the new German Länder it was not possible to derive wood stocks for Land converted to Forest Land directly from comparison of two inventories, the relevant values for the old German Länder were used.

The biomass stocks at the end of the 2002 vegetation period represent the increase in stocks in biomass throughout the entire period under consideration since 1987. That increase in stocks was linearly interpolated/extrapolated throughout the period 1990 to 2011. The data of the 2008 Inventory Study (IS08) are unsuitable for calculation of biomass of Land converted to Forest Land. For this reason, a constant figure is used for annual increases in the period from 1990 to the present. The C-stock increase in the biomass, for the entire afforested area, is 4.15 MgC ha^{-1} a^{-1} for each year. It must be remembered that afforested areas remain in this land-use category for 20 years. On the areas added each year, the C-stock losses from previous uses must be taken into account in the year in which conversion takes place; those losses are immediately assessed as emissions. In Table 240, the C stocks from previous uses for all land-use categories have been combined, weighted by area (cf. also Chapter 7.1.7).

Table 240: Carbon stocks from previous uses, as an area-weighted average of all previous-use categories

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
C stocks [MgC ha^{-1}]	15.43	15.51	15.36	15.60	15.47	15.53	15.61	15.65	15.61	15.68	15.64
Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
C stocks [MgC ha^{-1}]	8.47	8.21	7.90	8.63	8.45	16.40	16.51	16.70	12.37	12.21	12.36

7.2.4.1.3 Derivation of individual-tree biomass

For calculation of carbon stocks, data from BWI I (some 230,000 measured trees) were used for the old German Länder as of the 1987 sampling year. For calculations of C stocks in the new German Länder, suitable data are available, in the Datenspeicher Waldfonds database, in the form of aggregated data on forest-management plans through 1993. The BWI II survey, in which some 377,000 trees were measured, provides the database for the 2002 sampling year for Germany. Those data sources provide such a good basis for calculating estimated C-stock changes that it was preferable to use the stock-change method instead of the default method (IPCC, 2003: p. 3.24). The BWI data have been supplemented with repeat-survey data for some 83,000 trees, from the Inventory Study 2008.

Forest inventories yield volume data that often emphasise usable dimensions (volume). For purposes of greenhouse-gas reporting, data on carbon mass in trees is required, however. Consequently, the biomass of a given tree is estimated via a step-by-step procedure – for example, via biomass functions that can be applied to measured inventory data. These functions directly yield tree dry masses, usually with the input quantities diameter at breast height (DBH) and height (H). In a second step, the so-determined biomass is multiplied by its carbon content, to obtain the entire C mass in the relevant individual tree. Unfortunately, findings from biomass studies carried out to date are based on small numbers of samples; or have been obtained from trees growing in other climate zones (Scandinavia, Siberia, North America); and/or represent only local growth and site circumstances and applicable management options. Use of such data would thus produce distorted biomass estimates. For this reason, a procedure was applied (PISTORIUS et. al., 2006) whereby the raw-wood volume, as determined in the inventory, is converted into the above-ground tree volume. The above-ground tree volume includes branches and, for evergreen trees, the leaf organs. To estimate tree wood volumes from raw-wood volumes, regression equations are used that describe the relationship between the above-ground raw-wood volume and the above-ground tree wood volume. These volume-expansion functions were derived from the tables of Grundner & Schwappach (1952), which are based on an extensive database comprising 71,051 trees. In spite of its age, that database is still assumed to be the most suitable database for Germany at present.

In a next step, the above-ground biomass of individual trees was estimated by multiplying the raw-wood volume by the applicable volume density. Density data from KOLLMANN (1982), for specific tree-species groups, were used for that purpose. Since those data include statistics relative to applicable value ranges, they support error analysis via triangular distribution. With this method, the greater volume densities found in branches (HAKKILA, 1972) can be taken into account, since the difference between tree-wood volume and raw-wood volume correlates with branch mass. That separation was carried out for the densities pursuant to KOLLMANN (1982).

The below-ground living biomass was taken into account via stock-mass relationships. To that end, the above-ground biomass, broken down by tree species, was aggregated to hectare values for each random-sample point. The resulting values were multiplied with the IPCC default values (IPCC, 2003, Table 3A.1.8), to derive root biomass.

For use of the stock-change method, the relevant living biomass was divided into the categories of raw-wood volume, branch-wood volume and root mass. Above-ground volumes were converted into masses using specific volume densities for the various tree species in question. Equation 14 and Equation 15 for C-stock determination via the stock-change method were thus converted, pursuant to PISTORIUS et al. (2006), into the form exhibited by Equation 16. The first term of that equation (raw wood, branch wood) was applied to each tree, and the results were aggregated to obtain values for entire stands. The stand values, broken down by tree-species groups, were used to derive the below-ground biomass for the second term of Equation 16.

Equation 14

$$\Delta C = (C_{t2} - C_{t1}) / (t_2 - t_1)$$

Equation 15

$$C = (D * rd * BEF) * (1 + R) * CF$$

Equation 16

$$C = (D * rd_{stamm} + D * rd_{ast} * (VEF - 1)) * (1 + R) * CF$$

where:

C	= carbon stocks
t	= time at which an inventory is taken
D	= raw-wood volume
rd_{stamm}	= stem bulk density
rd_{ast}	= branch bulk density
BEF	= biomass-expansion factor
VEF	= volume-expansion factor[78]
R	= root / shoot ratio
CF	= carbon fraction

7.2.4.1.4 Conversion into above-ground individual-tree biomass

Trees with at least 7 cm DBH

The raw-wood volume D of each individual tree is derived using the BWI volume function, which depends on the parameters diameter at breast height (DBH), tree height (H) and diameter at a height of 7 m (D7). The raw-wood volume D is converted to biomass (in tonnes) via bulk-density values rd_{stem} for each relevant tree-species group. The bulk-density values are derived via the formula

[78] The biomass-expansion factor (BEF) is used here in keeping with IPCC. In the literature, the term "BEF" is used in a variety of very different ways. For this reason, in the following, the term "volume-expansion factor" (VEF) is used, which describes the relationship "above-ground volume / raw-wood volume".

Equation 17

$$r = r_0(1 - \beta_V / 100)$$

where:

r	= bulk density
r_0	= raw density
β_V	= volume-loss measure

Those values depend on the volume-loss measures and raw densities given in KOLLMANN (1982). The raw densities – given in KOLLMANN (cf. Table 241) – also include the raw-density ranges and their average values for the most important tree species. The aforementioned ranges provide the basis for deriving the error framework that results from conversion of raw-wood volume into biomass. Table 241 lists bulk densities pursuant to IPCC and KNIGGE & SCHULZE (1966) by way of comparison. While those figures are comparable to those given by KOLLMANN (1982), they do not yield error data.

Table 241: Bulk densities *rd* in [g/cm³], as given by IPCC (2003), KOLLMANN (1982) and KNIGGE & SCHULZ (1966)

Genus	Species	Stem (IPCC)	Branch (IPCC)	Stem (Kollmann)	Branch (Kollmann)	Knigge & Schulz (branch and stem)	βV [%] (Kollmann)
Picea	**abies**	0.40	0.54	0.38	0.51	0.38	11.9
Picea	**(other)**	0.40	0.54	0.38	0.51	0.38	11.9
Pinus	**sylvestris**	0.42	0.56	0.43	0.58	0.43	12.1
Pinus	**strobus**	0.32	0.43	0.43	0.58	0.43	12.1
Pinus	**(other)**	0.42	0.56	0.43	0.58	0.43	12.1
Abies	**alba**	0.40	0.54	0.36	0.49	0.37	11.5
Abies	**(other)**	0.40	0.54	0.36	0.49	0.37	11.5
Pseudotsuga	**menziesii**	0.45	0.60	0.41	0.56	0.41	11.9
Larix	**decidua**	0.46	0.62	0.49	0.66	0.49	11.4
Larix	**kaempferi**	0.49	0.66	0.49	0.66	0.49	11.4
Thuja	**spec.**	0.31	0.42	0.38	0.51	0.38	11.9
Tsuga	**spec.**	0.42	0.56	0.38	0.51	0.38	11.9
Coniferous trees	**(other)**	0.40	0.54	0.38	0.51	0.38	11.9
Fagus	**sylvatica**	0.58	0.64	0.56	0.61	0.55	17.9
Quercus	**robur**	0.58	0.62	0.57	0.61	0.56	12.2
Quercus	**petraea**	0.58	0.62	0.57	0.61	0.56	12.2
Fraxinus	**exelsior**	0.57	0.60	0.56	0.60	0.56	13.2
Carpinus	**betulus**	0.63	0.69	0.64	0.70	0.56	18.8
Acer	**spec.**	0.52	0.57	0.52	0.57	0.56	11.5
Tilia	**spec.**	0.43	0.47	0.42	0.46	0.56	12.1
Robinia	**pseudoacacia**	0.58	0.64	0.65	0.71	0.56	11.5
Ulmus	**spec.**	0.51	0.54	0.56	0.59	0.56	14.9
Castanea	**sativa**	0.48	0.51	0.56	0.59	0.56	11.4
Betula	**spec.**	0.51	0.56	0.53	0.58	0.38	13.2
Alnus	**spec.**	0.45	0.49	0.43	0.47	0.38	17.9
Populus	**spec.**	0.35	0.38	0.35	0.39	0.38	13.7
Salix	**spec.**	0.45	0.49	0.46	0.51	0.38	13.7
Prunus	**spec.**	0.49	0.54	0.56	0.61	0.38	12.6
Deciduous trees	**(other)**	0.58	0.64	0.56	0.61	0.38	13.7

The raw-wood volume D was expanded into the above-ground tree wood volume B via the functions published in PISTORIUS et al. (2006) for derivation of volume-expansion factors (*VEF*). As used, the functions have the form

Equation 18

$$VEF = B / D = (a + bD) / D$$

The parameters a and b for calculation of *VEF* are listed in Table 242.

Table 242: Models for deriving volume-expansion factors

Model	a	b
Birch	0.017493	1.121933
Beech, age to 60	0.011942	1.207371
Beech, age 61 to 100	0.008184	1.196184
Beech, age at least 101	0.030255	1.128104
Oak	0.101879	1.051529
Alder	0.004825	1.068903
Spruce, age to 60	0.036697	1.148143
Spruce, age at least 61	0	1.177947
Pine, age to 80	0.009946	1.156659
Pine, age at least 81	0.036883	1.076103
Fir, age to 80	0.019457	1.168262
Fir, age 81 to 120	0	1.228069
Fir, age at least 121	0	1.219492
Larch	0.063265	1.057712

The difference between tree wood volume and raw-wood volume is defined as branch wood. Due to the stresses it is subject to, branch wood is denser than trunk wood. Differentiation of categories makes it possible to use branch-wood densities that differ from raw-wood densities. The necessary data were derived by analogy to HAKKILA (1972), who divides trees by physiological groups – into conifers, ring-porous deciduous trees and diffuse-porous deciduous trees. Table 243 shows average values for 8 conifers, 8 ring-porous deciduous trees and 4 diffuse-porous deciduous trees. A relationship for these physiological tree-species groups was derived, and the basic densities pursuant to KOLLMANN (1982) were correspondingly increased.

Table 243: Wood densities for branch wood

	Stem wood [g/cm³]	Branch wood [g/cm³]	Ratio, Branch density / stem density
Conifers	0.36	0.49	1.34
Diffuse-porous deciduous trees	0.49	0.54	1.1
Ring-porous deciduous trees	0.54	0.57	1.06

The above-ground biomass B_o for a given individual tree, therefore, is obtained as the sum of the raw-wood biomass and the branch-wood biomass, via the following equation:

Equation 19

$$B_o = D * rd_{stem} + D * (\frac{a + bD}{D} - 1) * rd_{branch}$$

Trees with less than 7 cm DBH

In the National Forest Inventory, the numbers of trees with DBH of less than 7 cm are tallied in sampling circles, and grouped into separate size classes. The mean individual-tree volumes for such size classes are known from studies carried out by the FVA Baden-Württemberg (an institute for forest trials and research): trees shorter than 50 cm have an average volume of 0.0002 m^3; trees > 50 cm height and < 7 cm DBH have an average volume of 0.001 m^3. Tree volumes are converted into biomass via multiplication by the bulk densities listed in Table 241.

7.2.4.1.5 Conversion into below-ground biomass

In contrast to derivation of above-ground biomass, the root dry substance was not calculated via a volume and the bulk density; instead, it was estimated directly from the above-ground mass. Dry-root substance was estimated using the root/shoot ratio, at the stand level, with values from Table 3A.1.8 IPCC (2003) (cf. Table 244). To obtain stand values, the above-ground biomass, differentiated by tree-species groups, was up-scaled to the hectare level for each sample point, and then the below-ground biomass was derived. An advantage of the IPCC table is that it gives the standard error for estimates.

The below-ground biomass can also be calculated via root-biomass functions. Because root studies are so difficult to carry out, few relevant functions are available. One such function, for estimating root biomass, was published by DIETER & ELSASSER in 2002. In the main, that function is based on data, for temperate forests, of CAIRNS et al. (1997), KURZ et al. (1996) and VOGT et al. (1996). With their approach, DIETER & ELSASSER managed to build a random-sampling set of 272 root studies. The function provided in DIETER & ELSASSER (2002) was not used for the present inventory, however, because no error information for that function was given. A calculation comparing the function of DIETER & ELSASSER (2002) and the IPCC values is presented by DUNGER et al. (2010c).

Table 244: Root/shoot-ratio at the plantation level, pursuant to IPCC (2003)

Vegetation type	Above-ground biomass [t ha^{-1}]	Average root / shoot ratio	Standard error	Lower range	Upper range
Coniferous trees, plantations	50	0.46	0.21	0.21	1.06
	50-150	0.32	0.08	0.24	0.50
	150	0.23	0.09	0.12	0.49
Oak forest	70	0.35	0.25	0.20	1.16
Other deciduous tree species	75	0.43	0.24	0.12	0.93
	75-150	0.26	0.10	0.13	0.52
	150	0.24	0.05	0.17	0.30

7.2.4.1.6 Conversion of individual-tree biomass to carbon

For conversion of biomass to C stocks, the IPCC default value, 0.5 (IPCC, 2003, Equation 3.2.3), was used. WIRTH et al. (2004) report that the differences between compartments, within one and the same tree species, are larger than the differences between tree species. They obtain a range of 0.50 to 0.56 gC g^{-1} in conifers. The relative standard error for carbon content in wood is given by BURSCHEL et al. (1993) as 1 to 2 %; WEISS et al. (2000) use 2 %. Overall, therefore, 0.5 gC g^{-1}, with a relative standard error of ±2 %, seems appropriate as a good assumption for mean C content.

7.2.4.1.7 Procedures for scaling up to relevant states in 1987, 2002, 2008

This section presents the procedures for scaling up the values "raw-wood stocks", "biomass" and "carbon", in the framework of a stratified sampling plan, for given time periods. Stratification is required, since some Länder have increased the density of their sampling networks, the so-called "sampling strata". The relevant states for the years 1987, 2002 and 2008 were calculated. The up-scaling procedures for different domains (all of Germany, various regions (old/new Länder) and different LULUCF/ARD categories) are identical.

The National Forest Inventory is designed on a basis of cluster sampling. The smallest sampling unit is the cluster, with four cluster points (sample points). Along the boundaries of the inventory area, or of sampling strata, incomplete clusters, of varying sizes, will be found, i.e. the number of sample points (cluster points in forest and non-forest) within such clusters can vary between 1 and 4. For each cluster *c* located within a stratum *l*, the local density (*Y*) must be calculated first:

Equation 20

$$Y_{lc} = \frac{\sum_{m=1}^{M} I_{l,c,m} Y_{l,c,m}}{M_{l,c}}$$

where $M_{l,c}$ = number of sample points in cluster *c* in stratum *l*. The estimator of means, with respect to forest and non-forest, for stratum *l* is then obtained as follows:

Equation 21

$$\hat{\bar{Y}}_l = \frac{\sum_{c_l=1}^{C_l} M_{l,c} Y_{lc}}{\sum_{c_l=1}^{C_l} M_l}$$

The estimator of means for a given value, throughout all sampling strata ($\hat{Y}_{st}$), is the mean of the individual stratum estimators, weighted with the area proportions for the various strata:

Equation 22

$$\hat{\bar{Y}}_{st} = \sum_{l=1}^{L} \hat{\bar{Y}}_l \frac{\lambda(U_{l)}}{\lambda(U)}$$

The estimator of the total is obtained by multiplying the estimator of means throughout all strata by the total area *λ(U)*.

Equation 23

$$\hat{Y}_{st} = \hat{\bar{Y}}_{st} \lambda(U)$$

The (forest-) area-related mean estimator is defined as the quotient or ratio estimator ($\hat{R}_{st}$); it is obtained as follows:

Equation 24

$$\hat{R}_{st} = \frac{\hat{Y}_{st}}{\lambda(U_{forest})}$$

7.2.4.1.8 Up-scaling procedures for obtaining changes between 1987 and 2002, and between 2002 and 2008 (derivation of stock changes via the "stock-change method")

For calculation of the changes between two time points, the "continuous forest inventory" (CFI) method was used, i.e. for up-scaling only those cluster points were used that were included at both times. The change estimate is thus based on the difference between the two status estimators. At the stratum level, the total change is estimated as follows:

Equation 25

$$\hat{G}_l = \hat{Y}_l^{(t_2)} - \hat{Y}_l^{(t_1)}$$

The total change throughout all strata for a given domain is estimated in the manner used in Equation 22. The estimated total change is calculated via Equation 23. The change in the area-related mean estimator is determined via:

Equation 26

$$\hat{G}_{R_{st}} = \hat{R}_{st}^{(t_2)} - \hat{R}_{st}^{(t_1)}$$

7.2.4.1.9 Interpolation of time periods, to obtain annual-change estimates

The National Forest Inventory (BWI; Bundeswaldinventur) is carried out periodically. Consequently, annual rates of change – "emission factors" – have to be obtained via interpolation between two points in time. For the time periods between BWI I (referenced to 1987) and BWI II (referenced to 2002) and the Inventory Study 2008, linear interpolation was carried out at the level of the LULUCF and ARD classes. The emission factor EF for a LULUCF class is thus defined as the quotient of the area-related mean estimator and the number of years *a* within the relevant inventory interval:

Equation 27

$$EF = \hat{R}_{st}^{(t_1,t_2)} / a$$

A linear trend was also chosen in cases in which change estimates had to be extrapolated beyond an inventory period.

7.2.4.2 Dead wood

7.2.4.2.1 Forest Land remaining Forest Land

The C stocks in dead wood were calculated with data of the BWI II (BMELV 2005) survey and the Inventory Study 2008. The terrestrial survey used for BWI II included only fallen dead wood with a thicker-end diameter of at least 20 cm, standing dead wood with a diameter of at least 20 cm at breast height (DBH), and trunks with either a height of at least 50 cm or a cut-surface diameter of at least 60 cm (BMVEL 2001). In keeping with requirements for climate reporting, in the Inventory Study 2008 the survey threshold for dead-wood objects was reduced to a diameter of at least 10 cm at the thicker end (BMELV 2010). In both forest inventories, trees were sub-divided into three main tree-species groups: conifers, deciduous trees (except for oaks) and oaks. In addition, dead wood was classified into a total of four decomposition-level categories (BMELV 2010, BMVEL 2001).

For purposes of reporting pursuant to IPCC (2003), the applicable dead-wood-stock relationship between the 10 cm and 20 cm survey limits was determined from the data collected in the Inventory Study. Under the assumption that that relationship was the same at the time of BWI II, the dead-wood stocks from the 10 cm survey limit upward were estimated for the year 2002. The biomass of the dead wood stocks from BWI II (2002) and the Inventory Study (2008), for the various relevant decomposition classes, was determined with the wood density figures pursuant to FRAVER et al (2002) for conifers, and with the wood density figures pursuant to MÜLLER-USING & BARTSCH (2009) for deciduous trees. To calculate the wood density of deciduous wood, the dead-wood objects in the deciduous (other than oak) and oak tree-species groups were combined. The annual C-stock change in dead wood was calculated pursuant to Equation 28 (IPCC 2003, Equation 3.2.12). It amounts to about 0.09375 MgC ha^{-1} a^{-1}.

Equation 28

$$\Delta C_{FF_{DW}} = \frac{A*\left(B_{t_2} - B_{t_1}\right)}{T} CF$$

where:

ΔC_{FFDW} =	Annual change in carbon stocks in dead wood, on forest land remaining forest land
A =	Area of forest land remaining forest land
B_{t1} =	Dead-wood stocks at time t_1 for forest land remaining forest land
B_{t2} =	Dead-wood stocks at time t_2 (previous time) for forest land remaining forest land
$T=(t_2-t_1)$ =	Time period between the two estimates
CF =	Carbon conversion factor (standard value = 0.5)

7.2.4.2.2 Land converted to Forest Land

On Land converted to Forest Land (0-20 years), no creditable accumulation of dead wood takes place, since the dead-wood objects produced on such land tend to have diameters smaller than 10 cm. Pursuant to the guidelines for climate reporting, the survey threshold for dead-wood objects is a diameter of at least 10 cm. The BWI II data indicate that the mean DBH of a 20-year-old stand is no more than 10 cm, throughout all tree species. For this reason, for the entire report period, no dead wood is reported on Land converted to Forest Land, and NO (not occurring) is entered at the corresponding locations in the CRF tables.

7.2.4.3 Litter

7.2.4.3.1 Forest Land remaining Forest Land

The calculation of C-stock changes in the soil and in litter is based on data from national forest-soil inventories (BZE I and BZE II) and on the BioSoil inventory data (cf. Chapter 7.2.2.2). A slight decrease in carbon stocks, amounting to -0.05 MgC ha^{-1} a^{-1}, occurred in the period from 1990 (BZE I) to 2006 (BZE II / BioSoil) (cf. Chapter 7.2.4.3.4). That trend has been assumed to be valid as well for the period 2007 to 2011.

7.2.4.3.2 Land converted to Forest Land

Carbon stocks in litter were calculated on the basis of status data from the BZEI, BZE II and BioSoil inventories. According to those calculations, the mean carbon stocks in litter, referenced to 1990 (BZE I), were 18.58 MgC ha^{-1}, and, referenced to 2006 (BZE II/BioSoil), 18.71 MgC ha^{-1} (cf. Chapter 7.2.4.3.3). For the period 1991 to 2005, the mean carbon stocks in litter are obtained via interpolation; for the period as of 2007 they are obtained via extrapolation and used as a basis for calculating afforestation areas (cf. Table 245).

Table 245: Emission factors for litter in the land-use categories with conversion to Forest Land (Land converted to Forest Land)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
IEF [MgC ha^{-1}]	0.4645	0.4633	0.4620	0.4608	0.4595	0.4583	0.4570	0.4558	0.4545	0.4533	0.4520
Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
IEF [MgC ha^{-1}]	0.4508	0.4495	0.4483	0.4470	0.4458	0.4445	0.4433	0.4420	0.4408	0.4395	0.4383

Litter forms only gradually in afforested areas. It was assumed that it takes 40 years for average carbon stocks to form in litter. The annual carbon-stock increase in litter is obtained by dividing the mean carbon stocks for the year in question by the number of years required for those mean carbon stocks to form. Those values are confirmed by standard values for carbon storage in litter, and by standard values for the time periods required for a new balance to form, pursuant to the Good Practice Guidance of the IPCC (2006) and PAUL et al. (2009).

7.2.4.3.3 Derivation of carbon stocks in litter

Litter was sampled at the relevant inventory points. This was accomplished by taking mixed samples at satellite points, using sampling frames of various sizes. The litter was considered to comprise the entire dead organic surface layer with a fraction < 20 mm. For some 80 % of points, the fraction > 20 mm was also included in the litter sample. Organic carbon concentrations in the litter were measured via comparable methods. The following relationship is relevant: total carbon (C_{ges}) is equal to organic carbon (C_{org}) ($[C_{ges}]=[C_{org}]$). In each case, the carbon stocks in litter are calculated from the area of the sampling frame, and from the weight and organic concentration of the relevant litter. A more detailed description of the relevant methodological aspects is provided by KÖNIG et al. 2005.

All points available from the BZEI, BZE II and BioSoil surveys, along with information as to the forest type concerned in each case, entered into calculation of litter carbon stocks. All values that were either smaller or larger than twice the standard deviation ($x \pm 2\sigma$) were considered to be outliers and were deleted. From the values of the remaining data points for the BZE I (n = 1664) and BZE II / BioSoil (n = 1670) surveys, it was possible to calculate carbon stocks separately for deciduous, coniferous and mixed forest (cf. Table 246). The mean C stocks given by the two inventories were calculated as a weighted mean from the carbon stocks for the three forest types concerned. The applicable weights were obtained from the forest types' area shares of the total forest area, as given by CORINE land-use data for 1990 and 2006, and from the regional densities of the inventory networks. The mean C stocks for the samples were 18.58 ± 0.30 Mg ha^{-1}, for BZE I, and 17.78 ± 0.33 Mg ha^{-1}, for BZE II/BioSoil. As country-specific values for litter, those values replace the recommended standard value in IPCC (2003) as the basis for calculating CO_2 emissions from litter in connection with deforestation (cf. Chapter 11.3.1.1.4) and carbon sequestration in litter in connection with afforestation (cf. Chapter 7.2.4.3.2).

Table 246: Carbon stocks in litter in German forests, as determined in the BZE I and BZE II / BioSoil inventories, along with the pertinent standard error

Forest type	Carbon stocks (BZE I) [Mg/ha]	Carbon stocks (BZE II/BioSoil) [Mg/ha]
Deciduous forest	9.38 ± 0.40	7.06 ± 0.29
Mixed forest	16.11 ± 0.65	14.89 ± 0.90
Coniferous forest	23.57 ± 0.44	23.54 ± 0.46
Total forest	**18.58 ± 0.30**	**17.78 ± 0.33**

7.2.4.3.4 Derivation of carbon-stock changes in litter in the period from 1990 (BZE I) to 2006 (BZE II/Biosoil)

The sampling plots entering into calculation of carbon stocks were analysed as unpaired samples. With a two-sided t-test for unpaired samples, it was tested whether the carbon stocks (which had been logarithmised) at the two inventory times differed. Each sampling plot was assigned a weight consisting of the area percentage for the relevant stratum and the regional network density. The average difference was -0.05 ± 0.03 MgC ha^{-1} a^{-1}. The value did not deviate significantly from zero.

For Land converted to Forest Land, annually decreasing factors for litter accumulation were calculated from the C stocks given by BZE I / BZE II and the average difference (cf. Chapter 7.2.4.3.2 and Table 245).

7.2.4.4 Mineral soils

7.2.4.4.1 Forest Land remaining Forest Land

Carbon stocks, and carbon-stock changes, in mineral soils were up-scaled on the basis of the national forest soil inventories (BZE I and BZE II) and of the BioSoil inventory data (cf. Chapter 7.2.2.2). With the available data, the changes in mineral soils were calculated, with respect to both inventories. The relevant methods are described in detail in chapters 7.2.4.4.3 and 7.2.4.4.4. The resulting extrapolation for the entire national territory yielded a mean annual increase in carbon stocks in mineral soils of 0.27 ± 0.09 MgC ha^{-1}. It has been assumed that that trend continued for the period 2007 to 2011.

7.2.4.4.2 Land converted to Forest Land

For Land converted to Forest Land, the carbon-stock changes in mineral soils were calculated in keeping with the procedure in Chapter 7.1.5. The calculated mean emission factors (implied emission factors) for the year 2011, which are summarised in Table 236 in Chapter 7.1.5, are oriented to annual carbon-stock changes in mineral soils in connection with land-use changes leading to Forest Land (Land converted to Forest Land), over a change period of 20 years.

7.2.4.4.3 Derivation of carbon stocks and carbon-stock changes

The carbon stocks and their changes were derived on the basis of inventory data (cf. Chapter 7.2.2.2). Mineral soil was sampled at depths of relevance for the national inventory report; at most BZE points, this involved depth ranges of 0-5 cm, 5-10 cm and 10-30 cm. In a few cases, samples were taken on a horizon basis. In the BioSoil inventory, samples were taken at depth ranges of 0-5 cm, 5-10 cm, 10-20 cm and 20-40 cm.

As part of sampling, the fine-earth bulk density (TRD_{fb}), the coarse-fragment content (GBA) and the organic-carbon concentration (C_{org}) were determined using comparable methods (KÖNIG et al. 2005). The fine-earth bulk density was determined via volume-adapted sampling, for different depth ranges; to some extent, estimated values based on soil profiles were used (WOLFF & RIEK 1996, WELLBROCK et al. 2006). Where fine-earth bulk-density data is lacking, existing relevant values from other inventories have been used. That procedure has also been applied to obtain coarse-fragment content values, which are needed for calculation of the TRD_{fb} and fine-earth stocks.

In carbonate-containing soils, the organic-carbon concentration (C_{org}) in fine soils was measured with respect to the inorganic-carbon concentration (C_{anorg}) ($[C_{org}] = [C_{ges}] – [C_{anorg}]$). In non- carbonate-containing soils, the relationship $[C_{org}] = [C_{ges}]$ applies.

The carbon stocks were calculated from the stocks for the individual depth layers. To that end, it was necessary first to translate horizon-based data into depth-layer sections. This was accomplished, in each case, by calculating the carbon stocks in a given depth layer, with stocks weighted in accordance with the thicknesses of overlapping sections and their carbon stocks. This was also carried out for the different depth layer, 20-40 cm, used by the BioSoil inventory.

An area-referenced approach, with strata formation, was used for calculation of carbon stocks and of their changes between the two inventory times. The basis for formation of area-relevant strata consisted of the 72 legend units used in the national soil map "Bodenübersichtskarte der Bundesrepublik Deutschland 1:1.000.000" (BÜK 1000). That source describes the dominant soil types, and parent material for soil formation, pursuant to the German soil system (AG BODEN 1994) and the FAO legend (FAO 1990). Since the classes concerned differed in the number of sample points they contained, the various dominant soil units were aggregated into new dominant soil groups. This increased the basic totality for each class, thereby increasing the pertinent statistical significance. The groups formed were oriented to comparable soil types, to substrate type and parent material and to texture and lime content. All in all, 16 new dominant soil groups, with their pertinent parent material, were then available for area-referenced evaluation (cf. Table 247). The inventory plots were allocated to the dominant soil groups on the basis of data, collected in the inventories, relative to the parent material and any layering of that material, to soil type, to horizon sequences and to soil texture.

Table 247: Combined legend units on the basis of the BÜK 1000 soil map

Abb.	Dominant soil groups, by substrate type, soil texture and lime content
1	Nutrient-poor soils from dry, nutrient-poor sands
2	Various soils from sandy to loamy terrace or riverine deposits
3	Various soils from partly calcareous, loamy-clayey terrace or riverine deposits
4	Pseudo-gleyed soils from sandy to loamy sediments overlying boulder clay
5	Various soils from sandy sediments overlying boulder clay
6	Brown earths from nutrient-rich sands
7	Soils of loess areas
8	Various soils from scree overlying calcareous, marl and dolomite rock, alternating with terra fusca from silty-clayey redeposited products of limestone weathering
9	Brown earth and terra fusca from redeposited products of weathering of calcareous, marl and dolomite rock, and rendzina from limestone
10	Pelosol – brown earth / pelosol-pseudogley from weathering products of marl and clay rocks and calcareous layers
11	Brown earth from alkiline and intermediary magmatic rock
12	Brown earth from acidic magmatic and metamorphic rock
13	Brown-earth / podzolic soils from hard clayey and silty slates with fractions of greywacke, sandstone, siltstone, quarzite and phyllite
14	Podzols / brown earths from low-alkilinity quarzites, sandstones and conglomerates
15	Various soils alternating tightly with greywacke, clay slate, limestone, sandy, silty and clayey stones and loess-loam overlying various rocks
16	High-mountain soils from limestone, dolomite rock and silicate rock

For purposes of analysis, carbon-stocks data was available from a total of 1,861 plots from the BZE I inventory, and from 1,822 plots from the BZE II inventory / BioSoil inventory. With the exception of the data from two German Länder (states), the data were available mainly as paired samples, i.e. samples in which it was possible to correlate each BZE I point with exactly one BZE II point or one BioSoil point. The number of points that entered into the final calculation of carbon stocks and their changes was lower than the number suggested by the above figures, however. This was because some organic-soil areas were excluded, because a) it proved impossible to assign them to points of a dominant soil unit or b) because their stocks were seen to be implausible, on the basis of outlier analysis, and thus were rejected. For the analysis, the total sample, broken down by German Länder (states), was divided into a paired sample subset and an unpaired sample subset. In the paired sample subset, it proved possible to identify outliers via residual analysis. To that end, the carbon stocks for each dominant soil unit, at the various inventory time points, were compared via plotting in a linear regression. A relevant example is presented in Figure 56 (on the left). Studentised residuals were used to eliminate outliers that seemed inconsistent with the rest of the data (cf. Figure 56 (on the right)). In addition, a "hat matrix" was generated, for identification of "leverage" points that represent outliers within the independent variable (cf. Figure 56 (right)) (WEISBERG 2005).

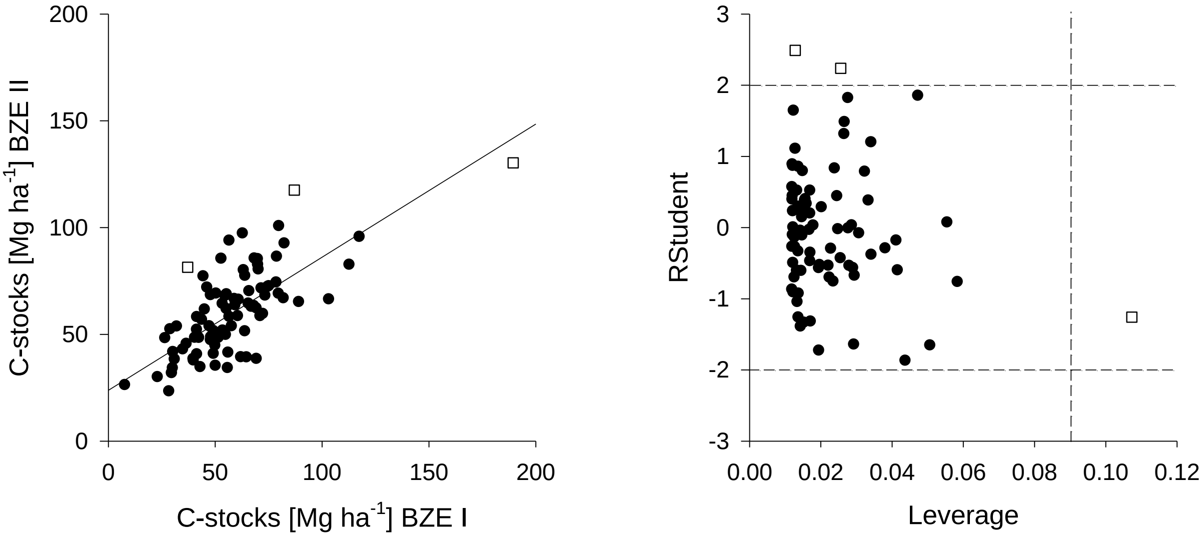


Figure 56: Regression between carbon stocks (0-30cm) as shown by BZE II / BioSoil data and the BZE I data (left), and outliers identified via residuals analysis with studentised residuals (middle) and "high-leverage" points (right), with regard to the example of the new dominant soil group

Since some Länder shifted the grid between the BZE I and BZE II inventories, the points for which assignment to a dominant soil group was possible were available as unpaired samples. Carbon stocks for those plots were calculated via formation of mean values for each dominant soil group. Outliers for each class were detected via double standard deviation ($x \pm 2\sigma$) and then removed. In addition, organic soils were excluded. Then, the mean carbon stocks for each dominant soil group were correlated with the relevant annual differences. After elimination of the outliers, via outlier analysis, a total of 1,469 points from the BZE I survey, and 1,491 points from the BZE II survey / BioSoil inventory, were left. Of those, a total of 1,030 points were available as paired samples.

To permit area-weighted calculation of carbon-stock changes, the forest areas on the new dominant soil groups were determined as percentage shares of Germany's total forested area. To that end, the CORINE land-use data were intersected with the BÜK 1000 data via a GIS. In each case, it proved possible to correlate a forest area with the mean carbon-stock change for a dominant soil group. That, in turn, made it possible to calculate the average annual change in organic carbon for Germany, taking account of the new dominant soil groups' shares of total relevant area.

7.2.4.4.4 Results of derivation of carbon stocks and carbon-stock changes

On the basis of the area-weighted approach, the carbon stocks in Germany's mineral soil, to a depth of 30 cm, amounted to 56.5 ± 1.8 Mg ha^{-1} at the time of the BZE I inventory, and to 61.1 ± 1.7 Mg ha^{-1} at the time of the BZE II / BioSoil inventories. Those figures translated into annual increases of 0.27 ± 0.09 MgC ha^{-1}. A variance analysis (type III – ANOVA) showed that the differences between the two inventories were significant ($p<0.001$). Both the rate of change and the total stocks lie within a range that other authors have already estimated for central Europe. Estimates of annual carbon sequestration in the root zone range from 0.1 Mg ha^{-1} a^{-1} (NABUURS & SCHELHAAS 2002) to 0.9 Mg ha^{-1} a^{-1} (SCHULZE et al. 2000). Most of the values given in the literature are based on model-based up-scaling, and they take the soil's entire root zone into account (LISKI et al. 2002; DE VRIES et al.

2006). In comparison to those studies, the present effort was able to draw on considerably more measurement plots, arrayed within a finer grid. Those data represent a more valid sample, one that supports conclusions for Germany that are more reliable and that have a complete-coverage focus.

For nearly all dominant soil groups, carbon stocks, broken down by classes, were estimated to be higher at the time of the BZE II / BioSoil inventories than they had been at the time of the BZE I inventory (cf. Table 248). In addition, carbon stocks were higher in soils with high clay content than they were in soils with high sand content. The reasons for this are discussed in, for example, SIX et al. (2002) and BARITZ et al. (2010). Evaluation of the time series between the BZE I and BZE II / BioSoil inventories shows greater annual changes in carbon stocks especially in sandy dominant soil groups of the North German lowlands. For example, the annual relevant rate of change for the dominant soil groups 1, 5 and 6 was greater than 0.6 MgC ha^{-1} a^{-1}. On the other hand, PRIETZEL et al. (2006) put carbon sequestration, in the upper 30 cm, at 0.2 Mg ha^{-1} a^{-1} on sandy locations and at 0.4 Mg ha^{-1} a^{-1} on loamy locations. Smaller positive changes in carbon stocks, ranging between 0.1 and 0.6 Mg ha^{-1} a^{-1}, were found in over half of all classes formed. A marked decrease in C stocks, between the two inventory times, was seen in class 9.

Table 248: Carbon stocks at the time of the BZE I inventory and at the time of the BZE II inventory in the newly formed dominant soil units

	Carbon stocks (BZE I) [MgC ha^{-1}]			Carbon stocks (BZE II) [MgC ha^{-1}]		
DSU	**n**	**MV**	**SE**	**n**	**MV**	**SE**
1	176	47.9	7.1	182	60.5	7.9
2	53	54.3	7.6	58	55.9	6.2
3	19	60.7	1.7	24	58.6	4.3
4	109	62.6	4.9	90	61.7	6.4
5	69	35.2	1.9	70	49.4	2.8
6	34	25.8	0.9	34	41.6	2.0
7	125	54.6	2.4	113	63.3	2.7
8	102	75.5	1.6	101	75.8	1.6
9	36	76.2	1.6	43	68.0	1.2
10	57	55.0	2.4	69	58.9	2.1
11	35	50.3	1.3	35	51.3	0.9
12	186	63.9	3.2	164	61.3	3.1
13	208	56.1	5.1	226	59.2	4.7
14	218	50.8	3.6	244	55.1	3.8
15	30	51.0	1.3	30	50.0	0.9
16	37	94.1	0.6	27	93.3	0.5

(DSU = dominant soil units, n = number of soil samples, MV = mean value, SE = standard error)

7.2.4.5 Organic soils

7.2.4.5.1 Forest Land remaining Forest Land

The areas covered by organic soils were determined via a georeferencing procedure, with intersection of BÜK 1000 and ATKIS® data (cf. also Chapter 7.1.6). In estimation of differences in carbon stocks in organic soils, the IPCC (2003) values from Table 3.2.3 were used for CO_2, while the values from Table 3a.2.1 were used for N_2O. For that process, it is assumed that all organic sites are affected by drainage[79] and that the drainage is solely responsible for the changes. For organic soils, carbon emissions of 0.68 MgC ha^{-1} a^{-1}, and nitrous oxide emissions of 0.6 kg N_2O-N ha^{-1} a^{-1}, were used.

7.2.4.5.2 Land converted to Forest Land

For all Land converted to Forest Land, as for Forest Land remaining Forest Land, it is assumed that drainage applies (cf. Chapter 7.1.6). For organic soils under Land converted to Forest Land, carbon emissions of 0.68 MgC ha^{-1} a^{-1}, and methane emissions of 0.6 kg N_2O-N ha^{-1} a^{-1}, were thus used. Those annual emissions are being reported for all years since the relevant conversions.

7.2.4.6 Other greenhouse-gas emissions from forests

No nitrogen fertilisation in forests takes place in Germany. In CRF Table 5(I), therefore, this activity has been marked "NO" (not occurring).

7.2.4.6.1 Liming

Figures for CO_2 emissions from liming of forest soils are provided in category 5.G. (Other). They range from 162.37 Gg a^{-1} (1992) to 52.35 Gg a^{-1} (2008), and show a decreasing trend (cf. Figure 57). For 2011, the pertinent CO_2 emissions amount to 64.32 Gg a^{-1}.

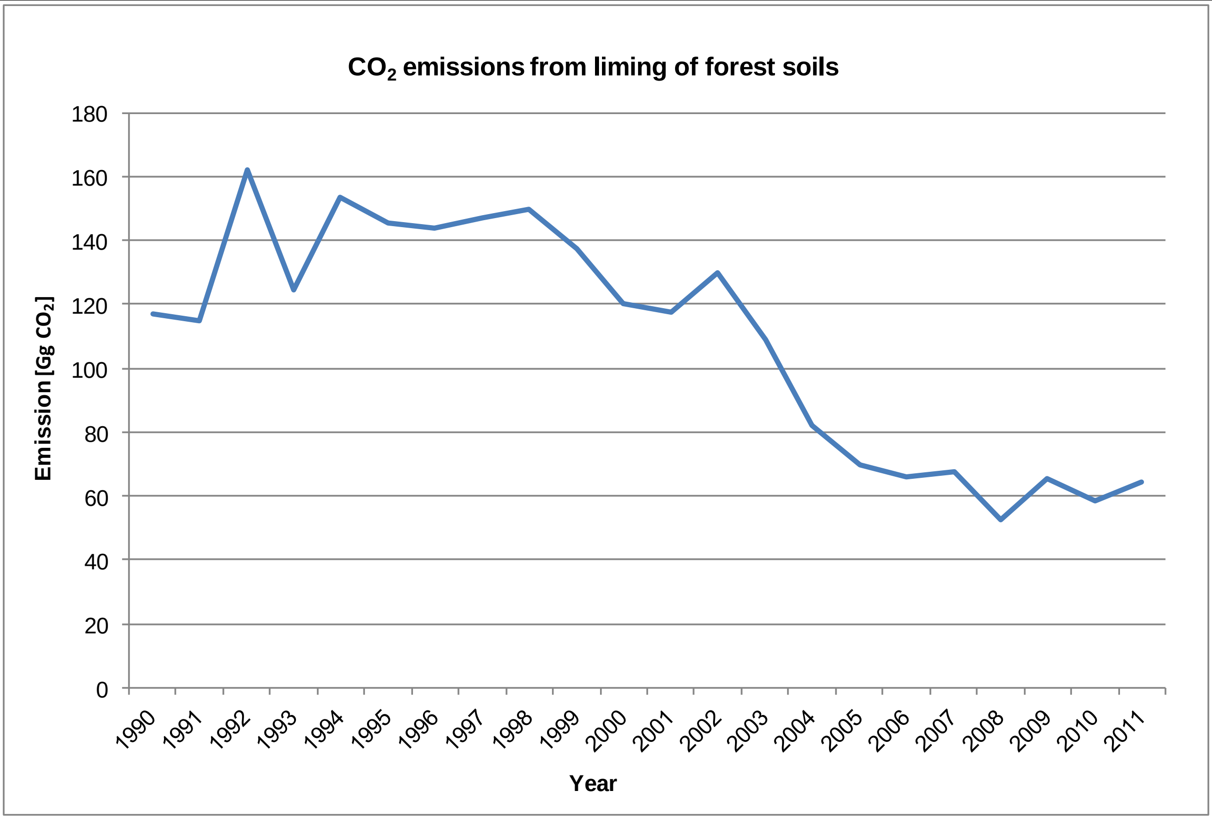


Figure 57: Emissions from liming of forests

The liming data were derived from the total-fertilisers calculation. They describe producers' and importers' deliveries to wholesalers and end users (STATISTISCHES BUNDESAMT

[79] Since no figures are available relative to the areas covered by undrained organic soils, a conservative approach is taken whereby all of the organic soil is assumed to be drained.

(FEDERAL STATISTICAL OFFICE), Fachserie 4, Reihe 8.2). For the calculation, the amount of fertiliser applied was assumed to be the same as the amount sold. The relevant emissions were derived using equation 3.3.6 from IPCC GPG-LULUCF (2003: p. 3.80). Additional information is presented in Chapter 7.3.4.5.

7.2.4.6.2 Forest fires / wildfires

While in other countries "prescribed burning" is an accepted method for clearing land or for managing ecosystems, no prescribed/controlled burning of biomass is carried out in Germany's managed forests. In keeping with Germany's climatic situation, and with measures taken in Germany to prevent wildfires, such fires tend to be rather seldom. This conclusion is confirmed by relevant wildfire statistics (BLE, 2011) and their data on areas affected by wildfires (cf. Figure 58). The mean area affected annually by wildfires, in the period 1990 – 2011, was 854 ha. In some years, unseasonably high summer temperatures have resulted in larger burn areas. This was the case, for example, in 1996 and 2003. An unusually large burn area, about 4,908 ha, was measured in 1992, which had an extremely warm summer.

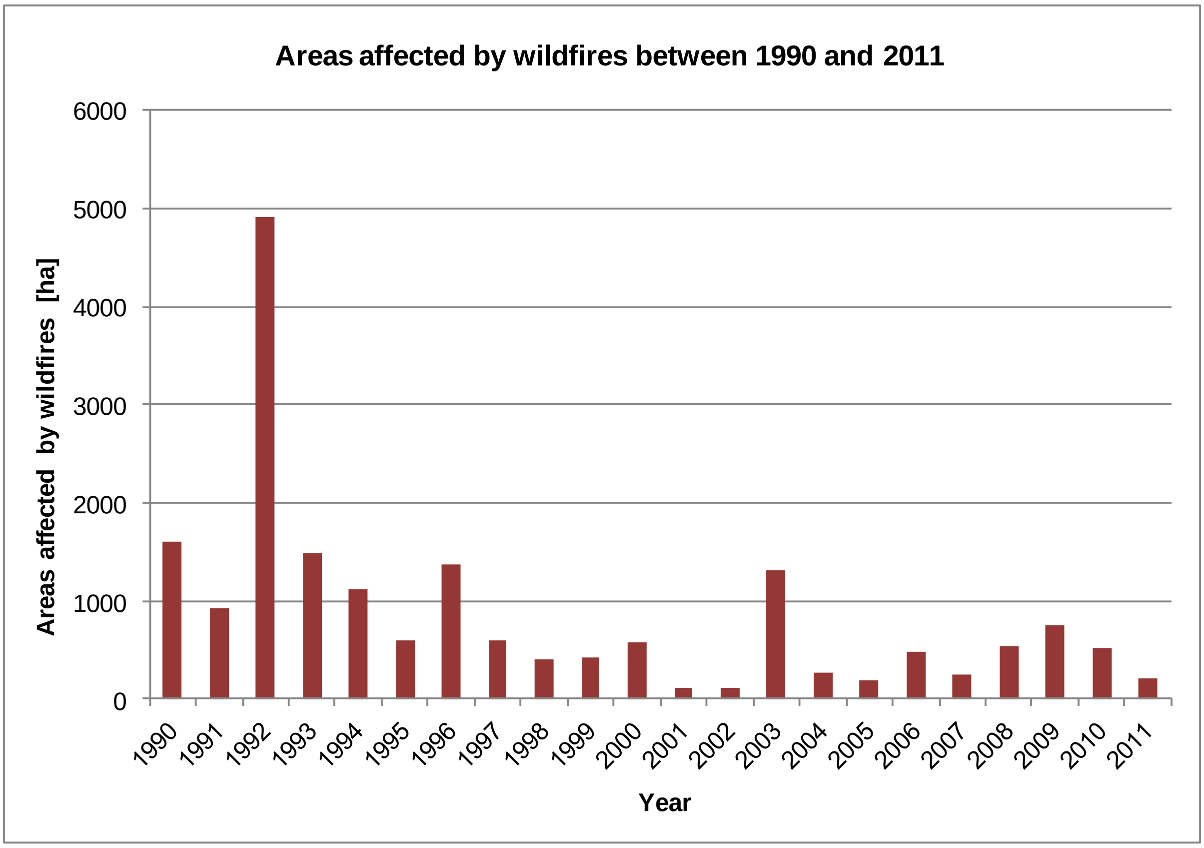


Figure 58: Areas affected by wildfires between 1990 and 2011 (pursuant to BLE, 2011)

Along with CO_2, wildfires release a range of other greenhouse gases (CO, CH_4, N_2O and NO_x). The CO_2 emissions resulting from biomass combustion have already been taken into account as part of changes of biomass stocks (CRF Sector 5.A.1 Forest land remaining Forest Land), via the "stock-change method". For this reason, they are listed as "IE" (included elsewhere). Emissions of other greenhouse gases were calculated with Equation 29 (IPCC 2003, Equation 3.2.20).

Equation 29

$$L_{fire} = A*B*C*D*10^{-6}$$

where:

L_{fire} = Quantity of greenhouse gas [t] released via fire
A = Wildfire burn area [ha]
B = Mass of fuel present on the relevant site (biomass) [kgTM ha^{-1}]
C = Combustion efficiency
D = Emission factor [g(kgTM)$^{-1}$]

The data on areas affected by wildfires in the period 1990 to 2011 have been taken from the wildfire statistics maintained by the Federal Agency for Agriculture and Food (BLE; Waldbrandstatistik – BLE 2011). The mean above-ground biomass for each year between 1990 and 2011 was derived via linear extrapolation and interpolation, using the data of the BWI II (National Forest Inventory II) and the Inventory Study 2008. Pursuant to the expert assessment carried out by KÖNIG (2007), 80 % of the wildfires in Germany remain on the ground surface and 20 % rise into tree crowns. In accordance with Table 3A.1.12 (IPCC 2003), a combustion efficiency (mass loss via direct combustion) of 0.15 was used for fires remaining on the ground surface, and an efficiency of 0.45 was used for fires rising into tree crowns. The emission factors for CH_4 and N_2O were taken from Table 3A.1.16 (IPCC 2003).

Germany suffers relatively little wildfire damage in terms of burn area, and thus the relevant CH_4 and N_2O gas emissions are low. With the exception of 1992, the pertinent CH_4 emissions range between 34 and 433 Gg, and the N_2O emissions range between 0.5 and 6.7 Gg. Those emissions levels were exceeded in 1992 (CH_4: 1.33 Gg, N_2O: 20.7 Mg), as a result of that year's unusually large burn area, which stemmed from that year's extremely warm summer. The complete time series for greenhouse gases resulting from wildfires is shown in Table 249.

Table 249: Greenhouse gases emitted as a result of wildfires, in the period 1990-2011

Year	Above-ground biomass [Mg ha^{-1}]	Wildfire burn area [ha]	Emitted gases [Mg] CH_4	N_2O
1990	180.7	1,606	433	6.7
1991	181.4	920	249	3.9
1992	182.1	4,908	1,333	20.7
1993	182.9	1,493	407	6.3
1994	183.6	1,114	305	4.7
1995	184.4	592	163	2.5
1996	185.1	1,381	381	5.9
1997	185.9	599	166	2.6
1998	186.6	397	110	1.7
1999	187.4	415	116	1.8
2000	188.1	581	163	2.5
2001	188.8	122	34	0.5
2002	189.6	122	34	0.5
2003	190.3	1,315	373	5.8
2004	191.1	274	78	1.2
2005	191.8	183	52	0.8
2006	192.6	482	138	2.1
2007	193.3	256	74	1.1
2008	194.1	539	156	2.4
2009	194.8	757	220	3.4
2010	195.6	522	152	2.4
2011	196.3	214	63	1.0

7.2.4.6.3 Drainage

No area data are available with regard to drainage of mineral soils. It may be assumed that no drainage occurs on mineral soils. For this reason, the entry for N_2O emissions from mineral soils is "NO" (not occurring).

Information about drainage of organic soils, with regard to both CO_2 and N_2O, is provided in Chapter 7.2.4.5.

7.2.4.6.4 Land-use changes from forest land to cropland

The manner in which N_2O emissions from land-use changes leading to cropland, on mineral soils, are estimated is described in Chapter 7.3.4.3. The N_2O-N emissions for land-use changes from forest land to cropland, in the period 1990 through 2011, are summarised in Table 250. .

Table 250: N_2O-N emissions in connection with land-use changes from forest land to cropland, in the period 1990-2011

Year	1990-2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
N_2O-N emissions [g ha-1 a-1]	0.000	0.049	0.157	0.333	0.415	0.524	0.667	0.936	1.287	1.743

For organic soils, N_2O emissions in the agricultural sector are reported under 4.D. In the CRF tables, IE (included elsewhere) is entered for that category (cf. also Chapter 7.3.4.4).

7.2.5 Uncertainties and time-series consistency (5.A)

Various uncertainties have to be taken into account in calculation of carbon stocks. The actual uncertainties, however, can only be approximated, with the help of pragmatic approaches.

With the available data, the following uncertainties can be quantified:

- Uncertainties in estimation of areas affected by land-use changes
- Uncertainties in estimation of above-ground and below-ground biomass
- Uncertainties in estimation pertaining to litter and mineral soils

The uncertainties described in the following chapters enter into a total-error budget for the LULUCF sector that is presented in Chapter 19.5.4.

With regard to the uncertainties in the carbon-conversion factor, we call attention to Chapter 7.2.4.1.6. A comprehensive statistical study of the measurement errors in the Inventory Study 2008 found that such errors can be neglected (DUNGER et al. 2010c).

When aggregated, error estimates (U) for values (1,..,*i…l*) propagate themselves in two different ways. When two values are added or subtracted, the error propagation is additive (cf. Equation 30).

Equation 30

$$U = \frac{\sqrt{\sum_i (U_i x_i)^2}}{\sum_i x_i}$$

where:

U = Total uncertainty

U_i = Uncertainty for target value
x_i = Quantity of target value

On the other hand, when two values are multiplied or divided, the errors for the two values propagate themselves multiplicatively (cf. Equation 31).

Equation 31

$$U = \sqrt{\sum_i (U_i)^2}$$

7.2.5.1 Uncertainties in estimation of areas affected by land-use changes

The new, sample-based system for surveying land-use changes has made it possible, for the first time, to calculate the sampling errors for each LULUCF category and KP category, per year (cf. Table 251). The sampling error is calculated in keeping with the formulae in Chapter 7.2.5.2.4 "Sampling errors". Once validation has been completed, all other error sources can be ruled out (cf. also Chapter 7.1.3.3). All areas have been entered significantly.

Table 251: Sampling error (SE) in area estimation in % for LULUCF classes between 1990 and 2011

LULUCF category / year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Forest land remaining forest land	0.67	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Conversion of forest land to cropland	7.02	7.02	7.02	7.02	7.02	7.02	7.02	7.02	7.02	7.02	7.02	6.97	6.92	6.89	6.87
Conversion of forest land to grassland	5.89	5.89	5.89	5.89	5.89	5.89	5.89	5.89	5.89	5.89	5.89	5.75	5.64	5.56	5.49
Conversion of forest land to wetlands	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	20.54	20.18	20.26	20.65
Conversion of forest land to settlements	11.57	11.57	11.57	11.57	11.57	11.57	11.57	11.57	11.57	11.57	11.57	11.16	10.84	10.60	10.43
Conversion of forest land to other land	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Conversion of cropland to forest land	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.74	4.56	4.42	4.33
Conversion of grassland to forest land	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.18	4.11	4.06	4.03
Conversion of wetlands to forest land	28.23	28.23	28.23	28.23	28.23	28.23	28.23	28.23	28.23	28.23	28.23	28.00	27.81	27.64	27.50
Conversion of settlements to forest land	10.80	10.80	10.80	10.80	10.80	10.80	10.80	10.80	10.80	10.80	10.80	10.38	10.05	9.78	9.57
Conversion of other land to forest land	44.93	44.93	44.93	44.93	44.93	44.93	44.93	44.93	44.93	44.93	44.93	36.68	32.26	29.88	28.63

LULUCF category / year	2005	2006	2007	2008	2009	2010	2011
Forest land remaining forest land	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Conversion of forest land to cropland	6.86	6.85	6.84	6.83	6.81	6.79	6.78
Conversion of forest land to grassland	5.44	5.33	5.26	5.21	5.17	5.15	5.11
Conversion of forest land to wetlands	21.26	20.25	19.63	19.32	19.32	19.32	19.58
Conversion of forest land to settlements	10.32	10.05	9.85	9.71	9.52	9.40	9.29
Conversion of forest land to other land	nd	nd	nd	nd	nd	nd	nd
Conversion of cropland to forest land	4.26	4.19	4.14	4.11	4.10	4.09	4.06
Conversion of grassland to forest land	4.00	3.94	3.91	3.91	3.89	3.88	3.87
Conversion of wetlands to forest land	27.38	25.88	25.57	26.07	26.07	26.07	26.31
Conversion of settlements to forest land	9.41	9.30	9.21	9.14	9.09	9.05	8.94
Conversion of other land to forest land	28.02	27.77	27.55	27.37	27.37	27.37	27.19

(nd = not defined[80])

7.2.5.2 Uncertainties in estimation of above-ground and below-ground biomass

7.2.5.2.1 Conversion of raw-wood volume into tree wood volume

The natural variability of above-ground tree allometry has not been included. This error cannot be calculated, since the original figures of Grundner & Schwappach (1952) are not available. The trees with which they obtained their figures grew between 1750 and 1900, and it is not possible to identify relevant allometric differences resulting from changes in environmental conditions, and in management, that have occurred since then. The tables contain only already smoothed values, and thus the actual variance is systematically underestimated. This error consideration thus calculates only the error for conversion of raw-

[80] There are no areas in the land-use category Other Land

wood volume into tree wood volume. The standard deviation of the residuals of the models is shown in Table 252:

Table 252: Relative standard error of volume-expansion models

Model	Mean (tree wood) [m³]	Standard deviation (residuals) [m³]	Relative standard error [%]
Oak	4.69	0.19	4.10
Birch	0.69	0.01	1.09
Alder	0.69	0.01	0.91
Beech, age to 60	0.36	0.02	5.47
Beech, age 61 to 100	1.25	0.05	4.06
Beech, age at least 101	2.67	0.07	2.57
Spruce, age to 60	0.45	0.05	11.28
Spruce, age at least 61	3.60	0.16	4.55
Pine, age to 80	0.60	0.02	3.08
Pine, age at least 81	2.11	0.07	3.27
Fir, age to 80	0.89	0.06	6.22
Fir, age 81 to 121	3.53	0.26	7.50
Fir, age at least 121	6.98	0.62	8.94
Larch	3.21	0.07	2.22

Table 253 shows the uncertainties that arise in the volume expansion. It includes only the uncertainties for cases in which C stocks can be directly estimated.

Table 253: Uncertainties arising in the volume expansion

LULUCF category	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest Land remaining Forest Land	2.99	2.84	2.18	2.90	1.70	1.70	1.76	1.71
Conversion of forest land to cropland	2.12	–	–	–	–	–	–	–
Conversion of forest land to grassland	2.81	–	–	–	–	–	–	–
Conversion of forest land to settlements	2.14	–	–	–	–	–	–	–
Conversion of forest land to wetlands	3.08	–	–	–	–	–	–	–
Conversion of forest land to other land	–	–	–	–	–	–	–	–
Conversion of cropland to forest land	–	2.11	–	–	–	–	–	–
Conversion of grassland to forest land	–	2.07	–	–	–	–	–	–
Conversion of settlements to forest land	–	2.00	–	–	–	–	–	–
Conversion of wetlands to forest land	–	1.04	–	–	–	–	–	–
Conversion of other land to forest land	–	–	–	–	–	–	–	–

7.2.5.2.2 Bulk densities for specific tree-species groups

The bulk densities for wood vary from tree species to tree species – and within one and the same tree. KOLLMANN (1982) gives variation ranges for raw densities. With the help of those variation ranges, the standard deviation can be estimated pursuant to SACHS (1984). For left-leaning and right-leaning distributions (approximations of triangular distributions) of bulk densities, distributions that are actually seen in trees (BOSSHARD 1984; KOLLMANN 1982), the range is divided by 4.2. It was not possible to take account of the error arising in conversion of raw density into bulk density, since no relevant data are available. In this case, it was assumed that this error would not affect the bulk-density range.

Table 254: Relative standard error in estimates of bulk densities

Tree species	Mean raw density	Minimum raw density	Maximum raw density	Standard error estimated	Standard error se [%]
Beech	0.68	0.49	0.88	0.09	13.66
Douglas fir	0.47	0.32	0.73	0.10	20.77
Oak	0.65	0.39	0.93	0.13	19.78
Larch	0.55	0.40	0.82	0.10	18.18
Common ash[81]	0.65	0.41	0.82	0.10	15.02
Spruce	0.43	0.30	0.64	0.08	18.83
Pine	0.49	0.30	0.86	0.13	27.21
Poplar[82]	0.41	0.37	0.52	0.04	8.71
Fir	0.41	0.32	0.71	0.09	22.65

For tree-species groups that are relatively unimportant in terms of numbers, including deciduous trees with high life expectancies (4.4 % of total standing-timber volume) and deciduous trees with low life expectancies (5.2 %), the values for ash and poplar were used. Table 255 shows the uncertainties that arise in the volume expansion. It includes only the uncertainties for cases in which C stocks can be directly estimated.

[81] Including other long-lived deciduous species

[82] Including other short-lived deciduous species

Table 255: Uncertainties arising in connection with use of bulk densities

LULUCF classes	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest Land remaining Forest Land	9.19	8.63	8.16	13.87	12.31	12.41	7.14	6.86
Conversion of forest land to cropland	13.70	–	–	–	–	–	–	–
Conversion of forest land to grassland	8.65	–	–	–	–	–	–	–
Conversion of forest land to settlements	7.92	–	–	–	–	–	–	–
Conversion of forest land to wetlands	24.49	–	–	–	–	–	–	–
Conversion of forest land to other land	–	–	–	–	–	–	–	–
Conversion of cropland to forest land	–	8.05	–	–	–	–	–	–
Conversion of grassland to forest land	–	7.76	–	–	–	–	–	–
Conversion of settlements to forest land	–	6.83	–	–	–	–	–	–
Conversion of wetlands to forest land	–	6.65	–	–	–	–	–	–
Conversion of other land to forest land	–	–	–	–	–	–	–	–

7.2.5.2.3 Derivation of below-ground biomass

The only available sources for the standard error for root-biomass calculation were the tables pursuant to IPCC GPG-LULUCF (2003) (cf. Table 244). That source also uses quantity-weighted error up-scaling. To carry out error propagation by sums (IPCC, 2000: Equation 6.3), the sums of the above-ground mass calculations were computed for each stratum of the table. This made it possible to derive the total errors for conifers, oak and other deciduous trees (broadleaves). Table 256 shows the values for the state in which it was possible to estimate C stocks directly.

Table 256: Uncertainties arising in use of root/shoot relationships

LULUCF classes	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest Land remaining Forest Land	25.37	23.86	23.10	–	26.24	26.13	19.15	18.48
Conversion of forest land to cropland	32.36	–	–	–	–	–	–	–
Conversion of forest land to grassland	24.19	–	–	–	–	–	–	–
Conversion of forest land to settlements	22.43	–	–	–	–	–	–	–
Conversion of forest land to wetlands	32.34	–	–	–	–	–	–	–
Conversion of forest land to other land	–	–	–	–	–	–	–	–
Conversion of cropland to forest land	–	29.27	–	–	–	–	–	–
Conversion of grassland to forest land	–	26.61	–	–	–	–	–	–
Conversion of settlements to forest land	–	25.24	–	–	–	–	–	–
Conversion of wetlands to forest land	–	17.95	–	–	–	–	–	–
Conversion of other land to forest land	–	–	–	–	–	–	–	–

An advantage of the IPCC root-biomass calculation is that it also yields the standard error for the estimation – in contrast to other methods, such as those presented in the studies of DIETER & ELSASSER (2002). The values entered into the CRF tables were derived pursuant to IPCC (2003).

7.2.5.2.4 Sampling error

The National Forest Inventory uses cluster sampling. It thus includes only a random set of samples, rather than a basic totality of samples. The sampling elements themselves, as well as the mean and total values estimated on the basis of the sampling elements chosen, are subject to variance. The variance can serve as a tool for assessing the precision of the estimated target values. The variance of a measured value in stratum *l* is estimated via the following relationship:

Equation 32

$$v\left\langle \hat{\bar{Y}}_l \right\rangle = \frac{1}{c_l(c_l-1)} \sum_{c_l=1}^{C_l} \left(\frac{M_{l,c}}{E\left\langle M_{l,c}\right\rangle}\right)^2 (Y_{l,c} - \hat{\bar{Y}}_l)^2$$

where:

v	= Variance
Y	= Target value
c	= Number of clusters
E	= Expected value
M	= Number of points per cluster

The variance of the overall mean, throughout all strata, is defined as follows:

Equation 33

$$v\left\langle \hat{\bar{Y}}_{st} \right\rangle = \sum_{l=1}^{L} (\frac{\lambda(U_l)}{\lambda(U)})^2 v\left\langle \hat{\bar{Y}}_l \right\rangle \approx \sum_{l=1}^{L} (\frac{n_l}{n})^2 v\left\langle \hat{\bar{Y}}_l \right\rangle$$

where

$$n = \sum_{l=1}^{L} n_l = \sum_{l=1}^{L} c_l E\left\langle M_{l,c} \right\rangle = \sum_{c_{l=1}}^{C_l} M_{l,c}$$

The estimated variance of the change $v\left\langle \hat{\bar{G}}_l \right\rangle$ between two inventories whose sampling elements were repeatedly surveyed is calculated as follows:

Equation 34

$$v\left\langle \hat{\bar{G}}_l \right\rangle = v\left\langle \hat{\bar{Y}}_l^{(2)} \right\rangle + v\left\langle \hat{\bar{Y}}_l^{(1)} \right\rangle - 2r_{y^2y^1} \sqrt{v\left\langle \hat{\bar{Y}}_l^{(2)} \right\rangle} \sqrt{v\left\langle \hat{\bar{Y}}_l^{(1)} \right\rangle}$$

With $r_{y^2y^1} = \frac{s_{y^2y^1}}{s_{y^2y^1}}$ as a correlation coefficient and:

Equation 35

$$s_{y^2y^1} = \frac{1}{c_l(c_l - 1)} \sum_{c_{l=1}}^{C_l} (\frac{M_{lc}}{E\left\langle M_{l,c} \right\rangle})^2 (Y_{lc}^{(2)} - \hat{\bar{Y}}_l^{(2)})(Y_{lc}^{(1)} - \hat{\bar{Y}}_l^{(1)})$$

The variance of the area-related mean estimator (ratio estimator) $v\left\langle \hat{R}_{st} \right\rangle$ from $\hat{\bar{Y}}_{st} / \hat{\bar{X}}_{st}$ is estimated as follows:

Equation 36

$$v\left\langle \hat{R}_{st} \right\rangle = \frac{1}{(\hat{\bar{X}}_{st})^2} \sum_{l=1}^{L} w_l^2 \frac{\sum_{c_{l=1}}^{C_l} (\frac{M_{lc}}{E\left\langle M_{l,c} \right\rangle})^2 (y_{lc} - \hat{R}_{st} x_{lc})^2}{c_l(c_l - 1)}$$

where:

w_l	= Stratum weight of stratum l
X_{st}	= Target value

The variance in the change of a ratio estimator ($v\left\langle \hat{\bar{G}}_{R_{st}} \right\rangle$) is defined as follows:

Equation 37

$$v\left\langle \hat{\bar{G}}_{R\,st} \right\rangle = v\left\langle \hat{R}_{st}^{(2)} \right\rangle + v\left\langle \hat{R}_{st}^{(1)} \right\rangle - 2\,\mathrm{cov}\left\langle \hat{R}_{st}^{(2)}, \hat{R}_{st}^{(1)} \right\rangle$$

where:

$$\operatorname{cov}\left\langle \hat{R}_{st}^{(2)}, \hat{R}_{st}^{(1)} \right\rangle = \frac{1}{\hat{\bar{X}}_{st}^{(2)} \hat{\bar{X}}_{st}^{(1)}} \sum_{l=1}^{L} \left(\frac{\lambda(U_l)}{\lambda(U)} \right)^2 \frac{1}{n_{2,l}\left(n_{2,l}-1\right)}$$

$$\sum_{x \in F_1 \cap s_2} \left(\frac{M(x)}{E(M(x))} \right)^2 \left(d_c^{(2)}(x) - \hat{\bar{d}}_l^{(2)} \right) \left(d_c^{(1)}(x) - \hat{\bar{d}}_l^{(1)} \right)$$

where

$$d_c^{(2)}(x) = (Y_c^{(2)}(x) - \hat{R}_{st}^{(2)} X_c^{(2)}(x))$$

and

$$\hat{\bar{d}}_l^{(2)} = \frac{1}{n_{2,l}} \sum_{x \in F_1 \cap s_2} \left(Y_c^{(2)}(x) - \hat{R}_{st}^{(2)} X_c^{(2)}(x) \right)$$

with $d_c^{(1)}(x)$ and $\hat{\bar{d}}_l^{(1)}$ having the corresponding values.

The estimation procedures presented here can be used to calculate, on the basis of the National Forest Inventory, the precision of biomass estimates for each LULUCF category in which such estimates are made.

Since C-stock calculation for the new German Länder was possible only with the method pursuant to BURSCHEL et al. 1993, taking account of data in the publication "Der Wald in den neuen Bundesländern" ("The Forest in the New German Länder", BMELF, 1994), the procedure shown here for the old German Länder can be adopted for the new German Länder only partially. On p. 9 of that publication, the following statement about errors relative to stocks is made: "The stocks of the sub-area were determined, in the framework of the forest-management procedure, with a mean standard error of ± 12.5 %." Under the assumption that that error has systematically propagated itself throughout the up-scaling, one may assume a value of ± 12.5 % for the relevant tree-species groups.

Table 257: Sampling error for above-ground biomass

LULUCF category	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest Land remaining Forest Land	1.07	1.04	2.34	12.50	3.91	3.84	2.01	2.00
Conversion of forest land to cropland	55.12	–	–	–	–	–	–	–
Conversion of forest land to grassland	45.42	–	–	–	–	–	–	–
Conversion of forest land to settlements	18.73	–	–	–	–	–	–	–
Conversion of forest land to wetlands	69.85	–	–	–	–	–	–	–
Conversion of forest land to other land	–	–	–	–	–	–	–	–
Conversion of cropland to forest land	–	26.46	–	–	–	–	–	–
Conversion of grassland to forest land	–	15.37	–	–	–	–	–	–
Conversion of settlements to forest land	–	20.90	–	–	–	–	–	–
Conversion of wetlands to forest land	–	28.42	–	–	–	–	–	–
Conversion of other land to forest land	–	–	–	–	–	–	–	–

Table 258: Random-sampling error for below-ground biomass

LULUCF category	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest Land remaining Forest Land	1.05	1.03	2.18	12.50	3.84	3.80	1.98	1.97
Conversion of forest land to cropland	55.59	–	–	–	–	–	–	–
Conversion of forest land to grassland	43.11	–	–	–	–	–	–	–
Conversion of forest land to settlements	18.49	–	–	–	–	–	–	–
Conversion of forest land to wetlands	64.93	–	–	–	–	–	–	–
Conversion of forest land to other land	–	–	–	–	–	–	–	–
Conversion of cropland to forest land	–	25.41	–	–	–	–	–	–
Conversion of grassland to forest land	–	14.80	–	–	–	–	–	–
Conversion of settlements to forest land	–	20.93	–	–	–	–	–	–
Conversion of wetlands to forest land	–	28.31	–	–	–	–	–	–
Conversion of other land to forest land	–	–	–	–	–	–	–	–

7.2.5.3 Uncertainties in estimation pertaining to litter and mineral soils

7.2.5.3.1 Sampling error

In soil sampling, proper separation of litter and mineral soil can present a problem, since the transition between the two compartments cannot always be unambiguously identified. This problem becomes all the more important in light of the fact that carbon concentrations in litter differ considerably from those in mineral soil below the litter. In sampling, imprecise or improper separation of litter from mineral soil can thus have major impacts on the carbon stocks measured in a relevant horizon or depth layer.

7.2.5.3.2 Small-scale variability

Due to the high spatial variability in litter and mineral soil, and because carbon stocks maintain spatial continuity only over short distances, sampling of carbon stocks in such compartments is subject to a high degree of uncertainty. For litter in a beech forest, SCHÖNING et al. (2006) calculated stocks of 4.0 MgC ha^{-1}, with a variation coefficient of 38 %. In mineral soil (0 - 36 cm), they found carbon stocks of 64.0 Mg ha^{-1}, with variation coefficients between 30 % and 43 %. Similar values were recorded by LISKI (1995). He showed that different carbon stocks under a spruce site, and within a given horizon, were spatially independent as of a separation of 8 m.

7.2.5.3.3 Representativeness of points within strata

One problem in analysing samples in accordance with dominant soil units resulted from the different degrees to which classes were represented. Small classes lack statistical validity with respect to a major basic totality. Where no comparison between BZE I and BZE II / BioSoil data was possible, as a result of a lack of pertinent data, it was not possible to include the relevant forested dominant-soil-unit area in the calculation. In addition, it was not possible to have all dominant soil units represented, since some are found only on small areas of Germany's territory. All in all, as a result of these difficulties, 4.3 % of the forest area was not taken into account in this context.

7.2.5.3.4 Sampling error

In calculation of the sampling error with regard to stock changes in litter and mineral soil, paired and unpaired samples were differentiated, and stratification of mineral soils was taken into account. The variance of the mean stocks in stratum l, and of the unstratified total sample with n_l sample points, was calculated as follows:

Equation 38

$$v\langle \bar{Y}_l \rangle = \frac{1}{n_l\,(n_l - 1)} \sum_{j=1}^{n_l} (Y_{lj} - \bar{Y}_l)^2$$

For paired samples, the variance of the mean stock changes in stratum l, between times t_1 and t_2, was calculated via:

Equation 39

$$v\langle \overline{G}_l \rangle = v\langle \bar{Y}_{lt_2} \rangle + v\langle \bar{Y}_{lt_1} \rangle - 2r_{y^2y^1}\sqrt{v\langle \bar{Y}_{lt_2} \rangle}\sqrt{v\langle \bar{Y}_{lt_1} \rangle}$$

where

$$r_{y^2y^1} = \frac{s_{y^2y^1}}{s_{y^2y^1}}$$

and

$$s_{y^2y^1} = \frac{1}{n_l(n_l-1)}\sum_{j=1}^{n_l}(Y_{ljt_2} - \overline{Y}_{lt_2})(Y_{ljt_1} - \overline{Y}_{lt_1})$$

For unpaired samples, the variance of stock changes was calculated via:

Equation 40

$$v\langle\overline{G}_l\rangle = v\langle\overline{Y}_{lt_2}\rangle + v\langle\overline{Y}_{lt_1}\rangle$$

The total variance, throughout all strata, was estimated, taking account of the area shares w_l / w for strata, as follows:

Equation 41

$$v\langle\overline{Y}\rangle \approx \sum_{l=1}^{L}\left(\frac{w_l}{w}\right)^2 v[\overline{Y}_l]$$

and with

$$v\langle\overline{G}\rangle \approx \sum_{l=1}^{L}\left(\frac{w_l}{w}\right)^2 v[\overline{G}_l]$$

The carbon-stock changes for litter were calculated on the basis of unpaired samples, with stratification. A sampling error of 0.031 Mg ha^{-1}, or 61 %, was obtained. In calculation of carbon-stock changes in mineral soil, the overall sample was divided into a paired sample set and an unpaired sample set. In addition, stratification, in keeping with the applicable dominant soil units and the two sample subsets, was carried out. Overall, the sampling error for mineral soils amounted to 0.044 Mg ha^{-1}, or 17 %.

7.2.5.3.5 Quantification of methodologically related uncertainties

Another source of uncertainty, in addition to sampling variance, consists of discrepancies, in individual measurements, that originate in measuring methods and processes. A group of several samples taken independently, at one and the same location, would exhibit fluctuations in both the C concentration and fine-earth fraction – throughout a range determined by the precision of the measuring equipment and methods being used. This fluctuation range in measurement of C concentrations was quantified on the basis of the results of the ring analyses (BLUM & HEINBACH 2006, 2007). In the ring analyses for the Forest Soil Inventory II (BZE II), the repeatability standard deviation for a set of C measurements made by various laboratories was determined as the mean within-laboratory standard deviation (DIN ISO 5725 2) of the C measurements within the relevant laboratories, and the reference standard deviation was determined as the standard deviation of the mean values of the measurements. The reproducibility standard deviation was calculated from those standard deviations. The reproducibility standard deviation serves as a suitable estimate of the measurement uncertainty. The reproducibility standard deviations for mineral-soil measurements were as follows: 1.0 g kg^{-1} for (i.e. for measurements in) lime-free soils, 2.9 g kg^{-1} for calcareous soils and 20 g kg^{-1} for organic surface layers. With regard to the Forest Soil Inventory I (BZE I), the values provided by WOLFF & RIEK (1996) were used, including coefficients of variation ranging from 5 to 20 % for C measurements in mineral soils and from 5 to 10 % for C measurements in organic surface layers. The mean values of such coefficients were used in each case. No ring-analyses results were available as a basis for calculation of the uncertainties relative to fine-earth fractions. For this reason, all those BZE points were selected for which fine-earth-fraction results were available at both relevant inventory time points. The mean deviation between such measurement pairs was calculated. That mean deviation was 193 ± 35 Mg ha^{-1}. In keeping with the principle of conservative error estimation, it was assumed that the fine-earth fractions did not change between the two inventories, and that the mean deviation plus its spread serves as a measure of the uncertainty in measurement of fine-earth fractions. The uncertainty in the annual C-change range was expanded to include the uncertainties in the relevant individual measurements (Equation 42).

Equation 42:

$$s_{total}^2 = se^2 + \left(\frac{C_1}{(t_{II} - t_I)} MA_{FBV}\right)^2 + \left(\frac{FBV_1}{(t_{II} - t_1)} s_{C_1}\right)^2 + \left(\frac{FBV_{II}}{(t_{II} - t_1)} s_{C_{II}}\right)^2$$

The uncertainties in estimation of the annual rate of C change in mineral soils were as follows: for the sampling variance, 0.044 Mg ha^{-1}; for the laboratory analysis for C determination at the time of the BZE I, 0.033 Mg ha^{-1}; for such analysis at the time of the BZE II, 0.012 Mg ha^{-1}; and for determination of fine-earth fractions, 0.052 Mg ha^{-1}. These uncertainties yielded a total uncertainty of 0.09 Mg ha^{-1}. The total uncertainty in estimation of the annual C-change rate in the organic surface layer was 0.031 Mg ha^{-1}.

7.2.5.4 Time-series consistency

A time series is consistent if it is consistent within itself, is meaningful and has no internal contradictions. All of the time series concerned are consistent. While some time series contain "jumps", for methodological reasons, such jumps result from the available data, i.e. they do not constitute contradictions with regard to time-series consistency.

7.2.6 Category-specific QA / QC and verification (5.A)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Quality assurance for ATKIS® and BÜK 1000 input data, and for wildfire statistics, is the responsibility of the relevant data administrators.

Complete error analysis was carried out for the LULUCF sector, and an attempt was made to quantify all existing sources of error. That error analysis includes all error calculations, relative to the forest sector, for biomass, dead wood, litter, mineral soils, forest fires, drainage and liming. In Chapter 19.5.4, a total-error budget is presented that summarises the results of error analysis.

7.2.6.1 Biomass and dead wood

The estimates of carbon stocks in the biomass and dead-wood pools, at the various relevant times, and the estimates of carbon-stock changes are based on up-scaling that was carried out at the Thünen-Institute for Forest Ecosystems (TI-WO), using data from the National Forest Inventories and from the Inventory Study 2008. With regard to the quality assurance developed for the Federal Forest Inventory, we call attention to the literature for the Federal Forest Inventory (BMELV 2005). In work carried out independently of the TI-WO's calculations, the C stocks and C-stocks changes for biomass were calculated with a programme developed under PostGreSQL. The results of the two sets of calculations agree.

7.2.6.2 Litter and mineral soils

In order to achieve a consistent standard of laboratory analysis in analysis of sampling carried out in the framework of the BZE and BioSoil surveys, ring analysis was initiated. To that end, all laboratories underwent a quality test carried out by the Gutachterausschuss Forstliche Analytik ("forestry analysis auditors' committee") (BLUM & HEINBACH 2006, 2007). To ensure the comparability of the applicable laboratory methods, only laboratories that participated successfully in the ring analysis were permitted to carry out relevant analysis. Ring analysis was also carried out at the European level, with German participation (COOLS et al. 2006).

To harmonise laboratory measurements and topographical surveys, rules for determining relevant parameters were defined, in the framework of the BZE II survey, for participating laboratories. This was done with a view to preventing any discrepancies resulting from use of different analysis equipment or methods (KÖNIG et al 2005, WELLBROCK et al. 2006). Previous ring analyses served as the basis for certifying laboratories for relevant analysis. A similar approach was taken with regard to field sampling. On the basis of various preliminary studies, suitable sampling methods were defined and specified, and described in a field-sampling manual (WELLBROCK et al. 2006).

7.2.6.3 Comparison with results of neighbouring countries

A comparison of carbon-stock changes in living biomass (cf. Table 259) shows that Germany has the highest values in the "land converted to forest land" categories and, thus, the largest carbon sinks. Similarly high sink performance in these categories is seen in Switzerland, which has the highest sink performance in conversions from wetlands to forest land and from other land to forest land. The Netherlands, Belgium, the UK and Poland occupy a middle position in this regard in the area of conversions to forest land, while Denmark has the lowest sink performance. In the category "Forest Land remaining Forest Land", on the other hand, Germany ranks in the lower part of the range. Still-lower sink performance is seen only in Austria, the UK and Switzerland, while the highest sink performance is seen in Denmark, followed by the Netherlands.

In the dead organic matter category (cf. Table 260), Germany occupies a mid-range position in conversions to forest land, with sink performance comparable to that of France. The highest sink performance in this category is seen in Austria, followed by Switzerland. In the area of conversions to forest land, Denmark is the only country with a negative balance. Very low sink performance is seen in the UK and Poland. In the area of land remaining forest land, Germany ranks low in the sink-performance range, at a level comparable with those of Poland, Switzerland and Belgium. The largest carbon sinks in this category are seen in Denmark, followed by the UK. In this category, France is the only country with a carbon source.

With regard to mineral soils (cf. Table 261), Germany holds a mid-range position in the category of Forest Land remaining Forest Land, along with the UK. The highest sink performance levels in this category are seen in Belgium and Poland, while Austria is the only country with carbon losses. In the "conversions to forest land" categories, Germany mostly has carbon losses. The only exception is the area of conversions to settlements and other land, in which Germany has moderate sink performance. The largest carbon sinks in this area are seen in Belgium, Austria, Poland and Switzerland.

Along with Germany, only Switzerland, Denmark and the UK report with regard to organic soils (cf. Table 262). Germany has the largest losses of these countries in all categories. In the categories of Forest Land remaining Forest Land, and of conversions of cropland, grassland and wetlands to forest land, Switzerland reports identical values. The UK is the only one of these countries with carbon sinks in all categories. The largest sink, far and away, is seen in Switzerland, in the category of conversion from settlements to forest land.

Table 259: Carbon-stock changes in living biomass, in various countries (Germany, for 2011; other countries, for 2010)

Country	Forest land remaining Forest Land [MgC ha^{-1} a^{-1}]	Land converted to Forest Land [MgC ha^{-1} a^{-1}]	Cropland converted to Forest Land [MgC ha^{-1} a^{-1}]	Grassland converted to Forest Land [MgC ha^{-1} a^{-1}]	Wetlands converted to Forest Land [MgC ha^{-1} a^{-1}]	Settlements converted to Forest Land [MgC ha^{-1} a^{-1}]	Other Land converted to Forest Land [MgC ha^{-1} a^{-1}]
AUT	0.34	1.05	1.18	1.18	1.18	0.08	1.18
BEL	0.69	2.31	2.24	2.31	2.39	2.23	2.43
CHE	0.19	3.44	2.15	3.40	5.19	3.59	4.78
CZE	0.71	1.87	1.87	1.87	1.87	1.87	NA
DNK	2.35	0.25	0.20	0.47	0.37	NA	0.31
FRA	0.63	1.11	1.76	1.01	1.20	1.17	0.68
GBR	0.24	2.46	2.37	2.48	IE	2.41	2.46
GER	**0.43**	**4.11**	**4.12**	**4.08**	**4.15**	**4.06**	**4.15**
NLD	1.72	2.68	3.48	2.62	2.98	1.55	3.10
POL	0.78	2.44	2.44	2.44	NO	NO	NO

Source: UNFCCC 2012

Table 260: Carbon-stock changes in dead organic mass, in various countries (Germany, for 2011; other countries, for 2010)

Country	Forest Land remaining Forest Land [MgC ha^{-1} a^{-1}]	Land converted to Forest Land [MgC ha^{-1} a^{-1}]	Cropland converted to Forest Land [MgC ha^{-1} a^{-1}]	Grassland converted to Forest Land [MgC ha^{-1} a^{-1}]	Wetlands converted to Forest Land [MgC ha^{-1} a^{-1}]	Settlements converted to Forest Land [MgC ha^{-1} a^{-1}]	Other Land converted to Forest Land [MgC ha^{-1} a^{-1}]
AUT	0.06	1.27	1.26	1.27	1.55	1.21	1.21
BEL	0.01	NO	NO	NO	NO	NO	NO
CHE	0.03	1.55	0.10	1.58	1.24	0.59	1.47
CZE	NO	NA,NO	NO	NO	NO	NO	NA
DNK	0.58	-0.38	-0.38	-0.38	-0.38	NA	-0.38
FRA	-0.06	0.32	0.51	0.27	0.49	0.40	0.41
GBR	0.26	0.09	0.09	0.09	IE	0.09	0.09
GER	**0.02**	**0.44**	**0.44**	**0.44**	**0.44**	**0.44**	**0.44**
NLD	0.00	NE	NE	NE	NE	NE	NE
POL	0.02	0.01	0.01	0.01	NO	NO	NO

Source: UNFCCC 2012

Table 261: Carbon-stock changes in mineral soils, in various countries (Germany, for 2011; other countries, for 2010)

Country	Forest Land remaining Forest Land [MgC ha^{-1} a^{-1}]	Land converted to Forest Land [MgC ha^{-1} a^{-1}]	Cropland converted to Forest Land [MgC ha^{-1} a^{-1}]	Grassland converted to Forest Land [MgC ha^{-1} a^{-1}]	Wetlands converted to Forest Land [MgC ha^{-1} a^{-1}]	Settlements converted to Forest Land [MgC ha^{-1} a^{-1}]	Other Land converted to Forest Land [MgC ha^{-1} a^{-1}]
AUT	-0.19	0.72	0.98	-0.48	6.31	2.20	3.22
BEL	0.57	1.38	2.57	1.04	0.41	2.11	3.04
CHE	IE,NO	0.73	0.60	0.64	0.67	2.36	4.03
CZE	NO	0.16	0.49	0.05	NO	NO	NA
DNK	NA	0.15	0.14	0.16	0.42	NA	0.16
FRA	NO	0.12	0.80	-0.05	-3.10	1.57	
GBR	0.27	0.19	0.36	0.15	IE	0.29	0.22
GER	**0.27**	**-0.28**	**-0.05**	**-0.86**	**-0.68**	**0.01**	**0.20**
NLD	NE	NE	NE	NE	NE	NE	NE
POL	0.52	1.97	2.29	0.75	NO	NO	NO

Source: UNFCCC 2012

Table 262: Carbon-stock changes in organic soils, in various countries (Germany, for 2011; other countries, for 2010)

Country	Forest Land remaining Forest Land [MgC ha^{-1} a^{-1}]	Land converted to Forest Land [MgC ha^{-1} a^{-1}]	Cropland converted to Forest Land [MgC ha^{-1} a^{-1}]	Grassland converted to Forest Land [MgC ha^{-1} a^{-1}]	Wetlands converted to Forest Land [MgC ha^{-1} a^{-1}]	Settlements converted to Forest Land [MgC ha^{-1} a^{-1}]	Other Land converted to Forest Land [MgC ha^{-1} a^{-1}]
AUT	NO	NO	NO	NO	NO	NO	NO
BEL	NO	NO	NO	NO	NO	NO	NO
CHE	-0.68	-0.07	-0.68	-0.68	-0.68	3.85	NO
CZE	NA,NO	NA,NO	NO	NO	NO	NO	NA
DNK	-0.34	-0.34	-0.34	-0.34	-0.34	NA	-0.34
FRA	NO	NO	NO	NO	NO	NO	NO
GBR	0.58	0.44	0.44	0.44	IE	0.44	0.44
GER	**-0.68**	**-0.68**	**-0.68**	**-0.68**	**-0.68**	**-0.68**	**-0.68**
NLD	NE	NE	NE	NE	NE	NE	NE
POL	NO	NO	NO	NO	NO	NO	NO

Source: UNFCCC 2012

7.2.7 Category-specific recalculations (5.A)

For the current GG report, new data sources and methods were used that necessitated recalculations for certain time series.

With regard to activity data, the current data records of the Basis-DLM (2011) were taken into account in derivation of the relevant areas. This necessitated recalculations for the years 2009 and 2010. The resulting area changes, and a comparison with the corresponding areas as reported in the 2012 Submission, are shown in Table 263. Detailed descriptions of the methods used to prepare the land-use matrix are provided in Chapter 7.1.3.

Table 263: Comparison of the changes, as reported in 2012 and in 2013, in the land-area matrix used for purposes of UNFCCC reporting [kha]

[kha]	**2009**	**2010**
5.A.1 Forest Land remaining Forest Land 2012	10557.935	10584.982
5.A.1 Forest Land remaining Forest Land 2013	10557.185	10583.483
5.A.2 Land converted to Forest Land 2012	375.802	348.858
5.A.2 Land converted to Forest Land 2013	376.019	349.291

7.2.7.1 Forest Land remaining Forest Land

In the Forest Land remaining Forest Land category (5.A.1), recalculation was required only with regard to the litter pool. The emission factors (EF) were adjusted via analysis of the final

BZE data. As a result, the EF (1990-2011) for litter changed from 0 (2012 Submission) to -0.05 MgC ha^{-1}. Further pertinent information is provided in Chapter 7.2.4.3.

The new BZE database now available made it possible, for the first time, to enter values for the mineral soils pool into the CRF tables. The EF (1990-2011) for mineral soils is 0.27 MgC ha^{-1} a^{-1}. A description of the pertinent methods is presented in Chapter 7.2.4.4.

For the category Forest Land remaining Forest Land, Table 264 compares the time series in the current submission with those from the previous year's submission.

Table 264: Comparison of emissions [Gg CO_2], as reported in the 2013 and 2012 Submissions, from Forest Land remaining Forest Land (5.A.1)

[Gg CO_2-eq. a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	**-74,155.756**	**-74,225.048**	**-74,294.218**	**-74,363.267**	**-74,432.194**	**-74,500.999**	**-74,569.680**	**-74,638.238**	**-74,706.672**	**-74,774.981**
Total, 2012	**-66,121.247**	**-66,180.978**	**-66,240.589**	**-66,300.078**	**-66,359.445**	**-66,418.689**	**-66,477.811**	**-66,536.808**	**-66,595.682**	**-66,654.431**
Mineral soils, 2013	-9,905.411	-9,917.344	-9,929.277	-9,941.210	-9,953.144	-9,965.077	-9,977.010	-9,988.943	-10,000.876	-10,012.809
Mineral soils, 2012	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Organic soils, 2013	497.298	499.519	501.740	503.961	506.182	508.403	510.624	512.845	515.066	517.287
Organic soils, 2012	497.298	499.519	501.740	503.961	506.182	508.403	510.624	512.845	515.066	517.287
Biomass, 2013	-63,110.688	-63,168.191	-63,225.573	-63,282.833	-63,339.972	-63,396.988	-63,453.881	-63,510.650	-63,567.295	-63,623.816
Biomass, 2012	-63,110.688	-63,168.191	-63,225.573	-63,282.833	-63,339.972	-63,396.988	-63,453.881	-63,510.650	-63,567.295	-63,623.816
Litter, 2013	1,870.901	1,873.275	1,875.648	1,878.021	1,880.394	1,882.767	1,885.140	1,887.513	1,889.887	1,892.260
Litter, 2012	0	0	0	0	0	0	0	0	0	0
Dead wood, 2013	-3,507.857	-3,512.306	-3,516.756	-3,521.205	-3,525.655	-3,530.105	-3,534.554	-3,539.004	-3,543.453	-3,547.903
Dead wood, 2012	-3,507.857	-3,512.306	-3,516.756	-3,521.205	-3,525.655	-3,530.105	-3,534.554	-3,539.004	-3,543.453	-3,547.903
[Gg CO_2-eq. a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	**-74,843.165**	**-75,006.664**	**-27,492.158**	**-27,538.879**	**-27,585.524**	**-27,632.090**	**-27,680.664**	**-27,729.167**	**-27,777.599**	**-27,836.034**
Total, 2012	**-66,713.055**	**-66,858.354**	**-19,325.647**	**-19,354.168**	**-19,382.612**	**-19,410.978**	**-19,441.142**	**-19,471.235**	**-19,501.258**	**-19,543.958**
Mineral soils, 2013	-10,024.743	-10,047.432	-10,070.121	-10,092.810	-10,115.499	-10,138.188	-10,161.126	-10,184.065	-10,207.004	-10,231.394
Mineral soils, 2012	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Organic soils, 2013	519.508	523.409	527.310	531.211	535.111	539.012	542.836	546.660	550.484	554.627
Organic soils, 2012	519.508	523.409	527.310	531.211	535.111	539.012	542.836	546.660	550.484	554.706
Biomass, 2013	-63,680.211	-63,820.995	-16,283.773	-16,307.779	-16,331.708	-16,355.559	-16,381.055	-16,406.480	-16,431.835	-16,465.805
Biomass, 2012	-63,680.211	-63,820.995	-16,283.773	-16,307.779	-16,331.708	-16,355.559	-16,381.055	-16,406.480	-16,431.835	-16,469.460
Litter, 2013	1,894.633	1,899.121	1,903.610	1,908.098	1,912.587	1,917.075	1,921.604	1,926.134	1,930.663	1,935.484
Litter, 2012	0	0	0	0	0	0	0	0	0	0
Dead wood, 2013	-3,552.352	-3,560.768	-3,569.184	-3,577.599	-3,586.015	-3,594.431	-3,602.923	-3,611.415	-3,619.906	-3,628.946
Dead wood, 2012	-3,552.352	-3,560.768	-3,569.184	-3,577.599	-3,586.015	-3,594.431	-3,602.923	-3,611.415	-3,619.906	-3,629.204

[Gg CO_2-eq. a^{-1}]	2010
Total, 2013	**-27,894.431**
Total, 2012	**-19,586.633**
Mineral soils, 2013	-10,255.784
Mineral soils, 2012	NR
Organic soils, 2013	558.770
Organic soils, 2012	558.929
Biomass, 2013	-16,499.737
Biomass, 2012	-16,507.061
Litter, 2013	1,940.305
Litter, 2012	0
Dead wood, 2013	-3,637.986
Dead wood, 2012	-3,638.501

7.2.7.2 Land converted to Forest Land

For conversions of land to forest land (5.A.2), recalculations were carried out for the following pools:

- The emission factors for mineral soils were adjusted to take account of the new Forest Soil Inventory (BZE) data. Further pertinent information is provided in Chapter 7.2.4.4.
- With regard to the biomass pool, while the emission factors for increases in forest land did not change, adjustment of the biomass emission factors for land-use categories with conversions to forest land still made recalculations necessary (cf. Chapter 7.1.7).
- For the current submission, the new BZE data were available for the litter pool, as well as for the mineral soils pool. For this reason, the pertinent time series was recalculated here as well. Details relative to the data and the method used are provided in Chapter 7.2.4.3.

For afforestation, Table 265 compares the time series in the current submission with those from the previous year's submission.

Table 265: Recalculation of emissions [Gg CO_2 equivalents] for afforestation (5.A.2) as reported in 2013 and 2012

[Gg CO_2 eq. a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	**-6485.095**	**-6500.407**	**-6538.766**	**-6537.831**	**-6574.661**	**-6591.684**	**-6607.232**	**-6626.358**	**-6653.336**	**-6669.611**
Total, 2012	**-7286.756**	**-7276.503**	**-7289.315**	**-7262.454**	**-7273.734**	**-7264.995**	**-7254.873**	**-7248.217**	**-7249.443**	**-7240.039**
Mineral soils, 2013	1339.780	1313.785	1287.791	1261.796	1235.801	1209.807	1183.812	1157.817	1131.822	1105.828
Mineral soils, 2012	587.377	587.377	587.377	587.377	587.377	587.377	587.377	587.377	587.377	587.377
Organic soils, 2013	87.026	87.026	87.026	87.026	87.026	87.026	87.026	87.026	87.026	87.026
Organic soils, 2012	87.026	87.026	87.026	87.026	87.026	87.026	87.026	87.026	87.026	87.026
Biomass, 2013	-6955.182	-6947.074	-6962.013	-6937.658	-6951.067	-6944.670	-6936.798	-6932.504	-6936.062	-6928.917
Biomass, 2012	-6961.703	-6953.702	-6968.767	-6944.159	-6957.691	-6951.205	-6943.336	-6938.933	-6942.411	-6935.260
Litter, 2013	-956.719	-954.144	-951.570	-948.995	-946.421	-943.846	-941.271	-938.697	-936.122	-933.548
Litter, 2012	-999.457	-997.204	-994.952	-992.699	-990.446	-988.193	-985.941	-983.688	-981.435	-979.182
Dead wood, 2013	0	0	0	0	0	0	0	0	0	0
Dead wood, 2012	0	0	0	0	0	0	0	0	0	0
[Gg CO_2 eq. a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	**-6697.666**	**-7755.923**	**-7512.755**	**-7270.533**	**-6991.068**	**-6742.824**	**-6375.342**	**-6051.696**	**-5725.575**	**-5624.621**
Total, 2012	**-7242.305**	**-8260.724**	**-7984.099**	**-7709.624**	**-7397.890**	**-7118.630**	**-6720.643**	**-6366.785**	**-6011.502**	**-5897.210**
Mineral soils, 2013	1079.833	562.499	537.620	512.742	487.863	462.985	438.830	414.676	390.522	361.868
Mineral soils, 2012	587.377	1021.840	964.690	908.383	852.920	798.299	744.614	691.956	640.324	585.672
Organic soils, 2013	87.026	83.761	80.497	77.232	73.968	70.703	66.902	63.100	59.299	55.083
Organic soils, 2012	87.026	83.761	80.497	77.232	73.968	70.703	66.902	63.100	59.299	55.057
Biomass, 2013	-6933.551	-7964.247	-7693.523	-7424.803	-7118.675	-6844.873	-6459.087	-6117.250	-5773.809	-5674.125
Biomass, 2012	-6939.779	-7963.549	-7692.795	-7423.662	-7117.961	-6844.154	-6457.709	-6115.921	-5772.480	-5657.698
Litter, 2013	-930.973	-942.737	-908.692	-874.795	-841.046	-807.444	-767.288	-727.311	-687.514	-640.011
Litter, 2012	-976.929	-897.975	-865.146	-832.486	-799.995	-767.672	-729.149	-690.831	-652.718	-607.678
Dead wood, 2013	0	0	0	0	0	0	0	0	0	0
Dead wood, 2012	0	0	0	0	0	0	0	0	0	0
[Gg CO_2 eq. a^{-1}]	**2010**									
Total, 2013	**-5231.705**									
Total, 2012	**-5473.985**									
Mineral soils, 2013	333.215									
Mineral soils, 2012	532.255									
Organic soils, 2013	50.866									
Organic soils, 2012	50.815									
Biomass, 2013	-5265.291									
Biomass, 2012	-5251.943									
Litter, 2013	-592.724									
Litter, 2012	-562.883									
Dead wood, 2013	0									
Dead wood, 2012	0									

7.2.8 Category-specific planned improvements (5.A)

7.2.8.1 Land-use changes

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

Additional planned improvements relative to the land-use matrix are presented in Chapter 7.1.3.6.

7.2.8.2 Litter and mineral soils

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

7.3 Cropland (5.B)

7.3.1 Source category description (5.B)

CRF 5.B	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Cropland	**CO_2**	**L**	**T/T2**	**28,632.1**	**2.35%**	**28,632.5**	**3.09%**	**0.00%**
Cropland	N_2O	-	-	196.1	0.02%	206.7	0.02%	5.43%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	RS/NS	CS[83]
N_2O	CS/Tier 1	RS/NS	D

The source category *Cropland* (5.B) is a key source of CO_2 emissions in terms of emissions level and trend.

Reporting in the *Cropland* category covers emissions / removals of CO_2 from/in mineral and organic soils, from/in above-ground and below-ground biomass and from liming. It also includes nitrous oxide emissions from humus losses from mineral soils, following land-use changes leading to cropland. Burning of fields and crop residues is prohibited by law in Germany and thus is not reported (NO).

In 2011, the total emissions from cropland amounted to 28,839 Gg CO_2 equivalents. Of that amount, 25,289 Gg CO_2 consisted of emissions from agriculturally used bogs; 1,541 Gg CO_2 were released from mineral soils, as the result of conversions leading to cropland; and 14 Gg CO_2 were released from biomass, as the result of conversions leading to cropland. Decomposition of dead wood and litter in connection with deforestation produced emissions of 13 Gg CO_2. An additional 1,776 Gg CO_2 was released as a result of liming. While this total refers non-specifically to all agricultural lands, it was assigned wholly to cropland cultivation (cf. Chapter 7.3.4.5). N_2O releases as a result of humus losses from mineral soils, following land-use changes leading to cropland, amounted to 207 Gg CO_2 equivalents.

[83] The entry "CS/M" refers to determination of changes in stocks in biomass and in soil. Under Tier 1, changes in dead wood and litter were estimated to be 0.

The time series for emissions from cropland (cf. Figure 59 and Figure 60, and Table 271 and Table 272, in Chapter 7.3.7) highlight the fact that the changes in greenhouse-gas emissions from cropland have been slight and show no clear trend. The uncertainty in the time-series mean of 29,017 Gg CO_2 equivalents amounts to ± 0.8 % (standard error of the mean * 1.96 ≙ half of the 95% confidence interval). With respect to the base year, a slight increase, amounting to 11 Gg CO_2 equivalents (0.04 %), occurred in 2011 .

The increases in emissions from organic soils (976 Gg CO_2 ≙ 4 %), mineral soils (CO_2: 175 Gg CO_2 ≙ 12.8 %; N_2O: 11 Gg CO_2 ≙ 5.4 %) and from liming (617 Gg CO_2 ≙ 53 %) are nearly offset by decreases in emissions from biomass (-1,458 Gg CO_2 ≙ -99 %) and from dead organic matter (-310 Gg CO_2 ≙ -96 %). The increase in emissions from soils is due to increases in land-use changes from grassland to cropland. The strong decrease in emissions from biomass and dead organic matter is due to sharp reductions in land-use changes from forest land, and from woody grassland, to cropland. The shapes of the time-series plots – especially the noticeable changes they show – are due primarily to the changes in area data that have occurred as of the relevant explicitly defined survey dates (cf. Chapter 7.1.3.5, Table 233). Land-use changes were determined on the basis of spatially explicit land-use data – data records from the years 1990, 2000, 2005 2008 and 2011 (cf. Chapter 7.1.3). Land-use changes that occurred between those years were determined via linear interpolation, and thus the annual conversion areas did not change between the times for which spatially explicit data were available. The reasons for the emissions decrease between 2000 and 2001 include a considerable decrease in deforestation and the considerable reductions that occurred then in the quantity of aerated lime spread in the agricultural sector.

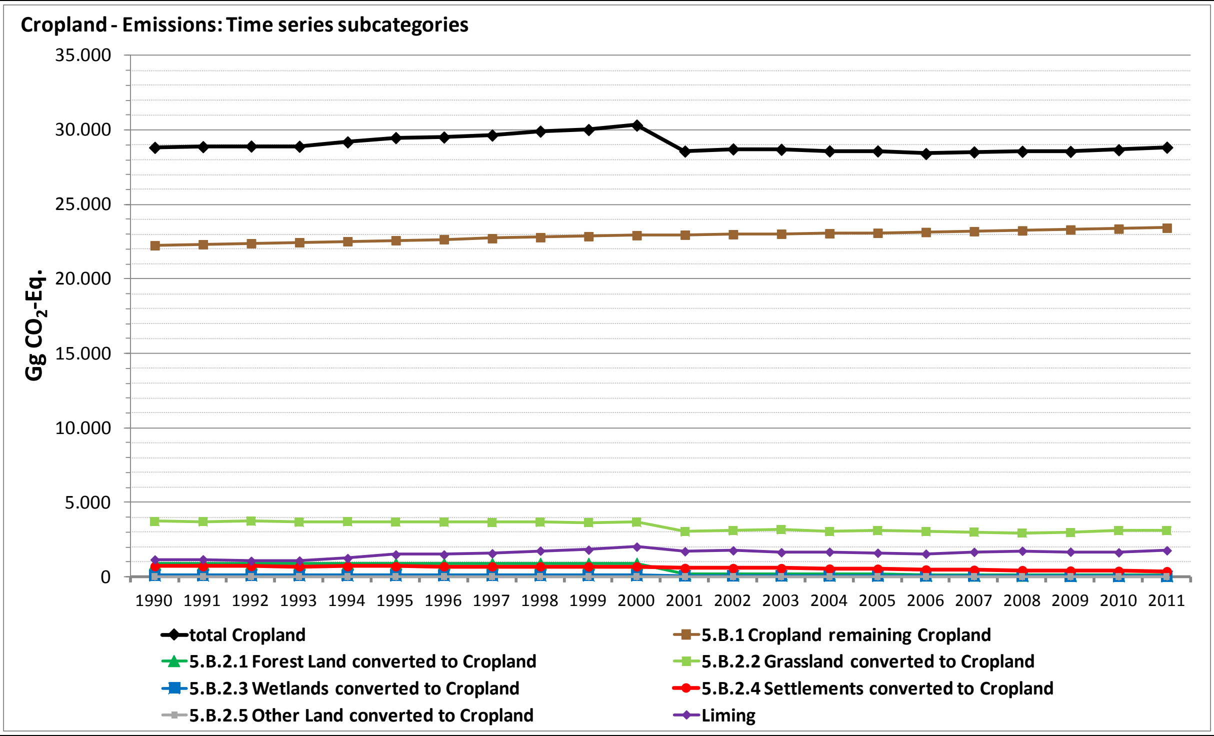


Figure 59: Greenhouse gas emissions [Gg CO_2-Eq.] from cropland, as a result of land use and land-use changes, 1990 – 2011, by sub-categories

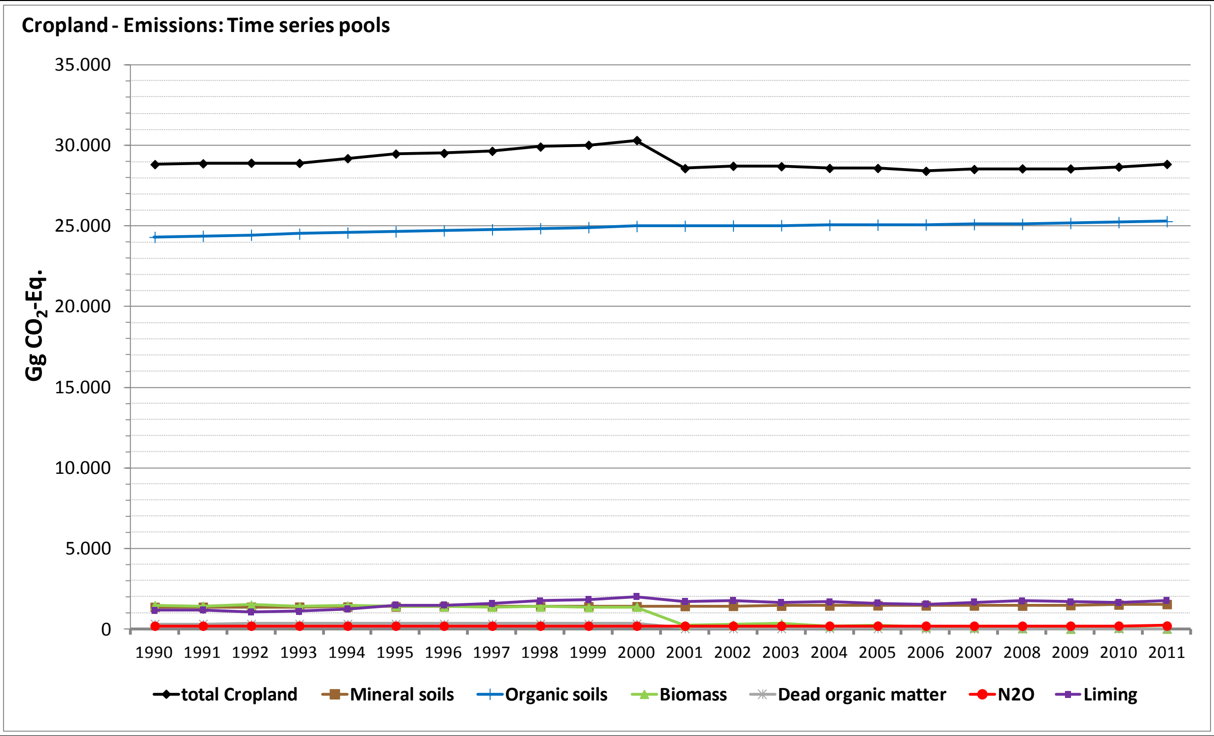


Figure 60: Greenhouse gas emissions [Gg CO_2-Eq.] from cropland, as a result of land use and land-use changes, 1990 – 2011, by pools

7.3.2 Information on approaches used for representing land areas and on land-use databases used for the inventory (5.B)

Cf. Chapter 7.1.3.

7.3.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.B)

Cropland is defined in Chapter 7.1.4. For purposes of emissions calculations, cropland is stratified by specific pools:

- Calculation of biomass stocks: Annually variable stratification by crop types, including permanent crops. The permanent crops category is subdivided into the categories of wine grapes, fruit trees (8 different categories) and Christmas trees (Chapter 19.5.3.1). Permanent crops account for a 1.2 % share of the total cropland area.
- Calculation of the emissions from soils: Chronologically constant stratification in accordance with the categories of organic soils and mineral soils. The mineral soils category is subdivided by usage, soil type / soil-parent-rock groups and climate region (cf. Chapter 19.5.2.2).
- Calculation of the emissions from land-use changes: Annually updated stratification in accordance with the categories "Cropland remaining Cropland" and "Land converted to Cropland". The relevant data are taken annually from the pertinent land-use information (Chapter 7.1.4; Chapter 7.1.3).

7.3.4 Methodological issues (5.B)

7.3.4.1 Data sources

Annual crops

- Statistisches Bundesamt, Fachserie 3, Reihe 3, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung und pflanzliche Erzeugung (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries, agricultural soil use and crop cultivation; various years)
- Statistisches Bundesamt, Fachserie 3, Reihe 3.2.1, Land- und Forstwirtschaft, Fischerei, Wachstum und Ernte – Feldfrüchte (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries, growth and harvests – crops; various years)
- Statistisches Bundesamt, Fachserie 3, Reihe 3.1.2, Land- und Forstwirtschaft, Fischerei,– Bodennutzung der Betriebe (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries – soil use by sectoral operations; various years)
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 - Agriculture, Forestry and Other Land Use (IPCC 2006)
- "Ordinance on application of fertilisers, soil additives, culture substrates and plant additives according to the principles of good practice in fertilization (Ordinance on Fertilisation – Düngeverordnung (DüV))“ (Ordinance on Fertilisation in the version as promulgated 27 February 2007 (Federal Law Gazette I, p. 221), last amended by Article 18 of the Act of 31 July 2009 (Federal Law Gazette I p. 2585).

Cultivation of fruit trees, wine grapes and Christmas trees

- "Obstanbau, Weinanbau und Weihnachtsbaumkulturen in Deutschland" ("Fruit cultivation, viticulture and Christmas-tree cultures in Germany") interim report in the research project "Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Wäldern“ (Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth") (PÖPKEN 2011)
- Statistisches Bundesamt, Fachserie 3, Reihe 3.1.4, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung – Baumobstflächen – 2007 (Federal Statistical Office, Fachserie 3, Reihe 3.1.4, agriculture and forestry, fisheries, agricultural soil use – fruit tree cultivation – 2007)

7.3.4.2 Biomass

No carbon-stock changes are given for the "Cropland remaining Cropland" category, since the carbon flows and the biomass in that category are assumed to be in balance. This assumption is made in light of the representative "equilibrium carbon stocks" determined for Germany's perennial woody cropland vegetation. In keeping with the IPCC guidelines, annual crops are not taken into account in the "Cropland remaining Cropland" category. The mean carbon stocks in fruit trees are calculated on the basis of a complete tree count with differentiation by tree type and age (< 1 - > 25 years). With this approach, it was possible to determine representative equilibrium carbon stocks for all cultivated woody plants, since the approach included summation over all age classes, tree / shrub types and plantation structures and combinations – Chapter 19.5.3.1. As a rule, annual growth increments in cultivated woody plants are completely pruned away. Since the rotation periods for woody plants tend to be relatively short (about 10 – 15 years for fruit trees), such plantations tend to rejuvenate frequently. Such rejuvenation occurs from the pool used to derive the pertinent emission factors, however. The processes of planting, growth, pruning, harvest and rejuvenation reach a state of dynamic equilibrium. In the case of land-use changes leading to cropland, the C stocks accruing through planting of wood biomass are thus credited completely in the year of the land-use change. In keeping with IPCC 2003, the carbon-stock changes resulting from land-use changes are determined, and reported, for both annual and perennial biomass.

7.3.4.2.1 Carbon stocks in the biomass of perennial arable crops

The carbon stocks in the biomass of perennial arable crops have been corrected, with respect to the previous year, with regard to the C stocks in grapevines. The relevant database, applicable individual factors and methods are described in Chapter 19.5.3.1. Table 266 shows the results, namely the carbon stocks for land with perennial arable crops.

Table 266: Area-weighted mixed value for carbon stocks [Mg ha^{-1}] of perennial arable crops (± half of the 95 % confidence interval)

Perennial crops	Carbon stocks [Mg C ha^{-1}]		
	Bio_{total}	$Bio_{above-ground}$	$Bio_{below-ground}$
Cropland: Perennial arable crops	11.23 ± 2.91	8.23 ± 2.24	2.99 ± 1.31

7.3.4.2.2 Carbon stocks in the biomass of annual arable crops

In connection with land-use changes, area-weighted mean figures are used for the above-ground and below-ground biomass of annual arable and horticultural crops, and of permanent crops. This approach is in keeping with IPCC 2003. The carbon stocks in the above-ground and below-ground biomass of annual arable crops are calculated annually on the basis of the Federal Statistical Office's harvest statistics. Mean carbon stocks, weighted by area and harvest, and referenced to the area of annual arable crops and horticultural crops, are then calculated from those stocks.

The basis for determination of the mean carbon stocks for field crops consists of the data on harvests and area under cultivation for a total of 65 field crops. These include:

- Winter wheat, spring wheat, rye, triticale, maslin, winter barley, spring barley, oats, mixed grains other than maslin, grain maize
- Field peas, broad beans
- Potatoes, sugar beets, fodder beets
- Winter oilseed rape
- Clover, alfalfa, grass, silage maize
- Cauliflower, broccoli, Chinese cabbage, kale, kohlrabi, Brussels sprouts, red cabbage, white cabbage, savoy, oak-leaf lettuce, iceberg lettuce, endive, lamb's lettuce, head lettuce, lollo lettuce, radicchio, romana lettuce, arrugula, other lettuce types, spinach, rhubarg, asparagus, celery, fennel, celeriac, horseradish, carrots, radishes, (larger) radishes, red beets, pickling cucumbers, slicing cucumbers, edible pumpkins, zucchini, sweet corn, bush beans, broad beans, runner beans, split peas, peas, bunching onions, onions, parsley, leeks, chives

Pursuant to HAENEL et al. (2012), for grassland and cropland, the dry biomass of individual plant parts is derived from harvest data, using relevant ratios and water-content data (obtained from various sources).

For calculation of biomass carbon stocks, an average carbon content of 45 % by weight was assumed – and used instead of the IPCC default value (50 % by weight) – since OSOWSKI et al. (2004) give carbon contents of 44 – 48 % by weight for plants in central Europe and since PÖPKEN (2011), in her studies of cultivated trees (carried out for the German inventory), also found average values of 45 to 46 % by weight. The relevant results for annual arable and horticultural crops are shown in Table 267.

Table 267: Area-referenced carbon stocks [Mg C ha^{-1}] of cropland with annual vegetation (± half of the 95 % confidence interval)

Year	Carbon stocks [Mg C ha^{-1}] Cropland$_{annual}$		
	Bio$_{total}$	Bio$_{above-ground}$	Bio$_{below-ground}$
1990	6.03 ± 0.52	4.84 ± 0.41	1.19 ± 0.33
1991	6.27 ± 0.54	5.07 ± 0.43	1.21 ± 0.34
1992	5.81 ± 0.50	4.71 ± 0.40	1.10 ± 0.31
1993	6.57 ± 0.57	5.32 ± 0.45	1.25 ± 0.35
1994	6.15 ± 0.53	4.97 ± 0.42	1.18 ± 0.33
1995	6.35 ± 0.55	5.14 ± 0.43	1.21 ± 0.34
1996	6.60 ± 0.57	5.35 ± 0.45	1.24 ± 0.35
1997	6.73 ± 0.58	5.46 ± 0.46	1.27 ± 0.36
1998	6.62 ± 0.57	5.37 ± 0.45	1.25 ± 0.35
1999	6.84 ± 0.59	5.56 ± 0.47	1.29 ± 0.36
2000	6.70 ± 0.58	5.45 ± 0.46	1.25 ± 0.35
2001	6.99 ± 0.61	5.67 ± 0.48	1.31 ± 0.37
2002	6.45 ± 0.56	5.25 ± 0.44	1.21 ± 0.34
2003	5.82 ± 0.50	4.75 ± 0.40	1.07 ± 0.30
2004	7.32 ± 0.63	5.95 ± 0.50	1.36 ± 0.38
2005	6.96 ± 0.60	5.64 ± 0.48	1.32 ± 0.37
2006	6.56 ± 0.57	5.30 ± 0.45	1.26 ± 0.35
2007	6.84 ± 0.59	5.54 ± 0.47	1.31 ± 0.37
2008	7.33 ± 0.64	5.92 ± 0.50	1.40 ± 0.39
2009	7.51 ± 0.65	6.08 ± 0.51	1.43 ± 0.40
2010	7.01 ± 0.61	5.67 ± 0.48	1.35 ± 0.38
2011	7.48 ± 0.65	6.05 ± 0.51	1.43 ± 0.40

7.3.4.2.3 Total carbon stocks in cropland biomass

The total biomass in cropland is calculated as area-weighted annual carbon stocks, pursuant to Equation 43.

Equation 43:

$$EF_{crop} = (EF_{wood}*A_{wood}+EF_{annual}*A_{annual}) / (A_{wood}+A_{annual})$$

The values shown in Table 268 are used as a basis for all calculations relative to biomass in connection with land-use changes in the cropland and horticultural-land sectors.

Table 268: Area-weighted mixed value for carbon stocks [$Mg\ C\ ha^{-1}$] in the biomass of cropland in Germany (± half of the 95 % confidence interval)

Year	Carbon stocks [$Mg\ C\ ha^{-1}$] Cropland$_{annual}$		
	Bio$_{total}$	Bio$_{above\text{-}ground}$	Bio$_{below\text{-}ground}$
1990	6.13 ± 0.52	4.91 ± 0.40	1.22 ± 0.33
1991	6.38 ± 0.54	5.13 ± 0.42	1.24 ± 0.33
1992	5.92 ± 0.50	4.79 ± 0.39	1.14 ± 0.30
1993	6.66 ± 0.56	5.38 ± 0.44	1.29 ± 0.34
1994	6.26 ± 0.53	5.04 ± 0.41	1.22 ± 0.33
1995	6.45 ± 0.54	5.21 ± 0.43	1.24 ± 0.33
1996	6.69 ± 0.56	5.41 ± 0.45	1.28 ± 0.34
1997	6.82 ± 0.58	5.51 ± 0.45	1.31 ± 0.35
1998	6.71 ± 0.57	5.43 ± 0.45	1.29 ± 0.34
1999	6.93 ± 0.58	5.61 ± 0.46	1.32 ± 0.35
2000	6.79 ± 0.57	5.50 ± 0.45	1.29 ± 0.35
2001	7.07 ± 0.60	5.72 ± 0.47	1.35 ± 0.36
2002	6.54 ± 0.55	5.30 ± 0.44	1.24 ± 0.33
2003	5.93 ± 0.50	4.82 ± 0.40	1.11 ± 0.30
2004	7.39 ± 0.63	6.00 ± 0.49	1.39 ± 0.37
2005	7.04 ± 0.59	5.69 ± 0.47	1.35 ± 0.36
2006	6.64 ± 0.56	5.35 ± 0.44	1.29 ± 0.35
2007	6.92 ± 0.58	5.59 ± 0.46	1.34 ± 0.36
2008	7.40 ± 0.62	5.96 ± 0.49	1.43 ± 0.38
2009	7.58 ± 0.64	6.12 ± 0.50	1.46 ± 0.39
2010	7.09 ± 0.60	5.71 ± 0.47	1.38 ± 0.37
2011	7.54 ± 0.64	6.09 ± 0.50	1.46 ± 0.39

7.3.4.3 Mineral soils

No change in carbon stocks in mineral soils is listed for areas remaining as cropland. This assumption is supported by the results obtained on 140 regional long-term-trial areas (HÖPER und SCHÄFER 2012, FORTMANN et al. (to be published) and BAYERISCHE LANDESANSTALT FÜR LANDWIRTSCHAFT 2007). Recent meta-studies (BAKER et al. 2007; LUO et al. 2010) have also shown, for soil depths > 60 cm, that the type of soil cultivation used has no influence on the total carbon stocks in mineral soils. In agricultural soil use, the soil-cultivation and soil-management methods used thus do not change rapidly over large areas.

The manner in which CO_2 emissions resulting from conversions leading to cropland are calculated is described in Chapter 7.1.5, while the pertinent emission factors are described in Table 269 (Chapter 7.3.5), and derivation of the emission factors is described in Chapter 19.5.2.

The N_2O emissions resulting from conversions of land to cropland (CRF Table 5 (III)) were determined pursuant to IPCC GPG (2003). To that end, the carbon-stock changes determined for the various individual land-use-change areas were divided by the mean, area-weighted C/N ratios for the pertinent soils, in order to obtain the absolute changes in soil nitrogen stocks. Those stock changes were then tallied with the IPCC default value of 0.0125 Mg N_2O-N per Mg N (IPCC GPG 2003). The so-obtained N_2O emission factors, and their uncertainties, are shown in Table 269 (Chapter 7.3.5). The C/N ratios were derived from the estimated profile data of the BÜK 1000 n 2.3 soil map (BGR 2011). The nitrous oxide emissions are also subject to transition-time considerations; like the carbon-stock changes, they are distributed over 20 years.

7.3.4.4 Organic soils

The annual emissions following land-use changes are calculated with the same procedure used for emissions from cropland remaining cropland. The procedure for calculating CO_2 emissions from organic soils that result from land use and land-use changes, and the procedure for deriving the pertinent emission factors, are described in Chapter 7.1.6.

N_2O emissions from organic soils are reported as part of the "Agriculture" sector, under 4.D.1.5 "Cultivation of Histosols". To prevent double-counting, N_2O emissions from organic soils that result from conversions to cropland are listed in the LULUCF tables with the notation key "IE".

7.3.4.5 Liming

Emissions from liming are calculated from the total quantities of lime fertiliser applied. Fertiliser lime includes all carbonates of calcium and magnesium, either as pure substances or as additives. Reporting thus covers emissions from dissolving of calcium carbonate, mixed carbonates, carbonated lime, residual lime and calcium ammonium nitrate.

The quantities of lime applied are derived from the product quantities sold within the country, under the assumption that lime fertiliser is applied in the year in which it is sold. The product-quantity figures are taken from official statistics (STATISTISCHES BUNDESAMT (FEDERAL STATISTICAL OFFICE), Fachserie 4, Reihe 8.2). They list solely the fertiliser quantity corresponding to the total sum of relevant lime, as well as – in aggregated form – the percentage of the total quantity of lime that is sold to the forestry sector. As part of inventory-related estimation, it is assumed that the quantity of lime fertiliser applied to forests is equivalent to the forestry sector's percentage share of the total quantity sold. Lime quantities not explicitly assigned to the forestry sector are reported completely in the cropland category.

In fertiliser statistics, all lime-containing fertilisers, including magnesium carbonates, are reported as CaO. The relevant CO_2 emissions are derived from such statistics stoichiometrically.

In calcium ammonium nitrate, the nitrogen fraction is assumed to account for 27 %. As a result, ammonium nitrate accounts for 77.1 % and calcium carbonate accounts for 22.9 %. Here as well, the CO_2 emissions are determined stoichiometrically.

7.3.5 Uncertainties and time-series consistency (5.B)

The uncertainties for emission factors and activity data were determined in accordance with the publication Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000). Additional relevant information is provided in Chapter 19.5.4. Table 269 shows the uncertainties in the emission factors for the cropland sector, broken down by pools and sub-categories.

Table 269 highlights the fact that distributions based on natural processes are often not symmetric, in which case they have to be described with log-normal distributions. For example, the distribution functions for emission factors in the cropland sector tend to be log-normal. The standard normal distributions seen for biomass values are exceptions. Furthermore, the uncertainties seen in this area are the smallest of all relevant uncertainties.

The uncertainties for the activity data, the areas, are shown in Table 376 in Chapter 19.5.4. Those uncertainties have a normal distribution, and half of the 95 % confidence interval, in the cropland sector, falls within the range 1 – 86 %. For system-related reasons, the sampling error with the grid-point approach depends on the sample size, and thus on the relevant sub-category's share of the total area (cf. Chapter 7.1.3). Consequently, in the cropland sector major uncertainties are seen only for those sector sub-categories whose share of the total cropland area is < 0.1 %. Area-weighted derivation of a total uncertainty for the area data in the cropland category yields a value of 1.06 %.

Table 376 in Chapter 19.5.4 shows that, in the cropland sector, and in terms of total emissions, emissions from organic soils have an especially significant share of national LULUCF emissions. Emissions from mineral soils and, especially, those occurring in connection with biomass, have only a small share.

The uncertainties for emissions from liming arise via the tolerance limits, for active substances, specified by the Fertiliser Ordinance (Düngemittelverordnung; Federal Law Gazette 2012). That Ordinance allows uncertainties of only 2 - 4 %, depending on the type of lime fertiliser concerned, relative to quantities of active substances. As a result of the combination of lime-fertiliser types seen in 2011, the total uncertainty for the EF is 2.95 %. The survey for determination of activity data relative to liming is an exhaustive statistical survey. It is required by law, and all surveyed parties are required to provide the relevant information. As a result, the activity data may be considered complete, and normally subject to no statistical uncertainties. To take account of possible distortions resulting from delays in notification, and from methods for deriving quantities spread in forests, an additional, conservatively estimated uncertainty value of 5 % was added for the AD. The resulting total uncertainty for emissions from liming is then 5.8 % [half of the 95% confidence interval].

Table 269: Uncertainties of emission factors [in % of location scale] used for calculation of GG emissions from Germany's croplands in 2011, broken down by pools and sub-categories; positive: C sink or N_2O emissions; negative: C source

Cropland Land use$_{before}$ Mineral soils CO_2-C[84]	Area Land use$_{after}$	Emission factor [Mg C ha^{-1} a^{-1}]	Boundaries upper [%]	 lower [%]
Forest land	Cropland	0.07	25	16
Grassland (in a strict sense)	Cropland	-0.87	49	30
Woody grassland	Cropland	-0.66	51	28
Terr. wetlands	Cropland	-0.70	37	28
Waters	Cropland	0.00	51	33
Settlements	Cropland	0.07	49	28
Other land	Cropland	0.22	52	27
Mineral soil N_2O-N[85]		**[kg N_2O-N ha^{-1} a^{-1}]**	**[kg N_2O-N ha^{-1} a^{-1}]**	**[%]**
Forest land	Cropland	0.002	84	82
Grassland (in a strict sense)	Cropland	1.34	106	99
Woody grassland	Cropland	1.06	107	98
Terr. wetlands	Cropland	0.89	101	99
Organic soil		**[Mg C ha^{-1} a^{-1}]**	**[Mg C ha^{-1} a^{-1}]**	**[%]**
	Cropland	-11.00	50	50
Biomass[86]		**[Mg C ha^{-1} 1 a^{-1}]**	**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**
Forest land	Cropland	-25.09	30	30
Grassland (in a strict sense)	Cropland	0.86	13	13
Woody grassland	Cropland	-39.39	163	55
Terr. wetlands	Cropland	-12.56	109	37
Waters	Cropland	7.54	8	8
Settlements	Cropland	-5.86	109	37
Other land	Cropland	7.54	8	8
Dead organic matter[87]		**[Mg C ha^{-1} 1 a^{-1}]**	**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**
Forest land	Cropland	-21.03	3	3

The calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2011.

7.3.6 Category-specific quality assurance / control and verification (5.B)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out in keeping with the "Implementation regulation for preparation of emissions and carbon inventories, and for relevant quality management for the area of source categories 4 and 5 – Annex to the concept for emissions and carbon inventories in the subordinate sphere of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) of 01 March 2012" ("Ausführungsbestimmung zur Erstellung von Emissions- und Kohlenstoffinventaren und deren Qualitätsmanagement für den Bereich der Quellgruppen 4 und 5 - Anlage zum

[84] Calculation for 20-year period
[85] Calculation for 20-year period
[86] Calculation only for the first year following the pertinent land-use change
[87] Calculation only for the first year following the pertinent land-use change

Konzept Emissions- und Kohlenstoffinventare im nachgeordneten Bereich des BMELV vom 01.03.2012") (Version 1.01, last revised on 31 August 2012; Thünen Institute 2012).

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Quality assurance for input data (ATKIS®, BÜK, official statistics) is the responsibility of the relevant data administrators (cf. the pertinent documentation in the inventory description).

The emissions-calculation results as presented in the present report cannot be compared with other relevant data sources for Germany, since no such other data sources exist that meet applicable requirements, i.e. provide complete coverage, are comprehensive and are independent of the methods and data sources described in the present report. An intra-European comparison of the implied emission factors shows – especially when the large pertinent uncertainties and broad scattering of reported values are taken into account (cf. Chapter 7.3.5) – that the country-specific values for Germany exhibit no conspicuous differences from those of Germany's neighbours in terms of order of magnitude. Germany uses the largest emission factor for CO_2 from drainage of organic soils under cultivation. The value used in Germany, which has been derived from national measurements, reflects the fact that use / drainage intensity is much higher in Germany than it is in countries neighbouring Germany. In the case of land-use changes leading to cropland, involving organic soils, the same emission factor applies, immediately, that applies for cropland remaining cropland.

In the German inventory, carbon-stock changes in mineral soils, biomass and dead organic matter (only for conversions from forest land to cropland) are taken into account only in connection with land-use changes leading to cropland; they are not taken into account in connection with cropland remaining cropland. The C losses from mineral soils and biomass, as shown in the German calculations, are lower than the corresponding European average, but would fall within the middle range of neighbouring countries' implied emission factors. The C losses from dead organic matter reflect forest lands' share of lands under conversion.

Nitrous oxide emissions are calculated as the result of soil carbon losses. The German emission factor is slightly higher than the European average. That said, it must be noted that nitrous oxide from mineral soils is not taken into account in some Member States, and that Denmark, Sweden and Slovenia clearly take a wider perspective on nitrous oxide (i.e. do not solely consider nitrous oxide emissions from mineral soils).

Table 270: Comparison of implied emission factors (IEF) for different cropland-sector pools in Europe, for the year 2010 (exception: Germany, NIR 2013: the 2011 figure is used, for comparison)

Implied emission factors (IEF), NIR 2012	Cropland remaining cropland Organic soils	Conversions to cropland Mineral soils	Biomass	Dead org. matter	Nitrous oxide
	Mg C ha^{-1}				kg N_2O-N ha^{-1}
Austria	NO	-1.00	0.048	-0.169	1.01
Belgium	NO	-1.86	-0.148	-0.005	1.65
Czech Republic	NO	-0.35	-0.217	-0.004	0.39
Denmark	-11.27	0.02	-0.062	-0.031	11.46
Finland	-4.90	-0.52	-1.011	-0.011	0.31
France	NO	-0.82	-0.189	-0.019	0.74
Hungary	NO	-0.64	-0.035	-0.004	0.53
Liechtenstein	IE	-3.91	-1.359	NO	1.18
Luxembourg	NO	-0.58	-0.111	-0.004	0.84
Netherlands	IE	NE	-1.887	-0.118	NE
Poland	-1.00	-0.98	NA,NO	NO	NO
Slovak Republic	NO	-1.00	-0.474	-0.011	NO
Slovenia	-10.00	-42.67	-20.67	-1.681	37.71
Sweden	-3.76	-0.29	-0.088	-0.075	2.50
Switzerland	-9.52	-0.22	-0.046	-0.001	0.54
UK	-1.93	-1.19	-0.025	IE,NO	0.25
European Union (15)	-7.44	-0.88	-0.154	-0.017	0.52
European Union (27)	-5.22	-0.91	-0.151	-0.017	0.55
Germany	**-11.00**	**-0.64**	**-0.058**	**-0.003**	**0.76**
Germany, NIR 2013	**-11.00**	**-0.66**	**-0.058**	**-0.005**	**1.04**

Positive: C sink or N_2O emissions; negative: C source or N_2O storage

7.3.7 Category-specific recalculations (5.B)

This year's submission includes category-specific recalculations for the entire period covered by the report. The emission factors have been recalculated to take account of new developments in a range of areas, as follows:

- Mineral soils: For the first time, the final results of the Forest Soil Inventory were available for calculation of emission factors for mineral soils in forests. Such calculation yielded new emission factors for carbon-stock changes in mineral soils, and for nitrous oxide removals/emissions in/from mineral soils, in all categories of conversion from and to forest land (Chapter 7.1.5).
- Dead organic matter: For the first time, the final results of the Forest Soil Inventory were available for calculation of emission factors (Chapter 7.1.7).
- Biomass: Changes in methods for calculation of below-ground biomass of hedges / trees/shrubs (Chapter 7.3.4.2 and Chapter 19.5.3.1.3); redetermination of the emission factor for cropland, via correction of the carbon stocks in grapevines, to take account of pruned wood fractions; and correction of an area error in calculation of the mean carbon stocks of annual arable crops.

In addition, the emissions in all pools and land-use categories had to be recalculated for the years 2009 and 2010, since the basis for calculation of the pertinent activity data was changed (cf. Chapter 7.1.3). In connection with such recalculation of emission factors and activity data, the pertinent uncertainties were also determined anew.

Table 271 and Table 272 show the impacts of the recalculations. In the "Cropland remaining Cropland" category, the emissions change that has resulted, with respect to last year's submission, from updating of area data affects only the years since 2009. The change amounts to -0.2 % in 2010. In the categories of land-use change leading to cropland, emissions have changed throughout the entire time series, as a result of the changes in emission factors and activity data. A difference of -2.4 % results for 1990, and a difference of 6.4 % results for 2010. With regard to total emissions from cropland, the recalculation yields differences of - 0.5 % for 1990 and 0.8 % for 2010.

Table 271: Comparison of emissions [Gg CO_2], as reported in the 2013 and 2012 submissions, from cropland remaining cropland (5.B.1)

[Gg a^{-1} CO_2 equiv.]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	22,256	22,323	22,391	22,458	22,526	22,594	22,661	22,729	22,796	22,864
Total, 2012	22,256	22,323	22,391	22,458	22,526	22,594	22,661	22,729	22,796	22,864
Mineral soils, 2013	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Organic soils, 2013	22,256	22,323	22,391	22,458	22,526	22,594	22,661	22,729	22,796	22,864
Organic soils, 2012	22,256	22,323	22,391	22,458	22,526	22,594	22,661	22,729	22,796	22,864
Biomass, 2013	0	0	0	0	0	0	0	0	0	0
Biomass, 2012	0	0	0	0	0	0	0	0	0	0
[Gg a^{-1} CO_2 equiv.]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	22,931	22,964	22,996	23,029	23,061	23,093	23,147	23,200	23,253	23,313
Total, 2012	22,931	22,964	22,996	23,029	23,061	23,093	23,147	23,200	23,253	23,317
Mineral soils, 2013	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Organic soils, 2013	22,931	22,964	22,996	23,029	23,061	23,093	23,147	23,200	23,253	23,313
Organic soils, 2012	22,931	22,964	22,996	23,029	23,061	23,093	23,147	23,200	23,253	23,317
Biomass, 2013	0	0	0	0	0	0	0	0	0	0
Biomass, 2012	0	0	0	0	0	0	0	0	0	0
[Gg a^{-1} CO_2 equiv.]	**2010**									
Total, 2013	23,373									
Total, 2012	23,381									
Mineral soils, 2013	0									
Mineral soils, 2012	0									
Organic soils, 2013	23,373									
Organic soils, 2012	23,381									
Biomass, 2013	0									
Biomass, 2012	0									

Positive: emissions; negative: sink

Table 272: Comparison of emissions [Gg CO_2], as reported in the 2013 and 2012 submissions, from land-use changes leading to cropland (5.B.2)

[Gg a^{-1} CO_2 equiv.]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	**5,414**	**5,384**	**5,452**	**5,353**	**5,415**	**5,393**	**5,364**	**5,350**	**5,370**	**5,344**
Total, 2012	**5,546**	**5,512**	**5,578**	**5,473**	**5,532**	**5,505**	**5,472**	**5,454**	**5,470**	**5,440**
Mineral soils, 2013	1,366	1,370	1,374	1,378	1,382	1,386	1,390	1,394	1,398	1,403
Mineral soils, 2012	1,484	1,484	1,484	1,484	1,484	1,484	1,484	1,484	1,484	1,484
Organic soils, 2013	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057
Organic soils, 2012	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057
Biomass, 2013	1,473	1,438	1,502	1,397	1,455	1,428	1,394	1,375	1,391	1,360
Biomass, 2012	1,469	1,435	1,500	1,394	1,452	1,424	1,391	1,372	1,387	1,356
Dead organic matter, 2013	322	323	324	325	325	326	327	327	328	329
Dead organic matter, 2012	336	336	337	338	339	340	340	341	342	343
N_2O from humus loss, 2013	196	196	196	196	196	196	196	196	196	196
N_2O from humus loss, 2012	199	199	199	199	199	199	199	199	199	199
[Gg a^{-1} CO_2 equiv.]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	**5,369**	**3,901**	**3,955**	**4,023**	**3,849**	**3,886**	**3,721**	**3,652**	**3,566**	**3,562**
Total, 2012	**5,460**	**3,978**	**4,026**	**4,091**	**3,909**	**3,941**	**3,771**	**3,697**	**3,606**	**3,544**
Mineral soils, 2013	1,407	1,418	1,429	1,440	1,451	1,462	1,456	1,450	1,444	1,476
Mineral soils, 2012	1,484	1,490	1,496	1,502	1,507	1,513	1,503	1,492	1,482	1,435
Organic soils, 2013	2,057	2,041	2,026	2,010	1,994	1,978	1,941	1,904	1,867	1,863
Organic soils, 2012	2,057	2,041	2,026	2,010	1,994	1,978	1,941	1,904	1,867	1,795
Biomass, 2013	1,380	215	273	344	175	215	117	93	51	9
Biomass, 2012	1,375	215	273	347	175	215	118	93	51	115
Dead organic matter, 2013	329	30	30	30	30	30	8	8	8	13
Dead organic matter, 2012	344	31	31	32	32	32	8	8	8	8
N_2O from humus loss, 2013	196	197	198	198	199	200	199	197	196	199
N_2O from humus loss, 2012	199	200	201	201	202	203	201	199	198	191
[Gg a^{-1} CO_2 equiv.]	**2010**									
Total, 2013	**3,660**									
Total, 2012	**3,439**									
Mineral soils, 2013	1,509									
Mineral soils, 2012	1,388									
Organic soils, 2013	1,860									
Organic soils, 2012	1,722									
Biomass, 2013	76									
Biomass, 2012	135									
Dead organic matter, 2013	13									
Dead organic matter, 2012	8									
N_2O from humus loss, 2013	203									
N_2O from humus loss, 2012	185									

7.3.8 Category-specific planned improvements (5.B)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

7.4 Grassland (5.C)

7.4.1 Source category description (5.C)

CRF 5.A	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Grassland	**CO_2**	**L**	**-/T2**	**11,327.5**	**0.93%**	**8,768.4**	**0.95%**	**-22.59%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	RS/NS	CS

The source category *Grassland* (5.C) is a key source of CO_2 emissions in terms of emissions level.

In 2011, net anthropogenic CO_2 emissions from grassland amounted to 8,768 Gg CO_2. Drainage of organic grassland soils resulted in emissions of 11,080 Gg CO_2. Via land-use changes, 1,096 Gg CO_2 were stored in mineral soils, and 1,279 Gg CO_2 were stored in biomass. Losses via decomposition of dead wood and litter from deforestation amounted to 64 Gg CO_2.

These emissions consist of the sum of the emissions from the sub-categories grassland (in a strict sense) and woody grassland, whose CO_2 emissions differ considerably, both quantitatively and qualitatively. As Figure 61 and Figure 62 show, grassland (in a strict sense) is a significant CO_2 source. Its absolute emissions level, 10,642 Gg CO_2, is determined primarily by emissions from organic soils in the "Grassland remaining Grassland" category. With the exception of mineral soils, which continue to function as a sink, the pools in the sub-category grassland (in a strict sense) are CO_2 sources. The time series shows a clear decreasing trend, however, amounting to an emissions reduction of -13 % with respect to 1990. It is due to a continual decrease in emissions from organic soils (-5 %) and, especially, from biomass (-75 %) and from dead organic matter (-92 %). The last of these decreases is due to a decrease in deforestation, as well as to a reduction in conversion of woody grassland to intensively managed grassland. The shapes of the time-series plots – especially the noticeable changes they show – are due primarily to the changes in area data that have occurred as of the relevant explicitly defined survey dates (cf. Chapter 7.1.3.5, Table 233). This applies especially to the sub-category woody grassland (cf. ibid.).

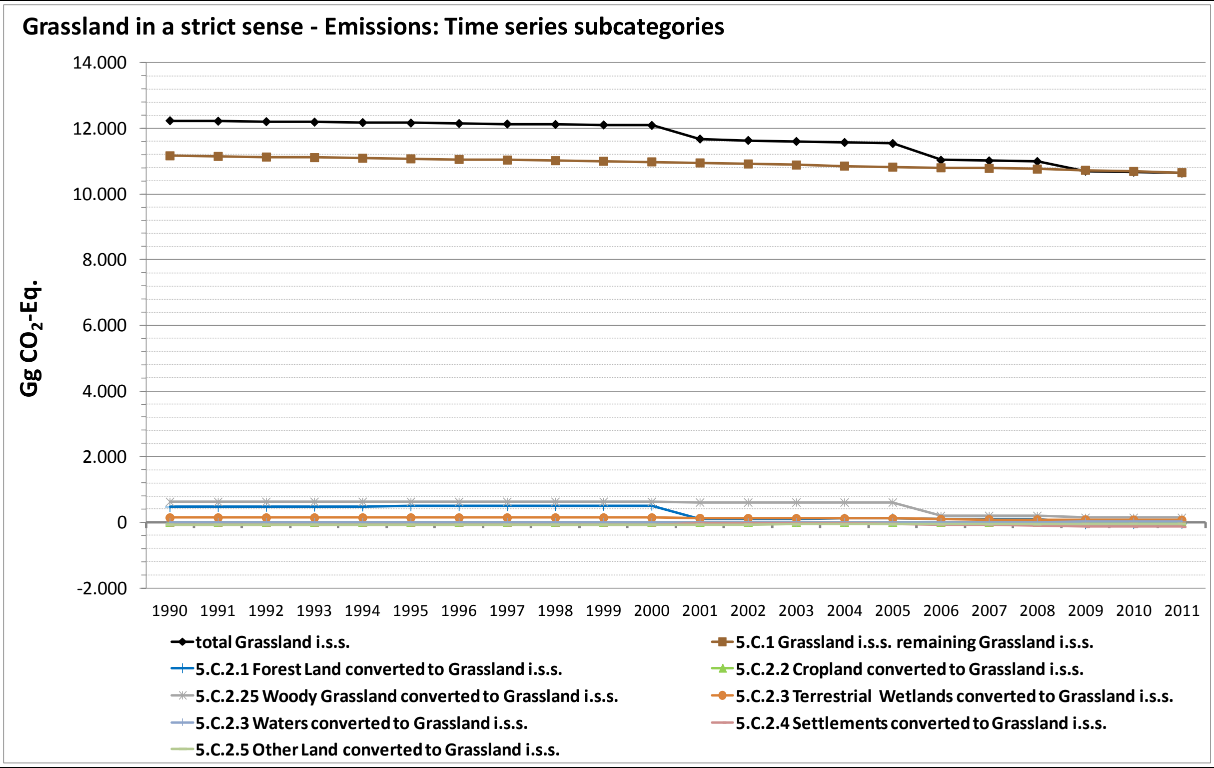


Figure 61: CO_2 emissions [Gg CO_2 eq.] from grassland (in a strict sense), as a result of land use and land-use changes, in Germany, 1990 – 2011, by sub-categories

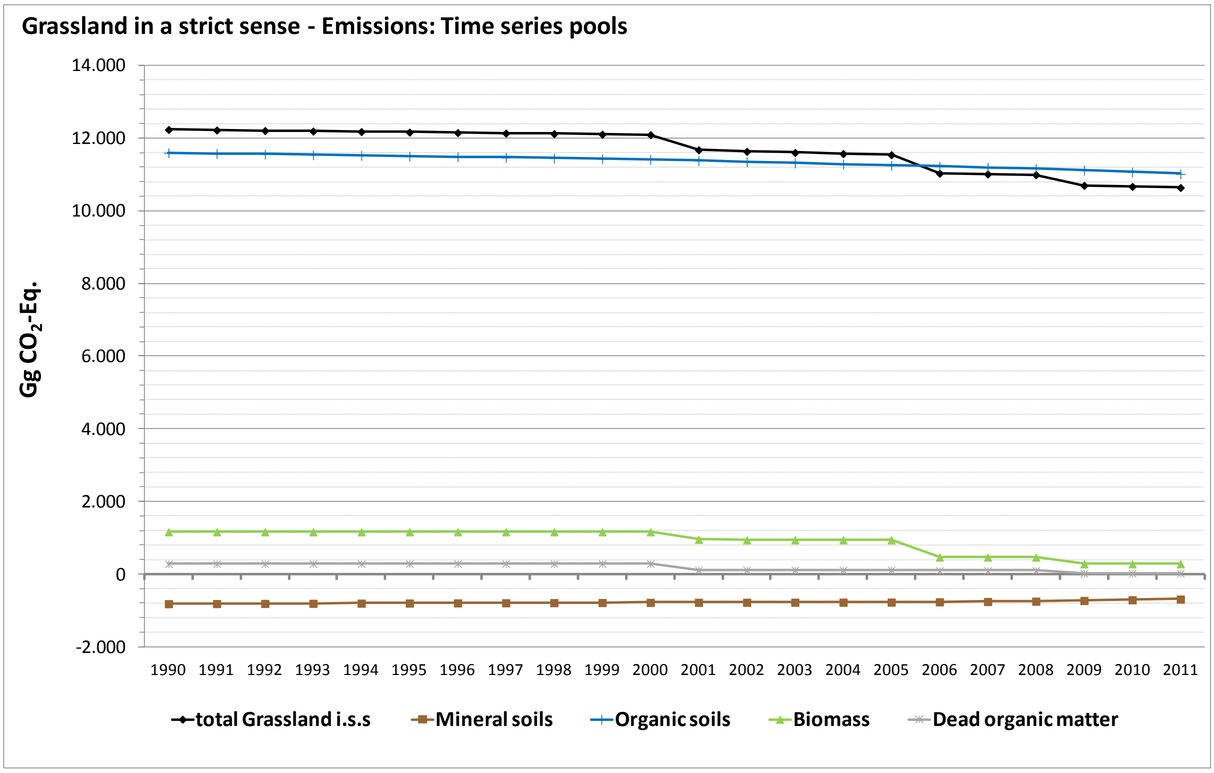


Figure 62: CO_2 emissions [Gg CO_2 eq.] from grassland (in a strict sense), as a result of land use and land-use changes, in Germany, 1990 – 2011, in Germany, 1990 – 2011, by pools

Unlike the other grassland sub-category, the "woody grassland" sub-category is a CO_2 sink (Figures 62 and 62a). In 2011, CO_2 removals into the pools in this category amounted to 1,873 Gg CO_2. Slight CO_2 emissions from organic soils (61 Gg CO_2) and dead organic matter

(41 Gg CO_2) are more than offset by large removals into mineral soils (-411 Gg CO_2) and, especially, into biomass (-1,565 Gg CO_2). This category's sink function has grown considerably since 1990 (106 %). In the main, this has resulted from discontinuation of cultivation of cropland areas, allowing such areas to become overgrown with bushes. Conversion of grassland areas (i.s.s.) and decreases in deforestation have also played a role.

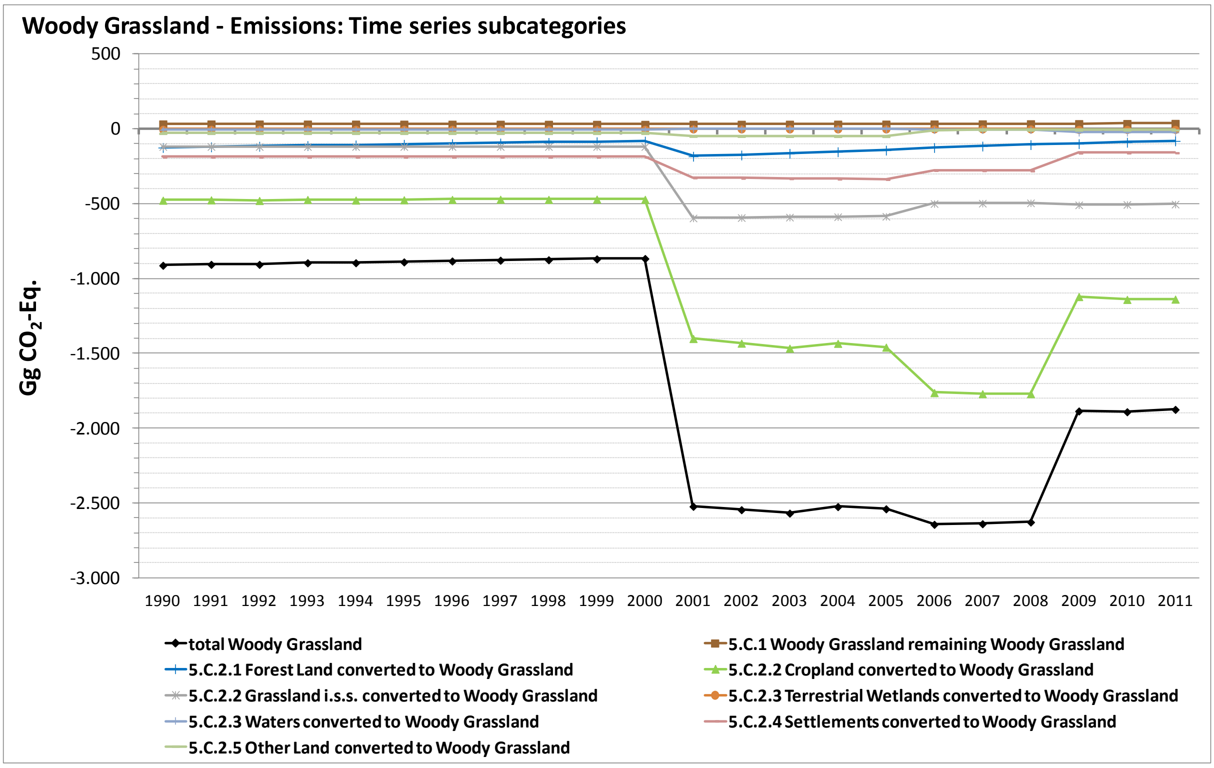


Figure 63: CO_2 emissions [Gg CO_2 eq.] from Germany's woody grasslands, as a result of land use and land-use changes, 1990 – 2011, by sub-categories

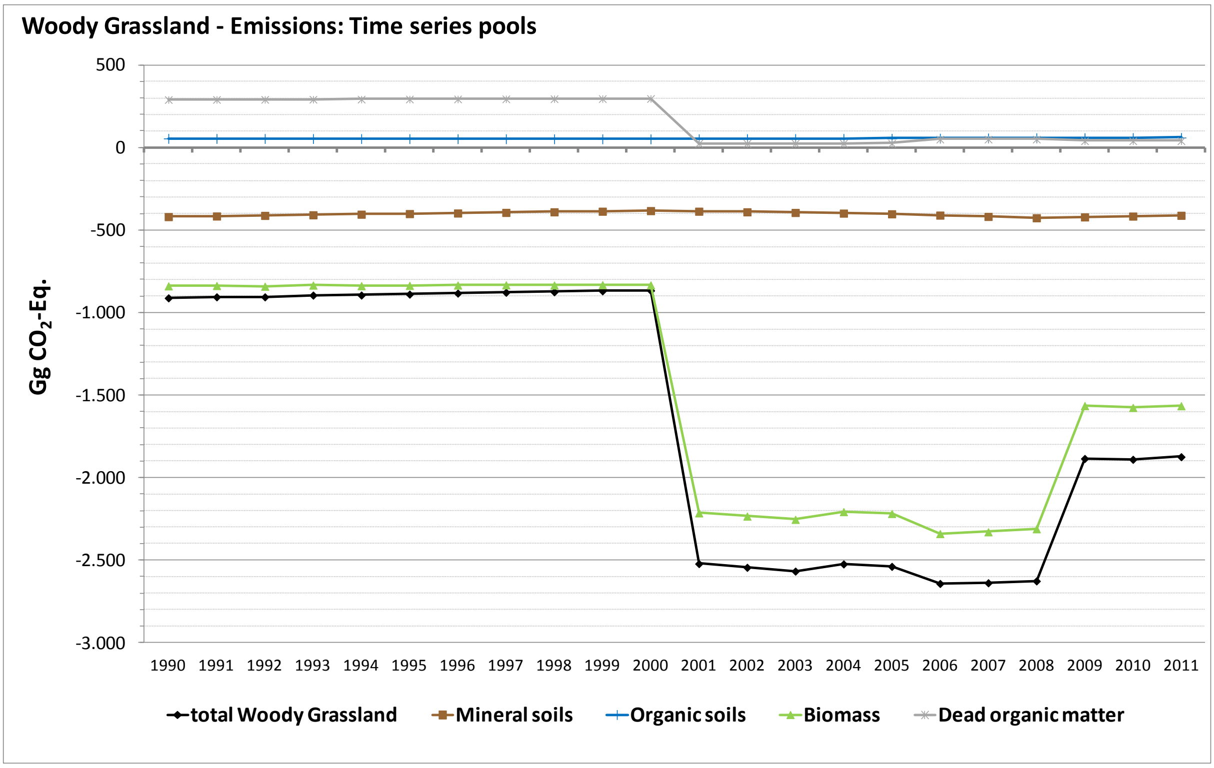


Figure 64: CO_2 emissions [Gg CO_2 eq.] from Germany's woody grasslands, as a result of land use and land-use changes, 1990 – 2011, by pools

7.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation (5.C)

Cf. Chapters 7.4.3 and 7.1.3.

7.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.C)

The definition of "grassland" includes all grass-covered areas. In addition, this category includes wooded areas that are not included in the definition of "forest land". It also includes object type 4106 "swamp, reeds" from the Basis-DLM (Chapter 7.1.3.2.1). That category, **which in the following is also referred to as "wet grassland", consists of undrained organic soils under grassland. Grassland (in a strict sense) accounts for 90 % of the total grassland area (of that 90 %, 0.3 % is wet grassland**), while **woody grassland accounts for 10 % of that total area.**

The sub-categories **in this area include the following types of land use and plants** (cf. Chapter 7.1.4):

- Meadows, pastures, alpine pastures, rough pastures, heath areas, natural-condition grassland, recreational areas and swamp/reeds are grouped under "grassland (in a strict sense)".
- Hedges, field copses and shrubbery make up the sub-category "woody grassland".

Changes between these two sub-categories are treated like land-use changes.

For purposes of emissions calculation, the two grassland sub-categories have been stratified by pools. To that end, area-weighted mean carbon stocks are determined, and the resulting figures are used in the inventory:

- Calculation of biomass stocks: Stratification within the sub-categories, by crop types. For grassland (in a strict sense), the stratifications include above-ground and below-ground biomass of grasses and herbaceous plants (Chapter 7.4.4.2.1). For woody grassland, a carbon-equilibrium value has been determined for hedge plants and field copses, stratified by species combinations, age, growth density and growth height (Chapter 7.4.4.2.2).
- Calculation of the emissions from soils: Chronologically constant stratification in accordance with the categories of organic soils and mineral soils. Organic soils are subdivided into the categories of "undrained wet grassland" and "bogs". The mineral soils category is subdivided by usage, soil type / soil-parent-rock groups and climate region (cf. Chapter 19.5.2.2).
- Calculation of emissions from land-use changes: Annually updated stratification, by the categories "grassland (in a strict sense) remaining as grassland (i.s.s.)", "woody grassland remaining as woody grassland" and "land converted to grassland". The relevant data are taken annually from the pertinent land-use information (Chapter 7.1.4; Chapter 7.1.3).

7.4.4 Methodological issues (5.C)

7.4.4.1 Data sources

- Statistisches Bundesamt, Fachserie 3, Reihe 3, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung und pflanzliche Erzeugung (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries, agricultural soil use and crop cultivation; various years)
- Statistisches Bundesamt, Fachserie 3, Reihe 3.2.1, Land- und Forstwirtschaft, Fischerei, Wachstum und Ernte – Feldfrüchte (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries, growth and harvests – crops; various years)
- Statistisches Bundesamt, Fachserie 3, Reihe 3.1.2, Land- und Forstwirtschaft, Fischerei,– Bodennutzung der Betriebe (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries – soil use by sectoral operations; various years)
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 - Agriculture, Forestry and Other Land Use (IPCC 2006)
- "Ordinance on application of fertilisers, soil additives, culture substrates and plant additives according to the principles of good practice in fertilization (Ordinance on Fertilisation – Düngeverordnung (DüV))“ (Ordinance on Fertilisation in the version as promulgated 27 February 2007 (Federal Law Gazette I, p. 221), last amended by Article 18 of the Act of 31 July 2009 (Federal Law Gazette I p. 2585) (Federal Law Gazette 2009)
- Interim report in the research project "Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Wäldern“ ("Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth") (PÖPKEN 2011)

7.4.4.2 Biomass

For calculation of carbon-stock changes in biomass, in connection with land-use changes to and from grassland, constant (over time) carbon stocks were determined for the sub-categories "grassland (in a strict sense)" and "woody grassland". In addition, conversions from grassland (in a strict sense) to woody grassland and vice-versa are treated like land-use changes, and listed as such in the CRF tables.

No carbon-stock changes are given for the biomass of areas in the sub-categories grassland (i.s.s.) and woody grassland, since the carbon flows and the wood biomass in these categories are assumed to be in equilibrium. This assumption is made in light of the representative "equilibrium carbon stocks" determined for Germany's field and hedge trees/shrubs. The biomass levels of the field and hedge trees/shrubs typically found in Germany have been determined in a research project focusing on a broad and diverse range of hedges, and differentiating hedges by criteria such as species composition, growth density, height and age (cf. Chapter 7.4.4.2.2). With this approach, it was possible to determine representative equilibrium carbon stocks for field and hedge trees/shrubs, since the approach included summation over all age classes, plant types and plantation structures and combinations. Since the rotation periods for woody plants tend to be relatively short (about 10 – 12 years), such plantations tend to rejuvenate frequently. Such rejuvenation occurs from the pool used to derive the pertinent emission factors, however. The processes of planting, growth, pruning and rejuvenation reach a state of dynamic equilibrium. In the case of land-use changes leading to land areas with woody grassland, the carbon stocks in the biomass of the relevant woody plants are thus reported completely in the year of the land-use change. With regard to changes in carbon stocks, such equilibria are disturbed only through changes in the relevant surveyed areas. Such changes are recorded as land-use changes, and the pertinent emissions are reported.

The manner in which CO_2 emissions from biomass, as a result of land-use changes, are calculated is presented in Chapter 7.1.7, while the method used to determine activity data is described in Chapter 7.1.3. The emission factors for the period 1990 to 2011, and their uncertainties, are shown in Table 276 and Table 277 in Chapter 7.4.5.

7.4.4.2.1 Grassland (in a strict sense) (i.s.s.)

Grassland (in a strict sense) is free of trees and shrubs. The carbon stocks in the above-ground and below-ground biomass of grassland (in a strict sense) have been calculated on the basis of the Federal Statistical Office's harvest statistics. The harvests and areas of all meadows, mowed pastures, alpine pastures and rough pastures enter into the calculations for grassland (in a strict sense). Since no significant trend emerged in the harvest covered by the harvest statistics, constant (over time) carbon stocks were calculated. For annual crops, the dry biomass of individual plant parts is derived from harvest data, pursuant to HAENEL et al. (2012), using relevant ratios and water-content data (obtained from various sources).

For calculation of biomass carbon stocks, an average carbon content of 45 % by weight was assumed – and used instead of the IPCC default value (50 % by weight) – since OSOWSKI et al. (2004) give carbon contents of 44 – 48 % by weight for plants in central Europe and since PÖPKEN (2011), in her studies of cultivated trees (carried out for the German inventory), also found average values of 45 to 46 % by weight.

The area-related carbon stocks obtained for grassland (in a strict sense) are shown in Table 273.

Table 273: Area-related carbon stocks [Mg C ha^{-1}] of grassland (in a strict sense) (± half of the 95 % confidence interval)

Grassland (in a strict sense)	Carbon stocks [Mg C ha^{-1}] Bio_{total}	$Bio_{above-ground}$	$Bio_{below-ground}$
Grassland (in a strict sense)	6.69 ± 1.64	4.36 ± 0.21	2.33 ± 1.62

7.4.4.2.2 Woody grassland

In order to determine carbon stocks in hedges, PÖPKEN (2011) has studied 40 hedges to date, working in the framework of the research project "Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen" ("Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth") . The hedges studied to date vary widely in their characteristics:

1. Age

- About 4 – 20 years old

2. Dimensions

- Height, about 2 - 8 m
- Depth, about 1 – 6 m
- Length, about 100 – 500 m

3. Species composition

- Typical hedge plants, such as dog rose (Rosa canina), blackthorn/sloe (Prunus spinosa), common hazel (Corylus avellana), elder (Sambuccus spec.), hawthorn (Crataegus spec.), honeysuckle (Lonicera spec.), willow (Salix spec.)
- Trees, such as field maple (Acer campestre), common hornbeam (Carpinus betulus), willow (Salix spec.), beech (Fagus silvatica), linden (Tilia spec.) and elm (Ulmus spec.),

As a result, the study has included a representative spectrum of relevant field trees and shrubs. Laboratory analysis of samples taken of the various species in question included measurement of weight, water content and carbon content. That, in turn, made it possible, in connection with size data for the relevant fields, to determine absolute and area-related carbon stocks (cf. Table 274).

For reasons of nature conservation, the study carried out by PÖPKEN (2011) was able to survey only above-ground biomass. **For the present submission, and in contrast to the procedure used last year,** the **below-ground biomass was estimated not on the basis of the** root / shoot ratios given, and summarised in tabular form, by MOKANY et al. (2006) **, but on the basis of those authors' regression equation for trees and shrubs, as derived for the purpose of such estimation:**

$\mathbf{Bio_{below} = 0.489 * Bio_{above}^{0,890}}$ (MOKANY et al. 2006)

$R^2 = 0.93$

Bio_{below}: below-ground biomass in Mg C ha^{-1}

Bio_{above}: above-ground biomass in Mg C ha^{-1}

This approach was able to prevent a dilemma that occurs in the boundary regions between the classes, leading to considerably higher absolute stocks of below-ground biomass and considerably lower absolute stocks of above-ground biomass. Use of this approach yielded carbon stocks totalling 11.66 Mg C ha^{-1} in the below-ground biomass of field and hedge trees/shrubs, a result that differed slightly from last year's result (11.43 Mg C ha^{-1}).

Table 274: Area-related carbon stocks [Mg ha^{-1}] in the biomass of trees and shrubs (range)

Trees and shrubs	Carbon stocks [Mg C ha^{-1}]		
	$Bio_{above-ground}$	$Bio_{below-ground}$	Bio_{total}
Trees and shrubs	35.27 (4.5 -125.8)	11.66 (1.9 – 36.1)	46.93 (6.3 – 162.0)

7.4.4.3 Mineral soils

No change in carbon stocks in mineral soils is listed for areas remaining as cropland. The constancy of carbon stocks is substantiated by the results obtained on 42 regional long-term-trial areas (HÖPER und SCHÄFER 2012, FORTMANN et al. (to be published) and BAYERISCHE LANDESANSTALT FÜR LANDWIRTSCHAFT 2007). The pertinent long-term observations cover a period of 20 - 25 years. During that period, most of the areas studied exhibited no changes in the carbon stocks in mineral soils. Some soils showed slight reductions, while others exhibited slight increases that nearly exactly offset the decreases, both in terms of numbers and in absolute terms. The manner in which CO_2 emissions resulting from conversions leading to grassland (in a strct sense) and to woody grassland are calculated is described in Chapter 7.1.5, while the pertinent emission factors are shown in Table 276 and Table 277 in Chapter 7.4.5, and derivation of the emission factors is described in Chapter 19.5.2.

7.4.4.4 Organic soils

The annual emissions from grassland remaining grassland are calculated with the following partial emission factors:

Grassland (in a strict sense) EF = 5 Mg C ha^{-1} a^{-1}
Swamp, reeds: EF = 0 Mg C ha^{-1} a^{-1}
Woodlands: EF = 0.68 Mg C ha^{-1} a^{-1} (same value as for forest land)

The undrained area for wet grassland is constant in the time series, while the area for grassland (in a strict sense) varies. As a result, the implied emission factor for the sub-category grassland (in a strict sense) varies slightly from year to year, as is shown in Table 275.

Table 275: Implied emission factors for the sub-category "grassland (in a strict sense)" [Mg C ha^{-1} a^{-1}]

	Implied emission factors, organic soils$_{grassland\ (in\ a\ strict\ sense)}$ [Mg C ha^{-1} a^{-1}]										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
IEF	-4.866	-4.866	-4.865	-4.865	-4.865	-4.865	-4.865	-4.864	-4.864	-4.864	-4.864
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
IEF	-4.863	-4.863	-4.863	-4.862	-4.862	-4.862	-4.861	-4.861	-4.861	-4.860	-4.860

The annual emissions following land-use changes leading to grassland are calculated with the same procedure used for emissions from cultivated grassland remaining cultivated grassland. The procedure for calculating CO_2 emissions from organic soils that result from land use and land-use changes, and the procedure for deriving the pertinent emission factors, are described in Chapter 7.1.6.

N_2O emissions from organic soils on grassland (in a strict sense) are reported as part of the "Agriculture" sector, under 4.D.1.5 "Cultivation of Histosols" (cf. Chapter 6.5.2). To prevent double-counting, N_2O emissions from organic soils that result from conversions to grassland (in a strict sense) are listed in the LULUCF tables with the notation key "IE".

7.4.4.5 Liming

Data for liming of grassland are not listed separately in the national database, and thus liming is assigned completely to cropland (cf. Chapter 7.3.4.5).

7.4.5 Uncertainties and time-series consistency (5.C)

Table 276 and Table 277 show the uncertainties relative to the emission factors for the grassland sub-categories grassland (in a strict sense) and woody grassland. As a rule, the relevant distribution functions show a log-normal distribution, and they are characterised by their upper and lower boundaries. The uncertainties relative to mineral soils are of the same order of magnitude for both sub-categories. With regard to biomass, the uncertainties for the emission factors are higher for the "woody grassland" sub-category. Those uncertainties reflect the great diversity of relevant woody grassland in Germany.

The activity-data uncertainties shown in Table 376 in Chapter 19.5.4 have a normal distribution. The value "half of the 95 % confidence interval" varies throughout the range 1.7 – 147 %. In this case as well, the uncertainty depends on the sample size, and thus on the area share being considered. Weighted by area, the total uncertainty for activity data in the grassland category is 1.7 %. In terms of total emissions, Table 376 in Chapter 19.5.4 shows that emissions from organic soils under grassland, like those from biomass in this category, contribute significantly to the emissions and total uncertainty of the LULUCF inventory.

Table 276: Emission factors [Mg C ha^{-1} a^{-1}], with uncertainties [% of location scale], as used for calculation of GG emissions from grassland (in a strict sense)

Grassland$_{in\ a\ strict\ sense}$ Land use$_{before}$ Mineral soils CO_2-C[88]	**Area Land use$_{after}$**	**Emission factor [Mg C ha^{-1} a^{-1}]**	**Boundaries upper [%]**	**lower [%]**
Forest land	Grassland$_{i.s.s}$	0.92	43	26
Cropland	Grassland$_{i.s.s}$	0.87	49	30
Woody grassland	Grassland$_{i.s.s}$	0.21	57	32
Terr. wetlands	Grassland$_{i.s.s}$	0.17	47	32
Waters	Grassland$_{i.s.s}$	0.00	78	46
Settlements	Grassland$_{i.s.s}$	0.94	57	33
Other land	Grassland$_{i.s.s}$	1.09	60	33
Organic soils (annual)		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
	Grassland$_{i.s.s}$	Chapter 7.4.4.4	50	50
Biomass[89]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Grassland$_{i.s.s}$	-25.95	31	231
Cropland	Grassland$_{i.s.s}$	-0.86	13	13
Woody grassland	Grassland$_{i.s.s}$	-40.25	163	55
Terr. wetlands	Grassland$_{i.s.s}$	-13.42	109	38
Waters	Grassland$_{i.s.s}$	6.69	25	25
Settlements	Grassland$_{i.s.s}$	-6.72	109	38
Other land	Grassland$_{i.s.s}$	6.69	25	25
Dead organic matter[90]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Grassland$_{i.s.s}$	-21.03	3	3

Forest land, cropland: annual variable; all other factors are constant

The calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2011.

[88] Calculation for 20-year period
[89] Calculation only for the first year following the pertinent land-use change
[90] Calculation only for the first year following the pertinent land-use change

Table 277: Emission factors [Mg C ha^{-1} a^{-1}], with uncertainties [% of location scale], as used for calculation of GG emissions in 2011 from woody grassland

Woody grasslands Land use$_{before}$ Mineral soils CO_2-C[91]	Area Land use$_{after}$	Emission factor [Mg C ha^{-1} a^{-1}]	Boundaries upper [%]	lower [%]
Forest land	Woody grassland	0.72	45	23
Cropland	Woody grassland	0.66	51	28
Grassland (in a strict sense)	Woody grassland	-0.21	57	32
Terr. wetlands	Woody grassland	-0.04	49	31
Waters	Woody grassland	0.00	83	43
Settlements	Woody grassland	0.73	60	31
Other land	Woody grassland	0.88	62	31
Organic soil		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
	Woody grassland	-0.68	181	40
Biomass[92]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Woody grassland	14.30	111	40
Cropland	Woody grassland	39.39	163	55
Grassland (in a strict sense)	Woody grassland	40.25	163	55
Terr. wetlands	Woody grassland	26.83	116	39
Waters	Woody grassland	46.93	186	63
Settlements	Woody grassland	33.53	149	51
Other land	Woody grassland	46.93	186	63
Dead organic matter[93]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Woody grassland	-21.03	3	3

Forest land, cropland: annual variable; all other factors are constant

The calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2011.

7.4.6 Category-specific QA / QC and verification (5.C)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out in keeping with the "Implementation regulation for preparation of emissions and carbon inventories, and for relevant quality management for the area of source categories 4 and 5 – Annex to the concept for emissions and carbon inventories in the subordinate sphere of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) of 01 March 2012" ("Ausführungsbestimmung zur Erstellung von Emissions- und Kohlenstoffinventaren und deren Qualitätsmanagement für den Bereich der Quellgruppen 4 und 5 - Anlage zum Konzept Emissions- und Kohlenstoffinventare im nachgeordneten Bereich des BMELV vom 01.03.2012") (Version 1.01, last revised on 31 August 2012; Thünen Institute 2012).

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Quality assurance for input data (ATKIS®, BÜK, official statistics) is the responsibility of the relevant data administrators (cf. the pertinent documentation in the inventory description).

The emissions-calculation results as presented in the present report cannot be compared with other relevant data sources for Germany, since no such other data sources exist that meet applicable requirements, i.e. provide complete coverage, are comprehensive and are

[91] Calculation for 20-year period
[92] Calculation only for the first year following the pertinent land-use change
[93] Calculation only for the first year following the pertinent land-use change

independent of the methods and data sources described in the present report. The intra-European comparison of implied emission factors shown in Table 278 shows that Germany, after Switzerland and the Netherlands, uses the third-highest emission factor for CO_2 from drainage of organic soils used as grassland. That value is a mixed, area-weighted value, however, consisting of -5 Mg C ha^{-1} a^{-1} from grassland (in a strict sense) and -0.68 Mg C ha^{-1} a^{-1} from woody grassland (Chapter 7.4.4.4). In the case of land-use changes leading to grassland, the emission factor used for organic soils is immediately the same as that used for grassland remaining grassland.

In the category "grassland remaining grassland", the carbon-stock changes in mineral soils and in biomass, as reported for Germany, refer to changes between grassland (in a strict sense) and woody grassland. The mean emission factors are very low, since only a small area share is involved. Such changes are handled very differently from country to country, and thus the relevant mean emission factors of different countries cannot be directly compared. Like Germany, most EU countries assign carbon sinks in mineral soils and biomass to the "grassland" category.

In Germany, land-use changes leading to grassland result in large C sinks, in mineral soils and biomass**, that exceed the corresponding mean values for the EU, especially those relative to biomass.** The reason for this, with regard to biomass, is that conversions to woodland account for a significant share of land-use changes in Germany. In neighbouring countries, mean emission factors are scattered throughout a range leading from C sources to C sinks. In each case, the values cannot be explained without data relative to the applicable shares of the pertinent original use categories.

Table 278: Comparison of implied emission factors (IEF) for different grassland pools, for Germany and for neighbouring countries in Europe, for the year 2010 (exception: Germany, NIR 2013: the 2011 figure is used, for comparison)

Implied emission factors (IEF), grassland, NIR 2012	Grassland remaining grassland			Land-use changes leading to grassland			
	Organic soils	Mineral soils	Biomass	Organic soils	Mineral soils	Biomass	Dead org. matter
	Mg C ha^{-1}						
Austria	IE	0.014	NO	NO	0.725	-0.886	-1.012
Belgium	NO	-0.173	NO	NO	1.728	-0.337	-0.030
Czech Republic	NO	NO	NO	NA,NO	0.482	0.004	-0.001
Denmark	-1.000	NA	-0.006	-1.250	-0.025	-0.123	-0.011
Finland	-3.200	0.084	NE	-3.200	0.940	-0.448	-0.005
France	NO	NO	NO	NO	0.727	-0.089	-0.013
Hungary	NO	-0.101	NO	NO	0.544	-0.639	-0.003
Liechtenstein	IE	-0.101	0.007	IE	1.456	-20.982	-0.676
Luxembourg	NO	NO	NO	NO	1.236	-1.786	-0.026
Netherlands	-5.892	NO	NE	NE	NE	-1.062	-1.323
Poland	-0.252	-0.029	NO	IE,NO	0.996	NO	NO
Slovak Republic	NO	NO	NO	NO	0.973	-0.144	-0.019
Sweden	-1.602	0.183	0.171	-1.600	0.383	0.559	-0.243
Switzerland	-8.833	0.005	0.002	-8.531	0.636	-0.957	-0.412
UK	NO	0.135	NO	IE,NO,NE	0.658	-0.003	IE,NO,NE
European Union (15)	-3.705	0.024	0.012	-2.867	0.725	-0.041	-0.023
European Union (27)	-2.160	0.016	0.009	-2.622	0.680	-0.065	-0.022
Germany	**-4.753**	**0.001**	**0.006**	**-3.653**	**0.757**	**0.663**	**-0.029**
Germany, NIR 2013	**-4.747**	**0.001**	**0.019**	**-3.644**	**0.788**	**0.590**	**-0.104**

Positive: C sink or N_2O emissions; negative: C source or N_2O storage

7.4.7 Category-specific recalculations (5.C)

This year's submission includes category-specific recalculations, for the entire period covered by the report, that have been carried out to take account of the recalculated emission factors for mineral soils, for dead organic matter and for biomass. The emission factors have been recalculated to take account of new developments in a range of areas, as follows:

- Mineral soils: For the first time, the final results of the Forest Soil Inventory were available for calculation of emission factors for mineral soils in forests. Such calculation yielded new emission factors for carbon-stock changes in mineral soils, and for nitrous oxide removals/emissions in/from mineral soils, in all categories of conversion from and to forest land (Chapter 7.1.5).
- Dead organic matter: For the first time, the final results of the Forest Soil Inventory were available for calculation of emission factors (Chapter 7.1.7).
- Biomass: Changes in methods for calculation of below-ground biomass of hedges/woods (Chapter 7.3.4.2 and Chapter 19.5.3); redetermination of the emission factor for cropland, via correction of the carbon stocks in grapevines, to take account of pruned wood fractions; and correction of an area error in calculation of the mean carbon stocks of annual arable crops.

In addition, the emissions in all pools and land-use categories had to be recalculated for the years 2009 and 2010, since the basis for calculation of the pertinent activity data was changed (cf. Chapter 7.1.3). In connection with such recalculation of emission factors and activity data, the pertinent uncertainties were also determined anew.

Table 279 and Table 280 show the impacts of the recalculations. With respect to last year's submission, the differences in total emissions from the grassland sector are 2.0 % for 1990 and 2.7 % for 2010.

Table 279: Comparison of emissions [Gg CO_2], as reported in the 2013 and 2012 submissions, from grassland remaining grassland (5.C.1)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	**11,708**	**11,689**	**11,670**	**11,651**	**11,632**	**11,614**	**11,595**	**11,576**	**11,557**	**11,536**
Total, 2012	**11,705**	**11,686**	**11,667**	**11,649**	**11,630**	**11,611**	**11,592**	**11,573**	**11,555**	**9,920**
Mineral soils, 2013	-49	-49	-49	-49	-49	-49	-49	-49	-49	-49
Mineral soils, 2012	-49	-49	-49	-49	-49	-49	-49	-49	-49	0
Organic soils, 2013	11,270	11,252	11,233	11,214	11,195	11,177	11,158	11,139	11,120	11,101
Organic soils, 2012	11,270	11,252	11,233	11,214	11,195	11,177	11,158	11,139	11,120	13,290
Biomass, 2013	486	486	486	486	486	486	486	486	486	483
Biomass, 2012	483	483	483	483	483	483	483	483	483	-3,371
[Gg CO_2 a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total, 2013	**11,520**	**10,991**	**10,962**	**10,933**	**10,905**	**10,876**	**10,535**	**10,518**	**10,500**	**10,393**
Total, 2012	**11,517**	**10,991**	**10,962**	**10,933**	**10,905**	**10,876**	**10,537**	**10,519**	**10,502**	**10,708**
Mineral soils, 2013	-49	-47	-44	-41	-39	-36	-32	-28	-24	-19
Mineral soils, 2012	-49	-47	-44	-41	-39	-36	-32	-28	-24	-21
Organic soils, 2013	11,083	11,051	11,020	10,989	10,957	10,926	10,905	10,884	10,862	10,824
Organic soils, 2012	11,083	11,051	11,020	10,989	10,957	10,926	10,905	10,884	10,862	10,861
Biomass, 2013	486	-14	-14	-14	-14	-14	-338	-338	-338	-412
Biomass, 2012	483	-14	-14	-14	-14	-14	-336	-336	-336	-131
[Gg CO_2 a^{-1}]	2010									
Total, 2013	**10,359**									
Total, 2012	**10,710**									
Mineral soils, 2013	-15									
Mineral soils, 2012	-18									
Organic soils, 2013	10,786									
Organic soils, 2012	10,859									
Biomass, 2013	-412									
Biomass, 2012	-131									

Positive: emissions; negative: sink

Table 280: Comparison of emissions [Gg CO_2], as reported in the 2013 and 2012 submissions, from land-use changes leading to grassland (5.C.2)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	**-380**	**-369**	**-365**	**-350**	**-345**	**-335**	**-324**	**-315**	**-307**	**-297**
Total, 2012	**-144**	**-139**	**-143**	**-134**	**-137**	**-134**	**-130**	**-127**	**-126**	**-123**
Mineral soils, 2013	-1,182	-1,175	-1,167	-1,160	-1,153	-1,146	-1,139	-1,131	-1,124	-1,117
Mineral soils, 2012	-973	-973	-973	-973	-973	-973	-973	-973	-973	-973
Organic soils, 2013	383	383	383	383	383	383	383	383	383	383
Organic soils, 2012	383	383	383	383	383	383	383	383	383	383
Biomass, 2013	-158	-156	-160	-153	-157	-155	-153	-152	-153	-151
Biomass, 2012	-154	-151	-156	-149	-153	-151	-149	-147	-148	-146
Dead organic matter, 2013	577	578	579	580	582	583	584	585	587	588
Dead organic matter, 2012	600	602	603	605	606	607	609	610	612	613
[Gg CO_2 a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total, 2012	**-290**	**-1,831**	**-1,868**	**-1,893**	**-1,852**	**-1,869**	**-2,141**	**-2,139**	**-2,130**	**-1,575**
Total, 2011	**-123**	**-1,691**	**-1,737**	**-1,772**	**-1,738**	**-1,765**	**-2,042**	**-2,048**	**-2,046**	**-1,647**
Mineral soils, 2012	-1,110	-1,114	-1,119	-1,124	-1,130	-1,135	-1,138	-1,142	-1,145	-1,125
Mineral soils, 2011	-973	-987	-1,001	-1,015	-1,029	-1,044	-1,055	-1,066	-1,077	-1,067
Organic soils, 2012	383	383	383	382	382	381	375	369	363	353
Organic soils, 2011	383	383	383	382	382	381	375	369	363	352
Biomass, 2012	-152	-1,242	-1,274	-1,293	-1,247	-1,258	-1,530	-1,519	-1,501	-866
Biomass, 2011	-148	-1,235	-1,267	-1,287	-1,240	-1,251	-1,521	-1,510	-1,492	-976
Dead organic matter, 2012	589	142	142	142	142	143	152	152	153	64
Dead organic matter, 2011	615	148	148	148	149	149	159	159	160	44

[Gg CO_2 a^{-1}]	2010
Total, 2012	**-1,576**
Total, 2011	**-1,660**
Mineral soils, 2012	-1,105
Mineral soils, 2011	-1,057
Organic soils, 2012	342
Organic soils, 2011	342
Biomass, 2012	-877
Biomass, 2011	-988
Dead organic matter, 2012	64
Dead organic matter, 2011	44

Positive: emissions; negative: sink

7.4.8 Category-specific planned improvements (5.C)

Furthermore, the previously used provisional emission factor for tree/shrub biomass has been improved, via inclusion of results from ten tree/shrub plantations in addition to the results from previously studied plantations.

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

7.5 Wetlands (5.D)

7.5.1 Source category description (5.D)

CRF 5.D	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Wetlands (5.D)	**CO_2**	**-**	**-/T2**	**2,233.2**	**0.18%**	**2,128.1**	**0.23%**	**-4.70%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS/Tier 1	RS/NS	CS/D
CH_4	Tier 1		
N_2O	Tier 1		

Pursuant to Tier-2 analysis, the source category Wetlands is a key source for CO_2 emissions.

In Germany, the "wetlands" category includes the country's few undrained semi-natural bogs that are largely free of anthropogenic impacts. It also includes other wetlands and water bodies without anthropogenic greenhouse-gas emissions and the peat-extraction areas used for production of horticultural peat.

Water-storage bodies (dammed lakes, reservoirs, etc.) and settling basins, including waters used for energy production, irrigation, shipping and recreation, and basins/beds that have been flooded or drained or whose water levels fluctuate very widely, are insignificant in Germany in terms of total area and do not have to be reported at the Tier-1 level.

Emissions from peat extraction are reported solely in the category "Wetlands remaining Wetlands". The relevant changes in carbon stocks in above-ground and below-ground biomass, and in soils, are reported in the various land-use-change categories.

In 2011, a total of 2,128 Gg CO_2 were released from wetlands. That figure represents the sum of emissions from the "Wetlands remaining Wetlands" category, amounting to 2,021 Gg CO_2 and caused by industrial peat extraction, and of emissions from the various land-use-change categories. The latter group consists of emissions of 111 Gg CO_2 from biomass and removals of 4 Gg CO_2 into mineral soils. The emissions from peat extraction comprise the emissions occurring at extraction sites, during extraction (on-site emissions: 15 Gg CO_2), and the emissions occurring in horticultural spreading of peat products (off-site emissions: 2,006 Gg CO_2).

The time series in Figure 65 and Figure 66 show no trend. The total emissions have decreased by about 5 % with respect to the base year. In contrast to other LULUCF land-use categories in which the course of time-series curves – and especially the sudden changes of direction in the relevant curves – are due primarily to area-data changes as of the relevant explicitly defined survey dates (cf. Chapter 7.1.3.5, Table 233), the shapes of time-series curves in the wetlands category are determined primarily by peat extraction, especially the annual quantities extracted. The absolute orders of magnitude of the emissions changes, with respect to the base year, in the various pools are all about the same. For example, a reduction of only 1 %, with respect to the base year, is seen in peat extraction, in keeping with the predominance of that pool. The other pool that has a major impact on total reductions is that of emissions, from biomass and from dead organic matter, resulting from land-use changes leading to waters. Those emissions have significantly decreased to the point of disappearing. By contrast, emissions from mineral soils and from dead organic matter, in connection with land-use changes leading to wetlands, have considerably increased with respect to the base year (> 400 %), although their absolute level is still very low.

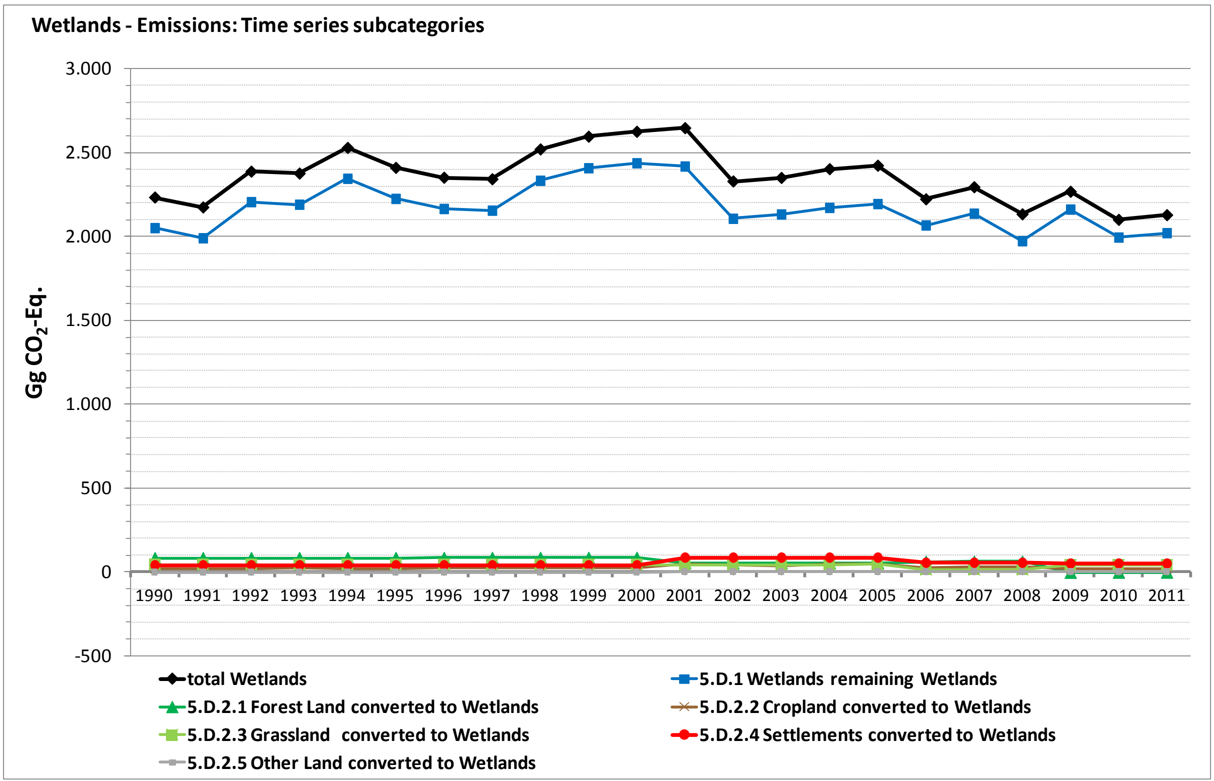


Figure 65: CO_2 emissions [Gg CO_2-Eq.] from Germany's wetlands, as a result of land use and land-use changes, 1990 – 2011, by sub-categories

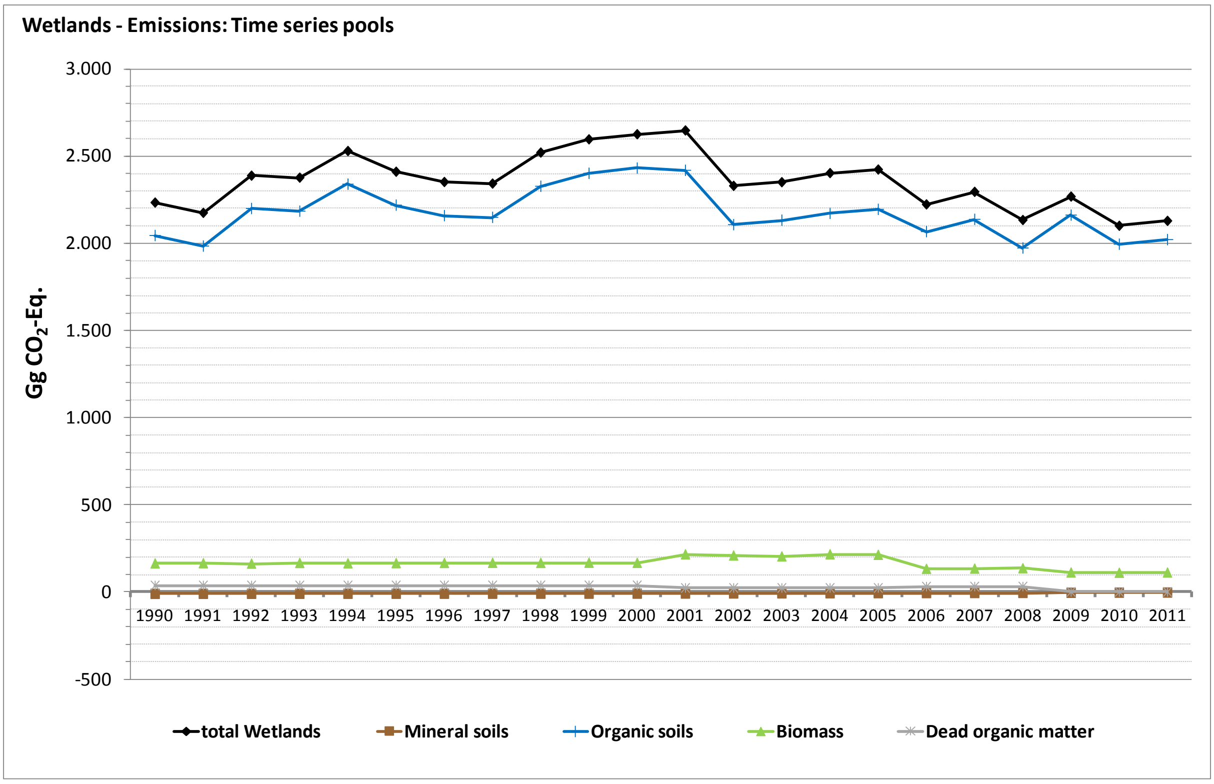


Figure 66: CO_2 emissions [Gg CO_2-Eq.] from Germany's wetlands, as a result of land use and land-use changes, 1990 – 2011, by pools

7.5.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Cf. Chapter 7.1.3.

7.5.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.D)

The "Wetlands" land-use category includes a range of terrestrial wetlands (including peat-extraction areas) and water bodies (open water bodies) that differ widely in terms of their emissions behaviour. While emissions from peat extraction are reported in the category "terrestrial wetlands remaining terrestrial wetlands", the "waters" category is maintained as a separate sub-category, along with other land-use categories, and is reported separately in the CRF tables (for details, cf. Chapter 7.1.4). Terrestrial wetlands account for 13 % of the total wetlands area. That figure consists of 3 % for peat-extraction areas and 10 % for terrestrial wetlands; i.e. water areas account for 87 %.

For purposes of emissions calculation, the two wetlands sub-categories, terrestrial wetlands and waters, are stratified by pools. To that end, area-weighted mean carbon stocks are determined, and the resulting figures are used in the inventory:

- Calculation of biomass stocks: No biomass is reported in the sub-category "waters". The biomass of the sub-category "terrestrial wetlands" has been derived from the relevant figures for grassland (in a strict sense) and woody grassland (Chapter 7.5.4.2; cf. Chapter 7.4.4.2.2).
- Calculation of the emissions from soils: No emissions are listed for the sub-category "waters". The "terrestrial wetlands" sub-category is differentiated, in a constant

manner over time, by "organic soils" and "mineral soils". Organic soils are stratified by peat-extraction areas and non-peat-extraction areas. For the latter, no emissions are reported, while both on-site and off-site emissions are reported for peat-extraction areas (Chapter 7.5.4.4). The "mineral soils" category is subdivided by usage, soil type / soil-parent-rock groups and climate region (cf. Chapter 19.5.2.2).

- Calculation of the emissions from land-use changes: Annually updated stratification by "terrestrial wetlands" and "waters remaining as waters", as well as by categories for land converted into waters or terrestrial wetlands. The relevant data are taken annually from the pertinent land-use information (Chapter 7.1.4; Chapter 7.1.3). The total area of peat-extraction land is assumed to be a constant 19,857 ha.

7.5.4 Methodological issues (5.D)

7.5.4.1 Data sources

The production-quantity data for industrial peat extraction were taken from official German statistics (STATISTISCHES BUNDESAMT (FEDERAL STATISTICAL OFFICE), Fachserie 4, Reihe 3.1).

For further sources, cf. Chapters 7.1.3.2, 7.1.4 and 19.5.2.

7.5.4.2 Biomass

Water-body areas are free of vegetation, and thus the carbon stocks in pertinent biomass are "zero".

For the sub-category "wetlands (terrestrial)", changes in biomass carbon stocks, as a result of land-use changes, are calculated with the procedures and methods described in Chapter 7.1.7.

As a rule, terrestrial wetlands are covered with trees and shrubs (throughout a spectrum ranging from scattered bushes to actual forests), mosses and grasses, with mosses and grasses predominating. Accordingly, the inventory uses the following assumption relative to the area-related distribution of carbon stocks in biomass: 1/3 trees and shrubs and 2/3 mosses/grasses.

Since no biomass surveys of such lands have been carried out in Germany, the relevant values for woody grassland (Chapter 7.4.4.2.2) and grassland (in a strict sense) (Chapter 7.4.4.2.1) are used as approximations. Therefore, the reporting methods are in keeping with those set forth in Chapter 7.4.4.2.

The carbon stocks in terrestrial wetlands can then be calculated pursuant to Equation 44. The relevant results are shown in Table 281.

Equation 44:

$$\text{C stocks}_{\text{terr. wetlands}} = \text{C stocks}_{\text{woody grassland}} * 0.333 + \text{C stocks}_{\text{grassland (in a strict sense)}} * 0.667$$

Table 281: Area-related carbon stocks [Mg ha^{-1}] for biomass in Germany's terrestrial wetlands (95% confidence interval)

Terr. wetlands	Carbon stocks [Mg C ha^{-1}]		
	$Bio_{above\text{-}ground}$	$Bio_{below\text{-}ground}$	Bio_{total}
Terr. wetlands	14.67 (5.2 - 42.7)	5.44 (2.3 – 13.1)	20.10 (10.2 - 49.2)

The emission factors and pertinent uncertainties are presented in Table 283 (Chapter 7.5.5).

7.5.4.3 Mineral soils

It was assumed that no changes in the carbon stocks of mineral soils occurred in connection with land-use changes leading to water bodies.

For the sub-category "terrestrial wetlands", changes in mineral-soil carbon stocks, as a result of land-use changes, are calculated with the procedures and methods described in Chapter 7.1.5.

The emission factors and pertinent uncertainties are presented in Table 283 (Chapter 7.5.5).

7.5.4.4 Organic soils

Apart from the drainage occurring on peat-extraction areas, no drainage of organic soils occurs in the terrestrial wetlands category. Land-use changes leading to wetlands are equivalent to conversions leading to semi-natural water-level conditions.

CO_2 emissions from peat extraction were calculated in conformance with the provisions of the 2006 IPCC Guidelines, using the applicable Tier 1 method and the default factors of the IPCC (2006). Both on-site and off-site emissions are reported. The activity data on which the estimation is based include a) the peat-extraction areas as determined via the B-DLM (cf. Chapter 7.1.3), and b) the pertinent production quantities. The latter are taken from official German statistics (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 3.1). The emission factors for the period 1990 to 2011 are summarised in Table 282. The areas of industrial peat-extraction sites were determined, for the first time, with the help of the B-DLM, since that resource now includes the relevant data. Since the B-DLM data records did not include such data (or did not include it completely) prior to 2011, the total peat-extraction area determined for 2011 has been carried backward, to the base year, 1990, for calculation of on-site emissions. The total extraction area has been a constant 19,857 ha.

CH_4 emissions from peat extraction (pursuant to IPCC GPG-LULUCF 2003, p. 1.11) are not reported.

N_2O emissions from peat extraction do not have to be reported, since they are negligible. The reason for this is that almost all of the peat extracted in Germany is extracted from raised bogs, which have C/N ratios > 25 (pursuant to IPCC GPG-LULUCF 2003, p. 1.11).

Table 283 (Chapter 7.5.5) includes a mean implied emission factor that represents the CO_2 emissions from industrial peat production per area of terrestrial wetlands remaining terrestrial wetlands. It consists of a value for on-site emissions, which remains constant, and of a production-quantity value, which varies annually.

Table 282: Implied emission factors for peat extraction [Mg C ha^{-1} a^{-1}] in Germany

	Implied emission factors for peat extraction [Mg C ha^{-1} a^{-1}]										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
IEF [Mg C ha^{-1} a^{-1}]	-28.1	-27.2	-30.2	-30	-32.1	-30.5	-29.6	-29.5	-32	-33	-33.4
$Emission_{on-site}$ [Gg C]	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97
$Emission_{off-site}$ [Gg C]	553.51	537.03	595.78	591.6	633.79	601.06	584.63	581.91	630.54	650.87	658.97
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
IEF [Mg C ha^{-1} a^{-1}]	-33.2	-28.9	-29.3	-29.8	-30.1	-28.4	-29.3	-27.1	-29.7	-27.4	-27.8
$Emission_{on-site}$ [Gg C]	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97	-3.97
$Emission_{off-site}$ [Gg C]	655.5	570.53	577.48	588.23	594.43	559.62	578.8	534.03	585.48	539.98	547.12

7.5.5 Uncertainties and time-series consistency (5.D)

The time series for activity data provided by the Federal Statistical Office for peat extraction are consistent and available for the entire period covered by the report. Pursuant to the Federal Statistical Office, the uncertainties for these activity data are "0", since the data have been obtained via an exhaustive survey entailing an obligation to provide information. Nonetheless, an uncertainty of 20 % is assumed, **in keeping with the IPCC Guidelines 2006.** That uncertainty is due primarily **to the uncertainty in conversion, for peat, of volume units to mass units**. The uncertainties listed in Table 283, ranging up to 40 % for peat extraction, are the result of an uncertainties-propagation calculation. They are due especially to the large uncertainties in the IPCC default factors. The large uncertainties for the EF, with regard to biomass, reflect the fact that woodlands account for a considerable share of the category.

The activity data and area data have a normal distribution. Their uncertainties, depending on the area and sampling sizes involved, range from 6 % to 162 % (cf. Table 376 in Chapter 19.5.4). The total uncertainty for the area data in the wetlands category is 5.4 %. The wetlands pool's contributions to the total emissions and total uncertainty in the LULUCF sector are very small. Only the values relating to peat extraction are large enough to be noticeable (cf. Table 376 in Chapter 19.5.4).

Table 283: Emission factors and uncertainties [in % of location scale] used for calculation of GG emissions from Germany's wetlands in 2011, broken down by pools and sub-categories

$Wetlands_{terrestrial}$ Land use_{before}	**Area Land use_{after}**	**Emission factor**	**Boundaries upper**	**lower**	**Waters Land use after**	**Emission factors**	**Boundaries lower**	**upper**
Mineral soils CO_2-C[94]		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
Forest land	$Wetlands_{terrestrial}$	0.74	29	24	Waters	No emissions		
Cropland	$Wetlands_{terrestrial}$	0.70	37	28	Waters	No emissions		
Grassland (in a strict sense)	$Wetlands_{terrestrial}$	-0.17	47	32	Waters	No emissions		
Woody grassland	$Wetlands_{terrestrial}$	0.04	49	31	Waters	No emissions		
Settlements	$Wetlands_{terrestrial}$	0.77	48	32	Waters	No emissions		
Waters	$Wetlands_{terrestrial}$	0	52	44	Waters	No emissions		
Other land	$Wetlands_{terrestrial}$	0.92	50	32	Waters	No emissions		
Organic soil		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
	$Wetlands_{terrestrial}$ Peat extraction	-10.16	39	39				
Biomass[95]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	$Wetlands_{terrestrial}$	-12.53	60	29	Waters	-32.63	37	37
Cropland	$Wetlands_{terrestrial}$	12.56	109	37	Waters	-7.54	8	8
Grassland (in a strict sense)	$Wetlands_{terrestrial}$	13.42	109	38	Waters	-6.69	25	25
Woody grassland	$Wetlands_{terrestrial}$	-26.83	116	39	Waters	-46.793	186	63
Terr. wetlands	$Wetlands_{terrestrial}$	0	0	0	Waters	-20.010	145	49
Waters	$Wetlands_{terrestrial}$	20.10	145	49	Waters	0	0	0
Settlements	$Wetlands_{terrestrial}$	6.70	109	37	Waters	-13.40	163	55
Other land	$Wetlands_{terrestrial}$	20.10	145	49	Waters	0	0	0
Dead organic matter[96]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	$Wetlands_{terrestrial}$	-21.03	3	3	Waters	-21.03	3	3

Positive: sink; negative: Source

The calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2011.

[94] Calculation for 20-year period

[95] Calculation only for the first year following the pertinent land-use change

[96] Calculation only for the first year following the pertinent land-use change

7.5.6 Category-specific QA / QC and verification (5.D)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out in keeping with the "Implementation regulation for preparation of emissions and carbon inventories, and for relevant quality management for the area of source categories 4 and 5 – Annex to the concept for emissions and carbon inventories in the subordinate sphere of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) of 01 March 2012" ("Ausführungsbestimmung zur Erstellung von Emissions- und Kohlenstoffinventaren und deren Qualitätsmanagement für den Bereich der Quellgruppen 4 und 5 - Anlage zum Konzept Emissions- und Kohlenstoffinventare im nachgeordneten Bereich des BMELV vom 01.03.2012") (Version 1.01, last revised on 31 August 2012; Thünen Institute 2012).

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Quality assurance for input data (ATKIS®, BÜK, official statistics) is the responsibility of the relevant data administrators (cf. the pertinent documentation in the inventory description).

The emissions-calculation results as presented in the present report cannot be compared with other relevant data sources for Germany, since no such other data sources exist that meet applicable requirements, i.e. provide complete coverage, are comprehensive and are independent of the methods and data sources described in the present report. In a comparison of Germany's implied emission factors, in the wetlands category, with those of European neighbouring countries, Germany's IEF lie within the middle of the overall range (Table 284). National definitions play an especially strong role in the wetlands category. Since the applicable national circumstances differ widely from country to country, the various implied emission factors span a wide range overall. Like Germany, most neighbouring countries list soils as moderate carbon sinks, and biomass as a carbon source, in connection with conversions leading to wetlands. Unlike Germany, some neighbouring countries also include dead organic matter as a carbon sink in connection with conversions to wetlands. In the relevant German calculation, that pool is not listed separately, and it thus includes only C losses in connection with conversions from forest land to wetlands.

Table 284: Comparison of implied emission factors (IEF) for various wetlands pools, for Germany and for neighbouring countries in Europe, for the year 2010 (exception: Germany, NIR 2013: the 2011 figure is used, for comparison)

Implied emission factors (IEF), wetlands, NIR 2012	Wetlands remaining wetlands	Land-use changes leading to wetlands		
	Organic soils	Mineral soils	Biomass	Dead org. matter
		Mg C ha^{-1}		
Austria	NE	-3.656	-0.503	-0.165
Belgium	NO	1.332	NO	NO
Czech Republic	NO	NA,NO	-0.818	-0.011
Denmark	-3.979	0.500	0.079	-0.001
France	NO	4.435	-0.453	-0.023
Netherlands	NE	NE	-8.888	-1.539
Poland	NA	NA,NO	-1.200	NA,NO
Sweden	-0.003	NA	NA	NA
Switzerland	0.001	-2.974	-3.679	-0.724
UK	-0.418	IE,NO	IE,NO	IE,NO
European Union (15)	-0.037	0.667	-0.433	-0.033
European Union (27)	-0.032	0.495	-0.431	-0.023
Germany	**-0.058**	**0.015**	**-0.622**	**NO**
Germany, NIR 2013	**-0.971**	**0.011**	**-0.337**	**NO**

Positive: sink; negative: Source

7.5.7 Category-specific recalculations (5.D)

This year's submission includes category-specific recalculations, for the entire period covered by the report, that have been carried out to take account of the recalculated emission factors for mineral soils, for dead organic matter and for biomass. The emission factors have been recalculated to take account of new developments in a range of areas, as follows:

- Mineral soils: For the first time, the final results of the Forest Soil Inventory were available for calculation of emission factors for mineral soils in forests. Such calculation yielded new emission factors for carbon-stock changes in mineral soils, and for nitrous oxide removals/emissions in/from mineral soils, in all categories of conversion from and to forest land (Chapter 7.1.5).
- Dead organic matter: For the first time, the final results of the Forest Soil Inventory were available for calculation of emission factors (Chapter 7.1.7).
- Biomass: Changes in methods for calculation of below-ground biomass of hedges/woods (Chapter 7.3.4.2 and Chapter 19.5.3.1.3); redetermination of the emission factor for cropland, via correction of the carbon stocks in grapevines, to take account of pruned wood fractions; and correction of an area error in calculation of the mean carbon stocks of annual arable crops.

In addition, the emissions in all pools and land-use categories had to be recalculated for the years 2009 and 2010, since the basis for calculation of the pertinent activity data was changed (cf. Chapter 7.1.3). In the "wetlands" land-use category, the area data for peat extraction, for all years concerned, have been replaced with the corresponding figures from B-DLM. As a result, recalculations had to be carried out for the entire period covered by the report. In connection with such recalculation of emission factors and activity data, the pertinent uncertainties were also determined anew.

Table 285 and Table 286 show the impacts of the recalculations. The comparison is shown for the entire wetlands category. With respect to last year's submission, the differences in total emissions from the wetlands sector are -0.7 % for 1990 and -2.6 % for 2010.

Table 285: Comparison of emissions [Gg CO_2], as reported in the 2013 and 2012 submissions, from wetlands remaining wetlands (5.D.1)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	**2,051**	**1,991**	**2,206**	**2,191**	**2,345**	**2,225**	**2,165**	**2,155**	**2,334**	**2,408**
Total, 2012	**2,062**	**2,002**	**2,217**	**2,202**	**2,357**	**2,237**	**2,176**	**2,166**	**2,344**	**2,419**
Mineral soils, 2013	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Organic soils, 2013	2,044	1,984	2,199	2,184	2,338	2,218	2,158	2,148	2,327	2,401
Organic soils, 2012	2,055	1,995	2,210	2,195	2,350	2,230	2,169	2,159	2,338	2,412
Biomass, 2013	7	7	7	7	7	7	7	7	7	7
Biomass, 2012	7	7	7	7	7	7	7	7	7	7
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	**2,438**	**2,418**	**2,107**	**2,132**	**2,171**	**2,194**	**2,066**	**2,137**	**1,973**	**2,161**
Total, 2012	**2,249**	**2,429**	**2,118**	**2,143**	**2,183**	**2,205**	**2,078**	**2,148**	**1,984**	**2,172**
Mineral soils, 2013	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Organic soils, 2013	2,431	2,418	2,107	2,132	2,171	2,194	2,066	2,137	1,973	2,161
Organic soils, 2012	2,442	2,429	2,118	2,143	2,183	2,205	2,078	2,148	1,984	2,172
Biomass, 2013	7	0	0	0	0	0	0	0	0	0
Biomass, 2012	7	0	0	0	0	0	0	0	0	0
[Gg CO_2 a^{-1}]	**2010**									
Total, 2013	**1,995**									
Total, 2012	**2,006**									
Mineral soils, 2013	0									
Mineral soils, 2012	0									
Organic soils, 2013	1,995									
Organic soils, 2012	2,006									
Biomass, 2013	0									
Biomass, 2012	0									

Table 286: Comparison of emissions [Gg CO_2], as reported in the 2013 and 2012 submissions, from land-use changes leading to wetlands (5.D.2)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	**183**	**184**	**182**	**185**	**183**	**184**	**186**	**187**	**188**	**189**
Total, 2012	**186**	**188**	**186**	**190**	**188**	**189**	**190**	**191**	**190**	**191**
Mineral soils, 2013	-11	-11	-11	-11	-11	-11	-10	-10	-10	-10
Mineral soils, 2012	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8
Organic soils, 2013	0	0	0	0	0	0	0	0	0	0
Organic soils, 2012	0	0	0	0	0	0	0	0	0	0
Biomass, 2013	157	158	156	159	157	158	159	160	160	161
Biomass, 2012	156	158	155	159	157	158	159	160	159	160
Dead organic matter, 2013	37	37	37	37	37	37	37	37	38	38
Dead organic matter, 2012	38	38	39	39	39	39	39	39	39	39
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	**188**	**230**	**223**	**219**	**231**	**229**	**155**	**158**	**161**	**106**
Total, 2012	**191**	**231**	**225**	**220**	**233**	**230**	**158**	**160**	**163**	**153**
Mineral soils, 2013	-10	-9	-9	-8	-8	-7	-7	-6	-6	-5
Mineral soils, 2012	-8	-8	-7	-7	-6	-6	-6	-5	-5	-4
Organic soils, 2013	0	0	0	0	0	0	0	0	0	0
Organic soils, 2012	0	0	0	0	0	0	0	0	0	0
Biomass, 2013	160	216	209	204	216	213	132	134	136	111
Biomass, 2012	160	215	208	203	215	212	132	133	136	157
Dead organic matter, 2013	38	23	23	23	23	23	30	30	31	0
Dead organic matter, 2012	39	24	24	24	24	24	32	32	32	0

[Gg CO_2 a^{-1}]	2010
Total, 2013	**106**
Total, 2012	**151**
Mineral soils, 2013	-4
Mineral soils, 2012	-4
Organic soils, 2013	0
Organic soils, 2012	0
Biomass, 2013	110
Biomass, 2012	155
Dead organic matter, 2013	0
Dead organic matter, 2012	0

7.5.8 Category-specific planned improvements (5.D)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

7.6 Settlements (5.E)

7.6.1 Source category description (5.E)

CRF 5.E	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Settlements (CRF 5.E)	**CO_2**	**-**	**-/T2**	**2,307.7**	**0.19%**	**2,256.0**	**0.24%**	**-2.24%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS/Tier 1	RS/NS	CS

Pursuant to Tier-2 analysis, the source category *Settlements* is a key source for CO_2 emissions.

Reporting for the land-use category "settlements" has to cover CO_2 emissions / storage in the pools "soil", "biomass" and "dead organic matter" on land designated for settlement and transport uses. Precise definitions and category allocations are presented in Chapter 7.1.4.

In 2011, CO_2 emissions from Germany's settlement and transport areas, and resulting from land use and land-use changes, amounted to 2,256 Gg CO_2. A majority of those emissions, amounting to 2,166 Gg CO_2, was caused by drainage of organic soils and was reported mainly in the pertinent "remaining" category (1.665 Gg CO_2). The remaining emissions are the result of land-use changes leading to settlements, and they comprise emissions of 625 Gg CO_2 from mineral soils, emissions of 61 Gg CO_2 from decomposition of dead organic matter and removals of -596 Gg CO_2 into biomass.

An overview of the development of total emissions over time shows that total emissions decreased temporarily between 2000 and 2003 (cf. Figure 67 and Figure 68) and then increased again until they had almost reattained their original level. Net emissions from the settlements category decreased by -2.2 % in 2011, with respect to the base year. The considerable increase in emissions from soils (mineral soils: +80 %; org. soils, +5 %) was offset by a sink-function increase in the area of biomass (113 %), as well as by a reduction of emissions from dead organic matter (-66 %). The shapes of the time-series plots – especially the noticeable changes they show – are due primarily to the changes in area data that have occurred as of the relevant explicitly defined survey dates (cf. Chapter 7.1.3.5, Table 233).

The emissions decrease between 2000 and 2003 was the result of intensified conversion of cropland into settlements – and, thus, of intensified carbon storage in new biomass on settlement areas. An additional emissions reduction resulted from a decrease in deforestation. Since mineral soils in settlements have small carbon stocks, land-use changes leading to settlements entail decreases in carbon stocks – especially in the case of conversions of grasslands.

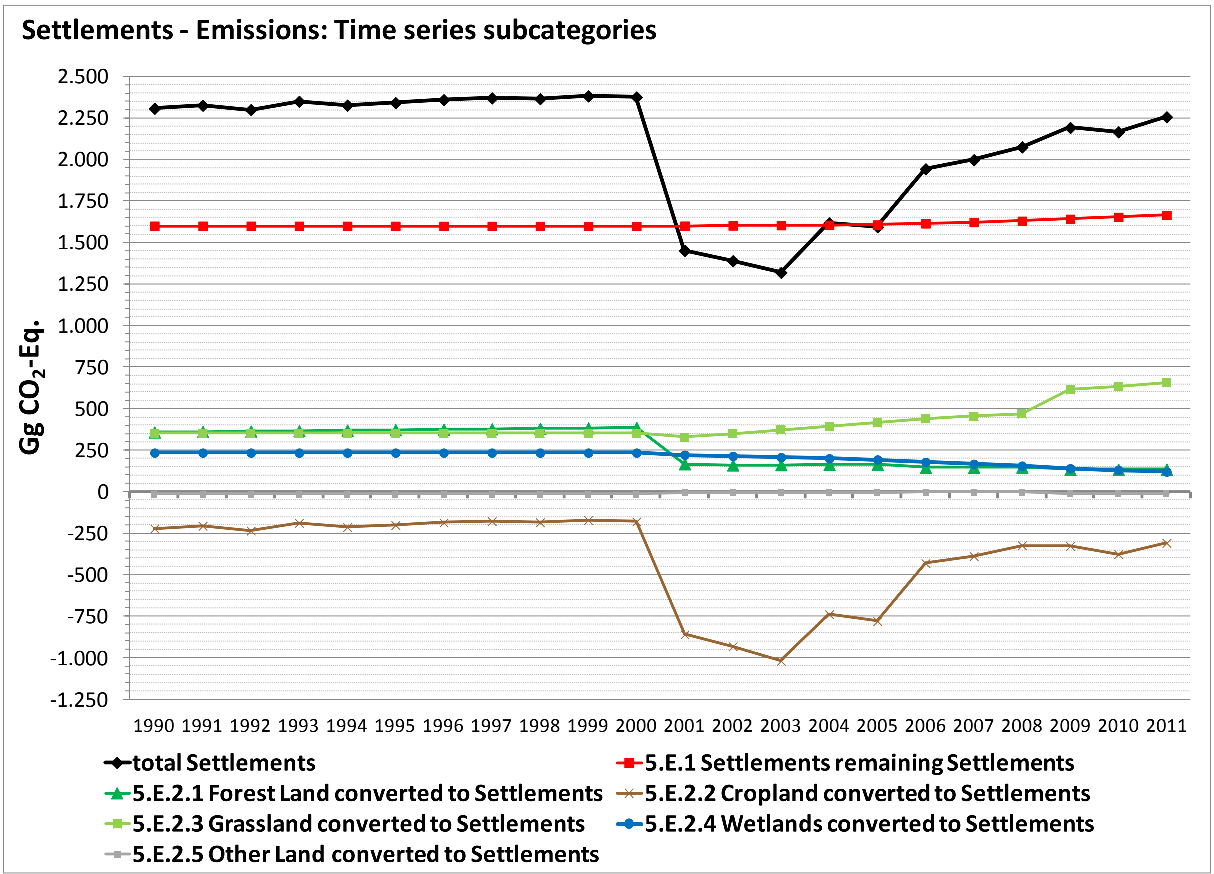


Figure 67: CO_2 emissions [Gg CO_2-eqs.] from Germany's settlements, as a result of land use and land-use changes, 1990 – 2011, by sub-categories

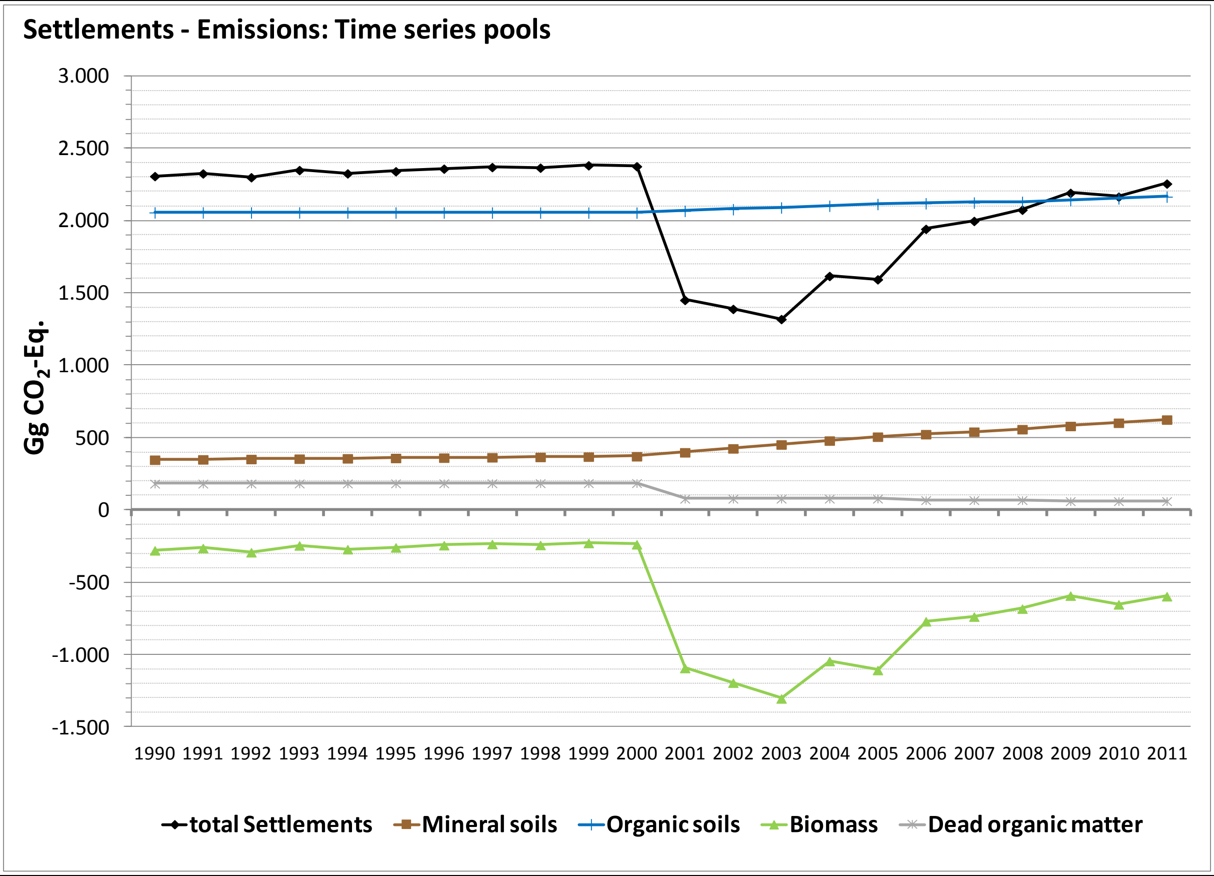


Figure 68: CO_2 emissions [Gg CO_2-eqs.] from Germany's settlements, as a result of land use and land-use changes, 1990 – 2011, by pools

7.6.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation (5.E)

Cf. Chapter 7.1.3.

7.6.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.E)

The entire settlement area has been combined within a single category. For the relevant definitions and descriptions, cf. Chapter 7.1.4.

For purposes of emissions calculations, the settlement category is stratified by specific pools. To that end, area-weighted mean carbon stocks are determined, and the resulting figures are used in the inventory:

- Calculation of biomass stocks The biomass of the "settlements" category has been derived from the relevant figures for grassland (in a strict sense) and woody grassland (Chapter 7.6.4.2; cf. Chapter 7.4.4.2.2).
- Calculation of the emissions from soils: Differentiation, unchanging over time, by organic and mineral soils. The mineral soils category is subdivided by usage, soil type / soil-parent-rock groups and climate region (cf. Chapter 19.5.2.2).
- Calculation of the emissions from land-use changes: Annually updated stratification in accordance with the categories "settlements remaining settlements" and "land converted to settlements". The relevant data are taken annually from the pertinent land-use information (Chapter 7.1.4; Chapter 7.1.3).

7.6.4 Methodological issues (5.E)

In the case of settlements remaining settlements, it is assumed that no carbon-stock changes occur in mineral soils (cf. Chapter 7.3.4.3 and Chapter 7.4.4.3) and biomass (cf. Chapter 7.4.4.2). It has also been assumed that organic soils in settlements have been drained.

All five carbon pools are reported in connection with land-use changes leading to settlements.

Cf. also Chapter 7.3.4.

7.6.4.1 Data sources

Cf. Chapter 7.1.3.2.

7.6.4.2 Biomass

Settlement and transport areas tend to have significant portions of unsealed land that is covered with vegetation. Representative-sample studies of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), an institute sited within the Federal Office for Building and Regional Planning (BBR), have shown that built-over and sealed areas account for 40 – 50 % of designated settlement and transport areas (EINIG et al. 2009). In the German inventory, areas covered with vegetation are assumed to account for an average of 50 % of settlement areas.

No data have been collected specifically with regard to biomass and carbon stocks on such areas within Germany's settlement and transport areas. The following assumption is used as a way of compensating for that lack: half of all areas covered with vegetation consist of woods (trees and bushes) and half consist of green areas comparable to "grassland (in a strict sense)". That assumption is approximately in keeping with the corresponding basic figures used in Switzerland. Via remote sensing, it was determined there that trees and bushes account for 47.4 % of plant cover, with trees accounting for 32.1 % and bushes accounting for 15.3 % (FOEN 2010). Since settlement and transport areas tend to have an enormous variety of trees and shrubs – including small-garden shrubs, many different types of hedges and large trees along roads and in forests – the tree/shrub biomass in this land-use category was determined on the basis of the country-specific value for woody grassland. **For that reason, no carbon-stock changes in tree/shrub biomass are reported for the "settlements remaining settlements" category. In addition, the calculation rules as described in Chapter 7.4.4.2 apply.** The carbon stocks in settlement areas can then be calculated pursuant to Equation 45. The relevant results are shown in Table 287.

Equation 45:

$$C\ stocks_{settlements} = (C\ stocks_{woody\ grassland} * 0.5 + C\ stocks_{grassland\ (in\ a\ strict\ sense)} * 0.5) * 0.5$$

Table 287: Area-related carbon stocks [Mg ha^{-1}] in biomass on settlement areas (95% confidence interval)

Settlements	Carbon stocks [Mg C ha^{-1}]		
	$Bio_{above-ground}$	$Bio_{below-ground}$	Bio_{total}
Settlements	9.909 (2.84 - 30.96)	3.495 (1.24 - 9.23)	13.404 (5.98 - 35.22)

7.6.4.3 Mineral soils

Cf. Chapters 7.1.5 and 19.5.2.

7.6.4.4 Organic soils

No data have been collected specifically with regard to drainage of organic soils in settlements. In compensation for that gap, it is assumed that such soils are drained in the same manner that cultivated grassland is drained, and thus the relevant emission factor for such drainage, 5 Mg C ha^{-1} a^{-1}, is used (Chapter 7.4.4.4).

In cases involving land-use changes leading to settlements, the relevant value for settlements remaining settlements is used from the outset.

7.6.5 Uncertainties and time-series consistency (5.E)

The consistency of the time series is assured with regard to the activity data and emission factors.

The uncertainties for the emission factors are relatively high, and the values have a log-normal distribution (cf. Table 288). The uncertainties, as shown in Table 376 in Chapter 19.5.4, and depending on the area size concerned, range from 2.8% to 131.0 %. The total uncertainty for the activity data in the settlements category is 2.8 %. The emissions' contribution to the overall inventory is small. It is noticeable only with respect to organic soils and to biomass.

Table 288: Uncertainties of emission factors [in % of location scale] used for calculation of GG emissions from settlement and transport areas in 2011, broken down by pools and sub-categories

Settlements Land use$_{before}$ Mineral soils CO_2-C[97]	Area Land use$_{after}$	Emission factor [Mg C ha^{-1} a^{-1}]	Boundaries upper [%]	 lower [%]
Forest land	Settlements	-0.19	41	22
Cropland	Settlements	-0.07	49	28
Grassland (in a strict sense)	Settlements	-0.94	57	33
Woody grassland	Settlements	-0.73	60	31
Terr. wetlands	Settlements	-0.77	48	32
Waters	Settlements	0.00	85	45
Other land	Settlements	0.15	63	32
Organic soil		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
	Settlements	-5.00	50	50
Biomass[98]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Settlements	-19.23	54	31
Cropland	Settlements	5.86	109	37
Grassland (in a strict sense)	Settlements	6.72	109	38
Woody grassland	Settlements	-33.53	149	51
Terr. wetlands	Settlements	-6.70	109	37
Waters	Settlements	13.40	163	55
Other land	Settlements	13.40	163	55
Dead organic matter[99]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	**Settlements**	-21.03	3	3

7.6.6 Category-specific QA / QC and verification (5.E)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out in keeping with the "Implementation regulation for preparation of emissions and carbon inventories, and for relevant quality management for the area of source categories 4 and 5 – Annex to the concept for emissions and carbon inventories in the subordinate sphere of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) of 01 March 2012" ("Ausführungsbestimmung zur Erstellung von Emissions- und Kohlenstoffinventaren und deren Qualitätsmanagement für den Bereich der Quellgruppen 4 und 5 - Anlage zum Konzept Emissions- und Kohlenstoffinventare im nachgeordneten Bereich des BMELV vom 01.03.2012") (Version 1.01, last revised on 31 August 2012; Thünen Institute 2012).

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Internally, data processing is checked pursuant to Thünen-Institut (2012). Quality assurance for input data (ATKIS®, BÜK, official statistics) is the responsibility of the relevant data administrators (cf. the pertinent documentation in the inventory description).

The emissions-calculation results as presented in the present report cannot be compared with other relevant data sources for Germany, since no such other data sources exist that meet applicable requirements, i.e. provide complete coverage, are comprehensive and are independent of the methods and data sources described in the present report.

[97] Calculation for 20-year period
[98] Calculation only for the first year following the pertinent land-use change
[99] Calculation only for the first year following the pertinent land-use change

Table 289 compares Germany's implied emission factors, for the settlements category, with those of European neighbouring countries.

Only Germany and Switzerland report CO_2 emissions from drained organic soils in settlement areas. The implied emission factors are referenced to the total settlement land area. Consequently, they also reflect organic soils' share of that total area. In the German inventory, other C pools are calculated only in connection with land-use changes leading to settlements.

In a comparison with its neighbouring countries, Germany has the lowest C losses in soils, after Poland, Sweden (sink) and Denmark. Along with Austria, it has the highest level of C removals in biomass per hectare, in connection with conversions leading to settlement areas. In addition, Germany's IEF for dead organic matter lie within the lower section of the relevant range. The implied emission factors for the three pools depend strongly on the original uses involved in each case, and thus the wide range seen throughout European countries cannot be interpreted without knowledge of such uses.

Table 289: Comparison of implied emission factors (IEF) for various settlements pools, for Germany and for neighbouring countries in Europe, for the year 2010 (exception: Germany, NIR 2013: the 2011 figure is used, for comparison)

Implied emission factors (IEF), settlements, NIR 2012	Settlements remaining settlements	Land-use changes leading to settlements		
	Organic soils	soils	Biomass	Dead org. matter
	Mg C ha^{-1}			
Austria	NE	-0.418	0.179	-0.157
Belgium	NO	-1.312	-0.280	-0.026
Czech Republic	NO	NA,NO	-0.470	-0.010
Denmark	NA	-0.309	-0.203	-0.007
France	NO	-1.543	-0.425	-0.043
Netherlands	NE	NE	-15.573	-2.876
Poland	NA	-0.120	0.170	-0.004
Sweden	NE	-1.786	0.016	-0.751
Switzerland	-0.020	-1.108	-0.425	-0.056
UK	-0.433	-2.948	-0.087	IE,NO
European Union (15)	-0.076	-1.517	-0.443	-0.099
European Union (27)	-0.056	-1.371	-0.467	-0.094
Germany	**-0.187**	**-0.392**	**0.208**	**-0.012**
Germany, NIR 2013	**-0.155**	**-0.389**	**0.206**	**-0.021**

Positive: sink; negative: Source

7.6.7 Category-specific recalculations (5.E)

This year's submission includes category-specific recalculations, for the entire period covered by the report, that have been carried out to take account of the recalculated emission factors for mineral soils, for dead organic matter and for biomass. The emission factors have been recalculated to take account of new developments in a range of areas, as follows:

- Mineral soils: For the first time, the final results of the Forest Soil Inventory were available for calculation of emission factors for mineral soils in forests. Such calculation yielded new emission factors for carbon-stock changes in mineral soils, and for nitrous oxide removals/emissions in/from mineral soils, in all categories of conversion from and to forest land (Chapter 7.1.5).

- Dead organic matter: For the first time, the final results of the Forest Soil Inventory were available for calculation of emission factors (Chapter 7.1.7).
- Biomass: Changes in methods for calculation of below-ground biomass of hedges/woods (Chapter 7.3.4.2 and Chapter 19.5.3.1.3); redetermination of the emission factor for cropland, via correction of the carbon stocks in grapevines, to take account of pruned wood fractions; and correction of an area error in calculation of the mean carbon stocks of annual arable crops.

In addition, the emissions in all pools and land-use categories had to be recalculated for the years 2009 and 2010, since the basis for calculation of the pertinent activity data was changed (cf. Chapter 7.1.3). Furthermore, the peat-extraction area has been removed from the land-use category "settlements". In the previous submission, the peat-extraction area was erroneously included in the organic soils pool in the "settlements remaining settlements" land-use category. For that reason, emissions from organic soils in the "remaining" category are an average of about 18 % lower than the figure reported in last year's submission. Consequently, recalculations were carried out for the entire period covered by the report. In connection with such recalculation of emission factors and activity data, the pertinent uncertainties were also determined anew.

Table 290 and Table 291 show the impacts of the recalculations. The differences in total emissions in the settlements category, between the two submissions, amount to 15 % for 1990 and 16 % for 2010. The magnitude of those differences is due mainly to the above-mentioned differences relative to organic soils in the "remaining" category.

Table 290: Comparison of emissions [Gg CO_2], as reported in the 2013 and 2012 submissions, from settlements remaining settlements (5.E.1)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	**1,600**	**1,600**	**1,600**	**1,600**	**1,600**	**1,600**	**1,600**	**1,599**	**1,599**	**1,599**
Total, 2012	**1,964**	**1,964**	**1,964**	**1,964**	**1,964**	**1,964**	**1,964**	**1,963**	**1,963**	**1,963**
Mineral soils, 2013	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Organic soils, 2013	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,599	1,599	1,599
Organic soils, 2012	1,964	1,964	1,964	1,964	1,964	1,964	1,964	1,963	1,963	1,963
Biomass, 2013	0	0	0	0	0	0	0	0	0	0
Biomass, 2012	0	0	0	0	0	0	0	0	0	0
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	**1,599**	**1,601**	**1,602**	**1,604**	**1,606**	**1,607**	**1,615**	**1,623**	**1,630**	**1,642**
Total, 2012	**1,970**	**1,965**	**1,966**	**1,968**	**1,970**	**1,972**	**1,979**	**1,987**	**1,994**	**2,005**
Mineral soils, 2013	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Organic soils, 2013	1,599	1,601	1,602	1,604	1,606	1,607	1,615	1,623	1,630	1,642
Organic soils, 2012	1,963	1,965	1,966	1,968	1,970	1,972	1,979	1,987	1,994	2,005
Biomass, 2013	0	0	0	0	0	0	0	0	0	0
Biomass, 2012	0	0	0	0	0	0	0	0	0	0
[Gg CO_2 a^{-1}]	**2010**									
Total, 2013	**1,654**									
Total, 2012	**2,016**									
Mineral soils, 2013	0									
Mineral soils, 2012	0									
Organic soils, 2013	1,654									
Organic soils, 2012	2,016									
Biomass, 2013	0									
Biomass, 2012	0									

Positive: emissions; negative: sink

Table 291: Comparison of emissions [Gg CO_2], as reported in the 2013 and 2012 submissions, from land-use changes leading to settlements (5.E.2)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2013	**706**	**726**	**699**	**749**	**726**	**740**	**760**	**770**	**766**	**783**
Total, 2012	**787**	**803**	**775**	**822**	**797**	**810**	**826**	**834**	**828**	**842**
Mineral soils, 2013	347	350	352	355	357	359	362	364	367	369
Mineral soils, 2012	417	417	417	417	417	417	417	417	417	417
Organic soils, 2013	456	456	456	456	456	456	456	456	456	456
Organic soils, 2012	456	456	456	456	456	456	456	456	456	456
Biomass, 2013	-279	-263	-292	-245	-271	-259	-243	-235	-242	-228
Biomass, 2012	-276	-260	-289	-242	-268	-255	-240	-232	-238	-225
Dead org. matter, 2013	182	183	183	183	184	184	185	185	185	186
Dead org. matter, 2012	190	190	191	191	192	192	193	193	193	194
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2013	**776**	**-148**	**-213**	**-284**	**12**	**-13**	**328**	**375**	**445**	**550**
Total, 2012	**834**	**-93**	**-160**	**-240**	**57**	**30**	**364**	**410**	**479**	**592**
Mineral soils, 2013	371	399	426	453	480	507	524	541	558	581
Mineral soils, 2012	417	441	465	489	513	538	552	567	582	583
Organic soils, 2013	456	467	477	487	497	507	505	502	500	500
Organic soils, 2012	456	467	477	487	497	507	505	502	500	493
Biomass, 2013	-237	-1,092	-1,194	-1,303	-1,044	-1,106	-769	-737	-682	-592
Biomass, 2012	-233	-1,083	-1,184	-1,298	-1,035	-1,097	-764	-731	-676	-517
Dead org. matter, 2013	186	78	78	79	79	79	68	69	69	61
Dead org. matter, 2012	194	82	82	82	82	82	71	72	72	32
[Gg CO_2 a^{-1}]	**2010**									
Total, 2013	**512**									
Total, 2012	**535**									
Mineral soils, 2013	603									
Mineral soils, 2012	584									
Organic soils, 2013	500									
Organic soils, 2012	486									
Biomass, 2013	-625									
Biomass, 2012	-567									
Dead org. matter, 2013	61									
Dead org. matter, 2012	32									

Positive: emissions; negative: sink

7.6.8 Category-specific planned improvements (5.E)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

7.7 Other land (5.F)

7.7.1 Source category description (5.F)

Since, by definition, the areas in the category "Other Land" consist of areas that are not cultivated, the sizes of such areas are included solely for the purpose of completing the area matrix. Emissions within the meaning of IPCC-LULUCF cannot occur on such areas. Therefore, no such emissions are reported.

7.7.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation (5.F)

Cf. Chapter 7.1.3.

7.7.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.F)

The following object types defined in ATKIS® are assigned to the "Other Land" category within the German LULUCF report system: "area currently not classifiable" (object number 4199), and "vegetation-free areas" (object number 4120). Areas are identified and classified in keeping with the algorithms described in Chapter 7.1.4.

7.7.4 Methodological issues (5.F)

In emissions calculation, Other Land areas are taken into account solely as a "before" category in connection with land-use changes leading to other categories. No conversions back to "Other Land" take place, since, by definition, land that has been used once can no longer be returned to an "unused land" land-use category.

The carbon stocks in biomass, dead wood and dead organic matter of Other Land are "zero".

The carbon stocks in mineral soils of Other Land are listed in Chapters 7.1.5 and 19.5.2.

Organic soils in Other Land are not drained.

7.7.5 Uncertainties and time-series consistency (5.F)

The uncertainties for emission factors and activity data were determined in accordance with the publication Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000) (cf. Chapter 19.5.4).

The time series is complete and consistent.

7.7.6 Category-specific QA / QC and verification (5.F)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

7.7.7 Category-specific recalculations (5.F)

Not applicable, since no greenhouse-gas sources and sinks are reported in this category.

7.7.8 Category-specific planned improvements (5.F)

Not applicable, since no greenhouse-gas sources and sinks are reported in this category.

7.8 Other sectors (5.G.)

The following emissions are reported under 5.G:

- CO_2 emissions from liming of forests (cf. Chapter 7.2.4.6.1). Data for liming of forests cannot be entered under 5.A in the CRF tables. For this reason, liming of forests has been entered under 5.G "Other" in CRF Table 5 (IV).

8 WASTE AND WASTE WATER (CRF SECTOR 6)

8.1 Overview (CRF Sector 6)

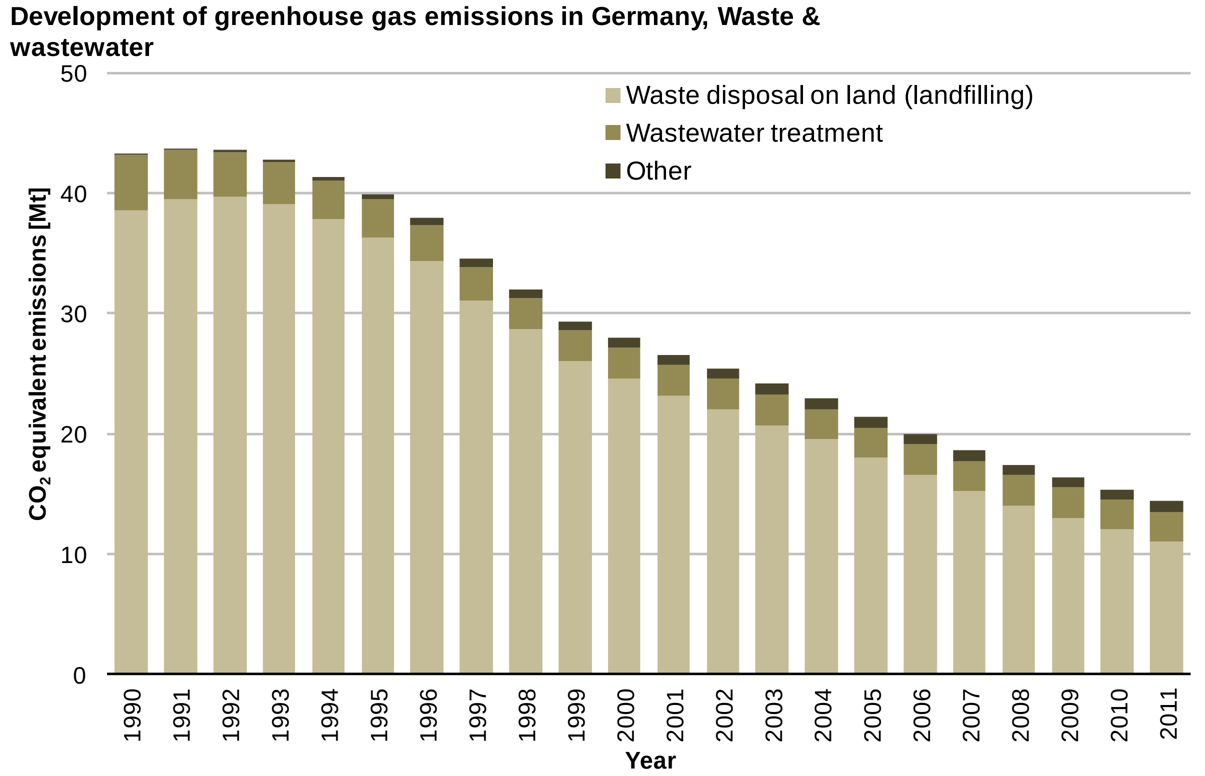


Figure 69: Overview of greenhouse-gas emissions in CRF Sector 6

8.2 Solid waste disposal on land (6.A)

CRF 6.A	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Solid waste disposal on land (managed) (CRF 6.A.1)	CH_4	L	T/T2	38,598.0	(3.17%)	11,046.0	(1.19%)	-71.38%

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 2	NS	CS/D

The source category *Solid waste disposal on land* is a key category of CH_4 emissions in terms of emissions level and trend.

Only managed disposal in landfills (6.A.1) is relevant for purposes of German emissions reporting under CRF 6.A. "Wild" or illegal dumping of solid waste (CRF 6.A.2) is prohibited by law in Germany.

Emissions from composting and from mechanical biological waste treatment (MBT) have been reported since 2004, in keeping with the growing importance of such other methods for treating biodegradable waste fractions. These emissions are reported under category 6.D Other.

In the CSE, source category 6.A Solid waste disposal on land includes landfilled household waste and sewage sludge.

8.2.1 Managed disposal in landfills – landfilling of municipal waste (6.A.1)

8.2.1.1 Source category description (6.A.1)

In the period since 1990 (and previously, to some extent), a number of legal provisions have been issued pertaining to Germany's waste-management sector, and a number of relevant organisational measures have been initiated. These moves have had a strong impact on trends in emissions from waste-landfilling. Relevant developments have included intensified collection of biodegradable waste from households and the commercial sector, intensified collection of other recyclable materials, such as glass, paper/cardboard, metals and plastics; separate collection of packaging; and recycling of packaging. In addition, incineration of municipal waste has been expanded, and mechanical biological treatment of residual waste has been introduced. As a result of such measures, amounts of landfilled municipal waste decreased very sharply from 1990 to 2006, and they have been stabilising at a low level since 2006 (cf. Figure 70). As the figure shows, over half of municipal waste produced in Germany today is collected separately and gleaned for recyclable materials (separate collection of recyclable materials and biodegradable waste). Official statistical data (*STATISTISCHES BUNDESAMT* (Federal Statistical Office) Fachserie 19, Reihe 1 Abfallentsorgung 2010 ("Waste management, 2010") of 12 July 2012) are available for the period until 2010. The activity data for 2010 have been carried forward, without change, for 2011. A similar procedure has been used for source categories 6.A and 6.D.

In 2004, about 330 landfills for municipal waste were in operation in the Federal Republic of Germany. By that year, strict legal regulations were already in place that require such landfills to have equipment for collecting and treating landfill gas. Those regulations have extensively reduced methane emissions from such facilities. In June 2005, in keeping with new, stricter requirements under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Kitchen-Waste-Treatment Facilities (AbfAblV) and the Landfill Ordinance (Deponieverordnung), over half of all landfills were closed. As a result, only about 150 landfills for municipal waste are now still in operation. As a result of regulations in force since June 2005, landfilling of biodegradable waste is no longer permitted. As a result, since June 2005 it has no longer been possible to landfill waste with the potential for significant methane formation. For conformance with pertinent requirements, municipal waste and other biodegradable waste must be pre-treated via thermal or mechanical biological processes. In waste landfilled after 2006, just a few waste components, with very small methane-formation potential (such as residues from treatment in MBT facilities; small wood fractions in construction rubble) have contributed to landfill-gas formation. As landfill-gas formation in older landfills drops off, methane emissions from landfills will again decrease extensively and will then, in the long term, stabilise at a very low level.

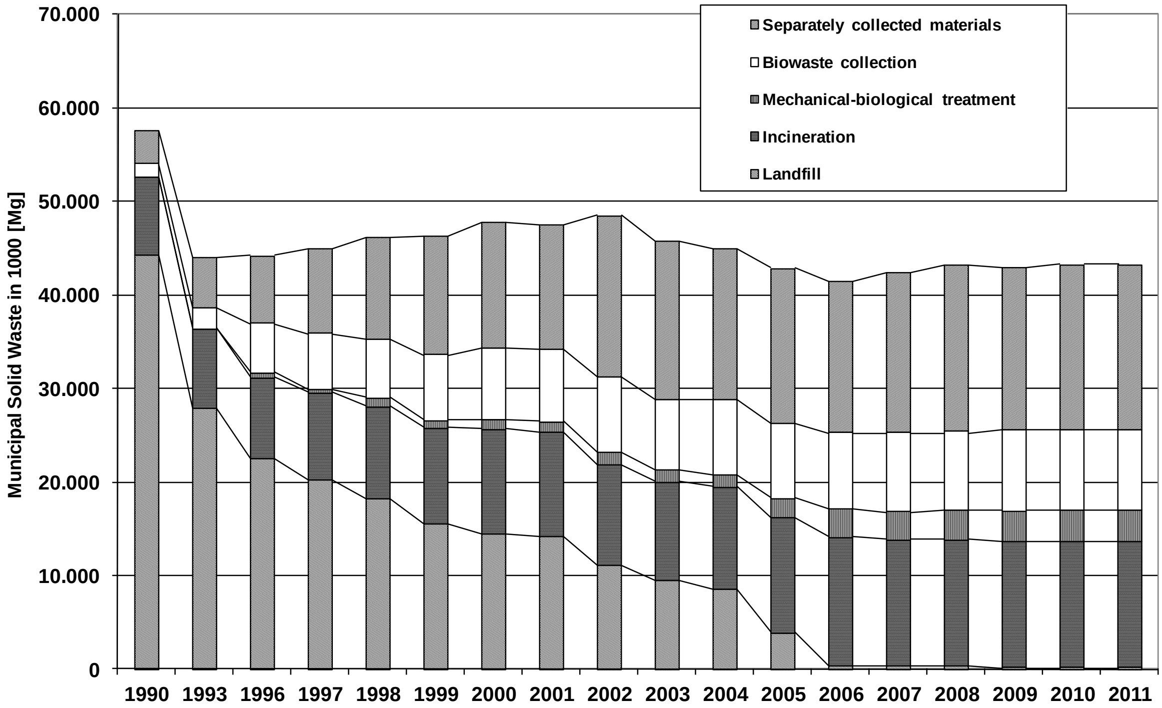


Figure 70: Changes in pathways for management of household waste, 1990 to 2011, with intermediate years

By reducing landfill methane emissions from 1.8 million Mg in 1990 to 0.5 million Mg in 2011, Germany's waste-management sector has made an important contribution to climate protection. The lower methane emissions from source category 6.A.1 amount to a decrease of 30 million tonnes of CO_2 equivalents per year and, thus, to a 3 % reduction of Germany's entire greenhouse-gas emissions. Experience gained by Germany's waste-management sector shows that reductions of landfilled quantities of biodegradable waste can provide significantly higher contributions to climate protection than can collection and treatment of landfill gas.

8.2.1.2 Methodological issues (6.A.1)

The *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 1996b) specify two methods for determining methane emissions from landfills, a default method (Tier 1), known as the "mass-balance approach", and the "first order decay method" (short name: "FOD method" or "Tier 2"). Whereas the default method functions under the assumption that methane from waste forms completely in the year in which the waste is placed in a landfill, the FOD method uses a kinetic approach that describes methane formation, more realistically, as taking place over several years.

There are at least two reasons why the Tier 1 method is inadequate for determining emissions in Germany:

IPCC *Good Practice Guidance* (IPCC, 2000) specifies that the first order decay method should be used when source category 6.A is a key category. At present, this source category is a key category in Germany in terms of emissions levels and trend.

The default method tends to underestimate emissions especially when quantities of waste being placed in landfills are decreasing, and this is occurring in Germany. For these reasons, in the following section, CH_4 emissions were calculated with the FOD method (Tier 2).

The following section describes the FOD method, and the relevant parameters used, for determining methane formation in landfills. The FOD method calculates in accordance with Equation 46:[100]

Equation 46: *(IPCC 2000 Good Practice Guidance, Chapter 5.1)*

$$CH_4 \text{ produced in year } t \ (Gg/year) = \sum_x [(A * k * MSW_T(x) * MSW_F(x) * L_0(x) * e^{-k(t-x)}]$$

$$where: L_0 (GgCH_4 / kgWaste) = MCF * DOC * DOC_F * F * 16/12$$

$$for \ x = first \ year \ to \ t$$

where:

t	*= Inventory year*
x	*= Year as of which the consideration begins and quantities data are collected*
MSW_T (x)	*= Total quantity of municipal waste*
MSW_F (x	*= Portion of waste that is landfilled*
A	*= $(1-e^{-k})/k$ = Normalisation factor for sum correction*
k	*= Constant methane-formation rate (1/year)*
L_0	*= Methane-formation potential*
MCF (x)	*= Methane correction factor for year x*
DOC (x)	*= Degradable organic carbon in year x (relevant share)*
DOC_F	*= Fraction of DOC converted into landfill gas*
F	*= Fraction of CH_4 in landfill gas*
16/12	*= Factor for conversion of C to CH_4*

A multi-phase model was used that calculates with, and then sums, a range of different half-lives for the various waste fractions involved, pursuant to Equation 46.

To obtain the final CH_4-emissions result, methane that is collected and then flared, or then used for energy recovery, is deducted, and a correction factor is applied that accounts for methane oxidation in landfill covering layers, as shown by Equation 47:

Equation 47 *(IPCC Guidelines, Equation 5.1)*:

$$CH_4 \text{ emitted in year t (Gg/year)} = (CH_4 \text{ produced in year t} - R(t)) \bullet (1- OX)$$

Where

R(t)	= CH_4 collection in year t
OX	= Oxidation factor (fraction)

For both Tier 1 and Tier 2, the relevant quantities of municipal waste (MSW_T), and the proportion of municipal waste that is landfilled (MSW_F), must be determined; for Tier 2, production of municipal waste over the previous decades must also be determined. Pursuant to IPCC Good Practice Guidance (2000), landfilled municipal waste should be broken down – via estimation – into waste types, since the further procedure takes account of the fact that different waste types have different DOC values.

100 A detailed description of the FOD method and its parameters is presented in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, in the Greenhouse Gas Inventory Reference Manual, known as the "IPCC Guidelines" (IPCC 1996b), and in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, known as the "Good Practice Guidance" (IPCC 2000).

8.2.1.2.1 Quantities of landfilled waste

The FOD model calculates emissions from landfilled municipal waste, landfilled industrial waste and landfilled sewage sludge.

Pertinent quantities of landifilled municipal waste (household and commercial waste) are taken from relevant statistics of the Federal Statistical Office, which are based on annual surveys of waste types, origins and final destinations, as well as on surveys taken of waste-storage facilities, every two years, that focus on specific equipment of the facilities. The surveys of landfilled quantities of municipal waste in the old German Länder commenced in 1975, on the basis of the Environmental Statistics Act of 1974. Waste quantities for the period from 1950 to 1975 were extrapolated on the basis of population data.

For the new German Länder, data on landfilled quantities of municipal waste, differentiated by Länder, is available for the years 1990 and 1993. For the 1980s in the former GDR, LALE (2000) has presented data that provide information about per-capita landfilled quantities of waste, waste composition, landfill types and types of waste storage involved. The per-capita quantities of landfilled waste in the former GDR, at 190 kg/person, were considerably lower than the corresponding quantities in the old German Länder (330 kg / person and year). The reason for this was that larger percentages of waste were recycled in the former GDR. In 1990, the year of German reunification, landfilled quantities of waste increased sharply in the new German Länder, to the extent that the relevant per-capita quantities even outstripped the corresponding quantities in the old German Länder. The reasons for this were that the former GDR's recycling systems collapsed in that year and that a flood of new products suddenly became available, leading to high levels of replacement purchases and to sharply increasing quantities of packaging waste. Since 1990, per-capita waste quantities in both parts of Germany have slowly been moving into alignment. In the former GDR, all non-recycled waste quantities were landfilled.

Since 1996, the Federal Statistical Office has published differentiated data on waste-landfilling by industry. The relevant inventory takes account of the landfilled waste quantities from industrial sectors as follows:

- Waste from agriculture, horticulture, forestry, fisheries and food processing
- Waste from wood processing
- Waste from production of pulp, paper and carton
- Waste from the textile industry
- Packaging waste
- Wood fractions in construction and demolition waste (data since 1975)

The quantities of industrial waste landfilled between 1975 and 1996 were derived on the basis of total quantities of landfilled waste. While the total quantities include industrial waste, the total-waste figures are not broken down to show industrial waste separately. Extrapolations between waste production and production data of relevant sectors, for the 1996-2002 period, produced no satisfactory statistical relationships. While production figures increased, waste-production figures decreased – considerably, in part – as a result of changes in production processes. Due to the lack of statistical relationships, the figures for landfilled waste quantities were kept constant for the period between 1950 and 1975. Changes in assumptions relative to industrial waste in the 1950-1970 period have only a very marginal effect on emissions in the base year.

Data on landfilling of sewage sludges from public and industrial wastewater treatment are available for the old German Länder for the period since 1975. Those data have been extrapolated via population data (public wastewater treatment), under the assumption that quantities of sewage sludge (industrial waste) remained constant. Here as well, changes in assumptions regarding industrial quantities for the 1950-1970 period have only slight impacts on base-year emissions, because the half-life for sewage-sludge decomposition in landfills is short – four years.

8.2.1.2.2 Waste composition

For purposes of inventory calculation, numerous studies on waste composition were evaluated to determine historical trends in waste fractions. In the years 1980 and 1985, waste composition was determined for the entire territory of the former Federal Republic of Germany (UBA 1983, 1986). For the subsequent period, a large number of individual studies exists – studies carried out by individual cities, administrative districts and Länder. Some of these had already been evaluated and combined within overarching studies. The pertinent figures were used to obtain time series for waste composition for the period between 1980 and 2005 (cf. Figure 71). Such evaluation of existing studies was carried out for household waste, household-like commercial waste and bulky waste, categories that are listed separately in national statistics. As to waste composition in the new German Länder, the figures provided by LALE (2000) for the 1980s in the former GDR were adopted (composition of household waste: 28 % vegetable waste, 14 % paper/cardboard, 2.3 % wood, rubber, composites, 3 % textiles; household waste accounted for only 16 % of total landfilled waste quantities, however). Quantities of municipal waste landfilled in the former GDR contain smaller fractions of biodegradable materials and large inorganic fractions (primarily ash from household combustion systems). Food waste was collected and used as feed; feeds tended to be scarce during certain periods of time. Paper was collected; it was also a scarce resource. Wood and paper were often burned in ovens for purposes of heating and cooking. The "SERO" recycling system efficiently collected the country's relatively small fractions of plastic packaging. Deposit systems were operated for glass, and glass was also collected. All in all, the former GDR's economy was subject to scarcities of resources, and this led to efficient waste recycling. Ash from household combustion systems accounted for large fractions of landfilled quantities of household waste.

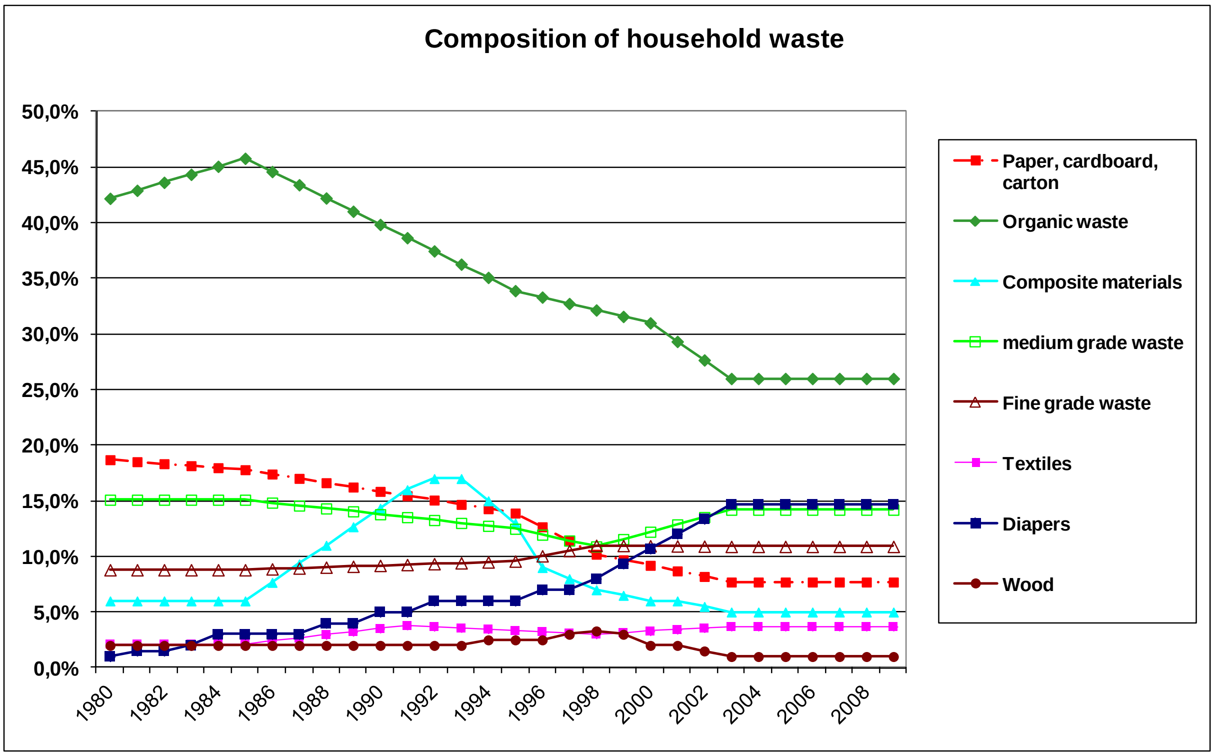


Figure 71: Trends in waste composition (old German Länder) between 1980 and 2009

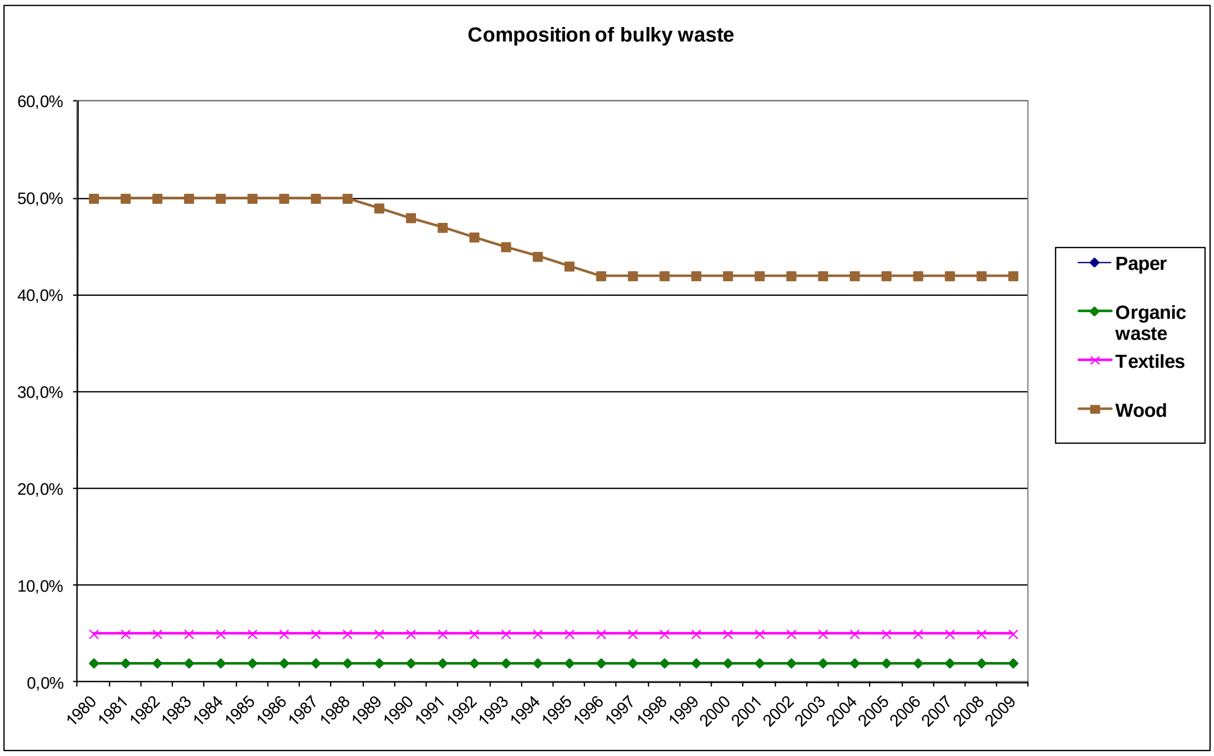


Figure 72: Trends in bulky-waste composition (old German Länder) between 1980 and 2009

Since 1 June 2005 only waste with a total carbon content < 3 %, and mechanically and biologically treated municipal waste, may be landfilled in Germany. Since that time, landfilled waste quantities have decreased very sharply and now make only very small contributions to gas formation. Table 292 outlines the development of quantities of landfilled biodegradable waste. Biodegradable waste fractions have decreased further with respect to 2009. For 2010, official waste statistics (DESTATIS, Fachserie 19, Reihe 1, 2010) list no waste for the areas of sewage sludge and garden and park waste. No data are yet available for 2011. Therefore, it has been assumed that waste quantities and waste composition have remained unchanged with respect to 2010.

Table 292: Quantities of biodegradable waste landfilled between 2002 and 2010, broken down by waste fractions

Waste fraction	Units	2002	2003	2004	2005	2006	2007	2008	2009
Organic	1000 t	2,050	2,227	1,667	785	1	0	0	0
Garden and park waste	1000 t	186	137	211	160	94	116	134	98
Paper	1000 t	1,448	1,515	995	499	26	12	9	3
Textiles	1000 t	336	376	293	135	5	3	2	1
Wood	1000 t	687	529	438	199	20	24	18	13
Diapers	1000 t	920	1,215	906	429	0	0	0	0
Diapers + textiles	1000 t	1,256	1,592	1,199	564	5	3	2	1
Composite materials	1000 t	379	414	309	146	7	5	4	2
Sewage sludge	1000 t TM	413	398	348	634	130	129	133	661
Output from MBT facilities	1000 t	0	0	743	1,092	665	545	616	647
Waste fraction	**Units**	**2010**	**2011**						
Organic	1000 t	1	1						
Garden and park waste	1000 t	1	0						
Paper	1000 t	5	5						
Textiles	1000 t	2	2						
Wood	1000 t	1	1						
Diapers	1000 t	0	0						
Diapers + textiles	1000 t	1	1						
Composite materials	1000 t	3	3						
Sewage sludge	1000 t TM	0	0						
Output from MBT facilities	1000 t	538	538						

During the 2010 inventory review, the review team requested that CH_4 emissions from landfilled MBT residues also be included in calculation of emissions from landfilling. While that fraction has now been included, there is no unambiguous method for that waste category, nor are there suitable national parameters for it. Furthermore, no results have yet been obtained with regard to the behaviour of landfilled waste from MBT facilities (i.e. behaviour in real landfills). Only laboratory data have been obtained to date, and thus the results in this area are subject to very high levels of uncertainty. The actual emissions from landfilled waste from MBT facilities are likely to be considerably lower than such laboratory data suggest.

In keeping with the recommendations provided in the inventory review 2010 (paragraph 146, FCCC/ARR/2010/DEU), additional information is provided in this regard as of the 2011 report. Table 293 shows the per-capita waste quantities landfilled, per day, between 1990 and 2011. Those values do not represent the per-capita waste-production rate that is to be reported, as additional information, in the CRF tables. That figure comprises total waste consumption, taking all waste-management pathways into account. It will be calculated for the next report.

In Germany, landfilling of municipal waste has decreased very sharply since 2005, and that trend is also reflected in the per-capita rate.

Table 293: Per-capita quantities of landfilled household waste

	Units	1990	1995	2000	2001	2002	2003	2004
Per-capita quantities of landfilled household waste	kg/capita/day	1.389	0.655	0.284	0.327	0.211	0.226	0.196
	Units	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Per-capita quantities of landfilled household waste	kg/capita/day	0.135	0.031	0.027	0.030	0.048	0.019	0.019

8.2.1.2.3 MCF (methane-correction factor)

Until 1972, when the first Waste Act was introduced, waste was usually stored in uncontrolled landfills; such landfills were closed after 1972. After 1972, waste was stored in managed landfills. In keeping with this history, a default MCF value of 0.6 was used for "unclassified landfills" ("nicht zugeordnete Deponien"), while an MCF of 1 was used after 1972.

Data are available from a 1989 survey of the territory of the former GDR that covered 120 managed landfills, some 1,000 controlled storage sites and some 10,000 uncontrolled dump sites (MNUW, 1990). Of the some 13,000 waste-storage sites, a total of 11,000 were for household waste and 2,000 were for industrial waste; most of the latter were plant-owned facilities (BMU, 1990: p. 28). Consequently, an MCF of 0.6 (default value for unclassified landfills) was assumed for the territory of the former GDR for the period 1970 to 1990. Upon German reunification, the Federal Republic of Germany's waste laws were extended to the territory of the new German Länder, and transitional regulations were introduced to ensure that facilities – including both decommissioned facilities and still-operational facilities in which waste was (or is) produced or disposed of – were accounted for and that suitable clean-up measures were initiated (BMU, 1990: p. 46). Uncontrolled landfills were closed in 1990, facilities permitted to remain open were secured, cleaned up and modernised/expanded in keeping with the standards of Federal German waste law, and sites for new facilities were sought. As of 1990, the Federal Statistical Office has collected statistics on both parts of Germany. For purposes of calculation for the period after 1990, an MCF of 1 is used for all of Germany's territory.

8.2.1.2.4 DOC

Both national data and IPCC default factors are used for DOC, the proportion of degradable organic carbon in waste. Table 294 below provides an overview of the DOC values used.

Table 294: DOC values used

Fraction	DOC	Source
Organic	18%	Various national studies show DOC levels that are higher than the IPCC default value
Garden and park waste	20%	National value
Paper and cardboard	40%	IPCC default
Wood and straw	43%	The national value is somewhat higher than the IPCC default
Textiles	24%	National value
Diapers	24%	National value
Composite materials	10%	National value
Sewage sludge	50%	IPCC default value for sewage sludge, referenced to dry weight
Waste from MBT facilities	2.3%	National value

8.2.1.2.5 DOC_F

DOC_F, the DOC fraction that can be converted into landfill gas, is put at 50 % for municipal waste, on the basis of a national study (RETTENBERGER et al, 1997: p. 277). That value lies within the IPCC default range of 0.5-0.6.

8.2.1.2.6 F = Fraction of CH_4 in landfill gas

A value of 50%, the mean value in the IPCC default-value range, is assumed for F. That value is based on data of the Federal Statistical Office for the years 2004, 2006 and 2008 (STATISTISCHES BUNDESAMT (FEDERAL STATISTICAL OFFICE), Fachserie 19 Reihe 1).

8.2.1.2.7 Half-life

The calculation model is a multi-phase model that takes account of the different half-lives of different waste fractions. Table 295 shows the half-lives and the methane-formation rate used for the pertinent waste fractions. For conformance with the recommendations provided in the inventory review 2010 (paragraph 146, FCCC/ARR/2010/DEU), additional information has been provided for reporting as of 2011. The constant methane-production rate that appears in the FOD method corresponds to the time required for biodegradable organic carbon in waste to decompose to the point at which it has lost half of its original mass. It thus can be derived from the half-lives of the various relevant fractions, in keeping with Equation 48.

Equation 48: (IPCC 2000 Good Practice Guidance, Chapter 5.1.1.2)

$$k = \ln 2 / t_{1/2}$$

Since the constant methane-production rates, and the half-lives, of the relevant individual waste types are considered separately, in the CRF table "Table6.A,C" the notation key "IE" was used, instead of a universal value.

Table 295: Half-lives and constant methane-formation rates of waste fractions

Type of waste	Half-life (years)	CH_4-formation rate (k value)
Food waste	4	0.173
Garden/park waste	7	0.099
Paper / cardboard	12	0.058
Wood	23	0.030
Textiles / diapers	12	0.058
Composite materials	12	0.058
Sewage sludge	4	0.173
Waste from MBT facilities	12	0.058

8.2.1.2.8 Landfill-gas use

The "TA Siedlungsabfall" of 1993[101] made gas collection one of the prerequisites for licensing of landfills for municipal waste. The amended version of the Environmental Statistics Act (UStatG) of 2005 mandates that in future the Federal Statistical Office, in its surveys, is to take account of, and publish, levels of landfill-gas collection. For the years 2004, 2006 and 2008, and with regard to landfill-gas collection and use, Fachserie 19 of 12 July 2012 includes only data for landfills in operation and decommissioning phases. Collection of gas-

[101] Technical instructions on recycling, treatment and other management of municipal waste (Third general administrative provision on the Waste Act (Abfallgesetz)) of 14 May 1993

collection data for all landfills, i.e. including landfills in the follow-on care phase, began for the first time for the year 2010.

As a result of the above-described data gaps, in reporting in recent years, total quantities of collected landfill gas have been determined by combining data from the energy sector and from Fachserie 19. The results for all landfills overall for the year 2010 show that the amounts of gas collected at landfills in the follow-on care phase have been considerably overestimated. For this reason, a recalculation had to be carried out to correct the amounts of gas collected at landfills in recent years and, thus, to correct the relevant methane emissions.

Table 296: Methane collection in landfills

Year	Gas formation	NIR 2012 Collected gas quantity in Gg	NIR 2012 Collection rate in %	NIR 2013 Collected gas quantity in Gg: Operation and decommissioning phase	Follow-on care phase	Total quantity	NIR 2013 Collection rate in %
1990	2,169	126	5.8			126	5.8
1991	2,228	136	6.1			136	6.1
1992	2,246	146	6.5			146	6.5
1993	2,223	156	7.0			156	7.0
1994	2,167	166	7.7			166	7.7
1995	2,095	176	8.4			176	8.4
1996	2,008	190	9.5			190	9.5
1997	1,906	260	13.6			260	13.6
1998	1,801	280	15.5			280	15.5
1999	1,703	349	20.5			328	19.3
2000	1,611	352	21.8			311	19.3
2001	1,520	356	23.4			293	19.3
2002	1,441	360	25.0			278	19.3
2003	1,355	363	26.8			261	19.3
2004	1,280	425	33.2	236(1)	11(2)	247	19.3
2005	1,202	447	37.2			252	19.3
2006	1,120	460	41.1	231(1)	11(2)	242	21.6
2007	1,026	445	43.4			221	21.6
2008	943	374	39.7	190(1)	11(2)	201	21.3
2009	874	358	41.0			186	21.3
2010	816	347	42.5	171(1)	11(1)	181(1)	22.2
2011	752					167	22.2

(1) Data from DESTATIS (Federal Statistical Office), Fachserie 19, Reihe 1 of 12 June 2012
(2) Estimate on the basis of the DESTATIS data for 2010

For the recalculation, it was necessary to close data gaps via extrapolation and qualified estimates, since official statistical data are available only for certain single years. For the years through 1998, continued use was made of gas-collection-rate data from earlier estimates (for sources and data derivation, cf. the NIR 2012). For the years 1999 through 2005, a collection rate of 19.3 % was assumed. That rate has been determined on the basis of gas formation and collected quantities of landfill gas for the year 2004. Using a similar approach, the collection rates for the years 2006 and 2007 were determined from the data for 2006, the rates for 2008 and 2009 were determined from the data for 2008 and the rates for 2010 and 2011 were determined from the data for 2008.

8.2.1.2.9 Oxidation factor

As to the factor determining the proportion of CH_4 that is oxidised in landfill covering layers, the IPCC default value of 0.1 was adopted for the entire time series. While in the early 1990s the former GDR probably had a higher percentage of uncontrolled landfills than did the old German Länder, a research project has found that the former GDR's landfills have a low CH_4-formation potential, and thus use of the factor 0.1 is also justified for that period (BMBF, 1997).

8.2.1.3 Uncertainties and time-series consistency (6.A.1)

The method's uncertainties were estimated for the first time for the NIR 2006.

Over the long, 30-year period covered by the activity data, inconsistencies in the time series are unavoidable, since the pertinent waste categories and survey methods changed several times as a result of improvements in legislation and waste statistics. In Germany, special problems arise especially via German reunification and the resulting merging of two different economic and statistical systems. For this reason, considerable effort has to be invested in reviewing data consistency and allocations to the reported categories, in the interest of making time series as consistent as possible.

8.2.1.4 Source-specific quality assurance / control and verification (6.A.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The selected parameters were compared with relevant data for other countries.

The per-capita rate for landfilling of municipal waste (Table 293) was compared with the default value in the Revised 1996 IPCC Guidelines (Table 6-1 in Chapter 6.2.4). For 1995, the default value is in line with the national value. In subsequent years, the national values decreased considerably – and, after 2005, drastically. Those decreases were caused by implementation, in June 2005, of the extensive requirements applying under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (Abfallablagerungsverordnung) and the Landfill Ordinance (Deponieverordnung).

In entry of data, the correctness of entries was checked via sum values – various waste categories were recorded solely for the purpose of checking correctness of data entry.

The national calculation model used to date was reviewed via the IPCC's FOD model – i.e. by entering the same pertinent parameters and data into that FOD model. The same result was obtained.

8.2.1.5 Source-specific recalculations (6.A.1)

As the NIR 2012 was being prepared, statistical data on landfilled waste quantities were available only up to 2009. Therefore, the emissions of the year 2010 were recalculated with the more recent data published in Fachserie 19 of 12 July 2012. In addition, landfill-gas collection for the period as of 1999 was recalculated. The recalculation was required because official statistical data on total collected quantities of landfill gas became available, for the first time, for 2010. Those data indicate that landfill-gas collection rates have been considerably overestimated in the past.

8.2.1.6 Planned improvements (6.A.1)

In 2011/12, the residual-gas emissions from landfill storage of mechanically and biologically treated waste were quantified in an expert opinion (IFAS, 2012). The opinion confirms that emissions calculations to data have been correct in applying low emissions contributions from landfilling of MBT waste. In addition, with regard to the progression of methane formation, the opinion provides indications of higher fractions of waste components with shorter half-lives in decomposition. This issue is being reviewed at present. The half-lives / reaction constants for MBT waste may be adjusted as a result.

In an international comparison, collection rates of landfill gas, at about 20 %, seem very low. They also seem low in that nearly all German landfills have gas-collection facilities and that the technical characteristics of German landfills would seem to provide a comparatively good basis for high collection rates. This apparent contradiction will need to be cleared up for future reports.

8.3 Wastewater handling (6.B)

CRF 6.B	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Domestic and Commercial Wastewater	**CH_4**	**-**	**T/-**	**2,226.2**	**(0.18%)**	**60.9**	**(0.01%)**	**-97.26%**
Domestic and Commercial Wastewater	N_2O	-	-/T2	2,342.2	(0.19%)	2,414.6	(0.26%)	3.09%

The source category *Wastewater handling* is a key category of CO_4 emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-96.81 %), and thus an extremely low emissions level has been attained (in 2010, emissions amounted to 2.0 % of the contribution of the smallest key category identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

Under source category 6.B Wastewater handling (treatment), the CSE includes wastewater quantities, treatment of sewage sludge and sewage-sludge production in wastewater treatment.

8.3.1 Industrial wastewater treatment

8.3.1.1 Methane emissions from industrial wastewater treatment (6.B.1)

8.3.1.1.1 Source category description (6.B.1)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	NA	NA	NA
CH_4	NA	NA	NA
N_2O	D	NS	D/CS

The source category "Methane emissions from industrial wastewater and sludge treatment" (6.B.1) is a key category only via the aggregated source category Wastewater handling (6.B). No calculations for this source category are carried out at present.

In its Fachserie 19 Reihe 2.2 (2010e, 2010f), the FEDERAL STATISTICAL OFFICE provides data on wastewaster quantities and on the structure of the wastewater sector. About 75 % of the wastewater is coolant water that is not subjected to further treatment. About 96 % of the non-coolant water is biologically treated (aerobically and/or anaerobically). Municipal wastewater treatment facilities treat more than 65 % of the industrial wastewater that is treated; the remainder is treated in the industrial producers' own facilities.

The following table shows the industrial sectors of importance with regard to wastewater production. The sectors listed account for about 90 % of the industrial wastewater produced.

Table 297: Treated wastewater discharged directly in 2007, pursuant to [Statistisches Bundesamt 2010c, Table 8.8]

Production area	Millions of m³ of wastewater
Production of chemical products	310
Production of paper and cardboard	234
Energy production and distribution	146
Production of iron, steel and ferroalloys	74
Production of food, feed and drink	65
Other	95
Total	**924**

The composition of industrial wastewater, in contrast to that of household wastewater, varies greatly; it varies by industrial sector. The various sectors differ significantly with regard to their COB and BOB_5 parameters, as well as to their nitrogen : phosphorous (N:P) and nitrogen : phosphorous : sulphur (N:P:S) ratios. The possible ranges for COB are given in IPCC 2006c. The ranges given in that source only partly reflect the situation in Germany, however.

In Germany, the biological stage of industrial wastewater treatment is partly aerobic and partly anaerobic. The Federal Statistical Office (Fachserie 19, Reihe 2.2) describes the applicable treatment percentages for biological wastewater treatment facilities in industry, but it does not differentiate treatment techniques and, in particular, does not differentiate techniques with regard to whether they are aerobic or anaerobic. Anaerobic wastewater treatment is especially useful for industries whose wastewater has high levels of organic loads. Its advantages are that it does not require large amounts of oxygen, produces considerably smaller amounts of sludge requiring disposal and generates methane that can be used for energy recovery. Pursuant to KORRESPONDENZ ABWASSER, ABFALL 2009

(p. 1147 ff), some 205 anaerobically operating facilities are in operation in Germany's industrial sector – largely in food-production and paper/cardboard- production areas (as of 2008). Additional anaerobically operating facilities are appearing only slowly.

Like treatment of municipal wastewater, treatment of industrial wastewater releases no methane emissions into the environment.

Owing to the applicable biological principles involved, aerobic procedures produce no methane emissions. Methane occurs only in anaerobic treatment of industrial wastewater. At the same time, the methane emissions are negligible, since all of the anaerobic wastewater treatment facilities in operation in Germany function as closed systems. The methane they produce is collected and used for energy generation. In addition, the facilities are equipped with gas flares for added safety. Methane emissions into the environment are thus prevented. Emissions occur only in cases of malfunction. No information on leakage rates is available.

Use for energy recovery is reported under CRF 1.A.1. In both treatment methods, no significant amounts of methane emissions are released into the environment.

Industrial sludge treatment and stabilisation, like industrial wastewater treatment, is carried out either aerobically or anaerobically with methane-gas use.

8.3.1.2 Nitrous oxide emissions from industrial wastewater treatment (6.B.1)

8.3.1.2.1 Source category description (6.B.1 nitrous oxide, industrial)

Nitrous oxide emissions can occur as a by-product of biological wastewater treatment with added nitrogen elimination. They occur mainly in connection with denitrification, although they are presumed to occur also in connection with nitrification. Presumably, in such treatment, reduction from N_2O to N_2 is hindered by various influencing factors, such as free oxygen, high concentrations of nitrite, ammonium and/or sulphides, and such hindrance leads to the formation of N_2O.

For estimation of N_2O emissions from municipal wastewater treatment (6.B.2), the pertinent N_2O emission factors are determined on the basis of the average per-capita (i.e. per inhabitant) protein intake. As a result, industrial wastewater may be considered completely separately. Since all wastewater in Germany undergoes biological treatment, the site at which industrial wastewater is treated – in a facility at the operational site or in a municipal wastewater treatment plant – is not an important factor to consider.

8.3.1.2.2 Methodological issues (6.B.1 nitrous oxide, industrial)

For determination of nitrous oxide emissions from industrial wastewater treatment, a research project collected data on product-specific wastewater production, on nitrogen concentrations and on COD (chemical oxygen demand) for all industrial areas and then, on the basis of annual production figures, determined annual nitrogen loads. The relevant procedure is set forth in detail in UBA 2011b. A COD:N ratio < 40 served as the threshold criterion for determining whether the wastewater of a given sector had a nitrogen surplus that would be able to cause nitrous oxide emissions in subsequent biological wastewater treatment. A possibility that nitrous oxide could be emitted in biological wastewater treatment can be assumed only if the wastewater contains so much nitrogen that, after conversion into biomass, a residual amount of nitrogen remains that has to be removed via biological nitrogen elimination. The value used is supported by the document ATV-DVKK-Arbeitsblatt A

131 which, as a simplification, considers the nitrogen load to amount to 2 to 2.5 % of the COD concentration. The data compilation made it possible to identify the 4 industrial sectors that are most important in this regard. Together, those sectors account for some 68 % of the nitrogen load from industrial wastewater treatment. They are as follows:

- Slaughterhouse and meat-processing operations,
- Milk processing,
- Processing of animal by-products,
- Beer production.

The following table shows the mean product-specific nitrogen loads for the 4 aforementioned industrial sectors, along with the annual nitrogen loads, as determined on the basis of annual production figures, that are discharged into raw wastewater. The data are valid for 2010. It is assumed that, as a result of organisational and technical measures, such discharges have reached their current levels through gradual reductions, and that the nitrogen quantities discharged into wastewater in 1990 were 30 % higher (expert estimate). For the years 1990 through 2000, annual nitrogen-load reductions of 2 percentage points are assumed, while one-percent reductions are assumed for the period 2000 through 2010 (expert estimate).

Table 298: Specific nitrogen load, production figures and nitrogen loads discharged into raw wastewater in 2010, for the 4 most important industrial sectors in this regard

Sector	Subdivision		NF Mean spec. N load per unit [g N per unit]	PZ Production figures in 2010	AD Mean nitrogen load discharged into raw wastewater in 2010 [t N_Z/a]
Slaughterhouse and meat-processing operations	Slaughtering	Swine	56 g N per slaughtered animal	58,350,146 animals	3,268
		Sheep	56 g N per slaughtered animal	1,048,391 animals	59
		Goats	56 g N per slaughtered animal	28,414 animals	2
		Cattle	224 g N per slaughtered animal	3,786,324 animals	848
		Horses	224 g N per slaughtered animal	9,340 animals	2
		Poultry	4.5 g N per slaughtered animal	683,114,084 animals	3,074
	Meat processing		552.5 g N per t of produced meat products	4,112,493 t of produced meat products	2,272
Processing of animal by-products			1,555 g N per t of processed raw materials	2,775,589 t of processed raw materials	4,316
Milk processing			198 g N per t of processed milk	30,353,700 t of processed milk	6,010
Beer production			27.6 g N per hL of beer ready for sale	93,915,576 hL of beer ready for sale	2,592
				Total	**22,443**

The activity-data calculation shown in Table 298 was carried out as follows:

$$AR = NF \times PZ \times 10^{-6}$$

where:

AR = Activity data [t N_Z/a]
NF = Mean spec. N load [g N per unit]
PZ = Production figures for the year 2010 [number of units / a]

10^{-6} = Factor for conversion of g into t
N_Z = Nitrogen in the inflow for wastewater treatment

The N_2O emission factor was determined by analysing various data from the literature. From those data, a weighted mean value was formed. As a result, it was found that 1 % of the nitrogen load in the inflow for a wastewater treatment plant is emitted as N_2O-N.

Emission = Emission factor x sum of activity data

N_2O-N = 0.010 [t N_2O-N emitted / t N_Z] x 22,443 [t N_Z/a]

N_2O-N = 224.4 [t N_2O-N emitted / a]

N_2O = N_2O-N [t N_2O-N emitted / a] x 44/28

N_2O = 352.6 [t N_2O emitted / a]

8.3.1.2.3 Uncertainties and time-series consistency (6.B.1, nitrous oxide, industrial)

The uncertainties in the production figures originate in the relevant Federal statistics, and other statistics, all of which are based on exhaustive surveys. The data are thus likely to have a very low degree of uncertainty.

By expert assessment, the uncertainty for the N_2O emission factor was determined to be very high, with a range of - 100 % / + 300 % (for the pertinent reasons, cf. 8.3.1.2.1).

The mean specific nitrogen loads shown in Table 298 have the uncertainties shown in Table 299, which were determined via expert assessment. In a conservative estimate, the total uncertainty for the activity data is assumed to be -50 % / +50 % (expert assessment)

Table 299: Uncertainties for the mean specific nitrogen loads for the 4 industrial sectors that are most important in this regard

Mean spec. N load of the industrial sector	Uncertainty, upper bound	Uncertainty, lower bound
Slaughtering of swine	40	40
Slaughtering of sheep	50	50
Slaughtering of goats	50	50
Slaughtering of cattle	40	40
Slaughtering of horses	50	50
Slaughtering of poultry	40	40
Meat processing	40	40
Processing of animal by-products	20	20
Milk processing	15	15
Beer production	30	30

8.3.1.2.4 Source-specific quality assurance / control and verification (6.B.1, nitrous oxide, industrial)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

8.3.1.2.5 Source-specific recalculations (6.B.1 nitrous oxide, industrial)

No recalculations are required.

8.3.1.2.6 Planned improvements (6.B.1 nitrous oxide, industrial)

Plans call for review of the possibility of determining the COD values for the sector-specific wastewater streams.

8.3.2 Municipal wastewater treatment (6.B.2)

8.3.2.1 Methane emissions from municipal wastewater treatment (6.B.2 wastewater treatment)

8.3.2.1.1 Source category description (6.B.2 wastewater treatment)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	NA	NA	NA
CH_4	D/CS	NS	D/CS
N_2O	D	NS	D/CS

The source category Municipal wastewater treatment is a key category.

In Germany, municipal *wastewater treatment* takes place under aerobic conditions (municipal wastewater-treatment plants, small wastewater-treatment plants), i.e. no methane emissions occur (default value for MCF = 0). Methane emissions can occur only under anaerobic conditions.

Treatment of human sewage from sources that are not connected to the public sewer network or to small wastewater-treatment plants, and that collect wastewater in cesspools or septic tanks, for transport to wastewater-treatment facilities, is an exception. In cesspools and septic tanks, some uncontrolled processes can occur (that are partly aerobic and partly anaerobic) that lead to methane formation. Since 1990, the organic loads discharged into cesspools and septic tanks have been drastically reduced, however, because the percentages of inhabitants connected to small wastewater-treatment facilities have continually increased. As a result, this sector's CH_4 emissions show a sharply decreasing trend.

8.3.2.1.2 Methodological issues (6.B.2 wastewater treatment)

Organic loads from cesspools and septic tanks are calculated pursuant to the IPCC method, in which the relevant population is multiplied by the average organic load per person. The average organic load is assumed to be 60 g BOD_5 per inhabitant. On the one hand, that value is the IPCC default value (IPCC Guidelines for National Greenhouse Gas Inventories 2006, Chapter 6, Table 6.4, page 6.14). On the other hand, that value is used in Germany and throughout Europe as a statistical mean (EC OJ, L 135/40 , 30 p. 91, Article 2 No 6).

Methane emissions from cesspools and septic tanks are determined in keeping with the IPCC method. The IPCC default value for methane-producing capacity (0.6 kg CH_4 / kg BOD_5) has been adopted. With regard to the MCF, a conservative assumption has been used: that the value listed in Table 6.3 (IPCC 2006c, Chapter 6.2.2.2, page 6.13) for "septic systems", 0.5, also applies to Germany. Initial studies of the literature indicate that that value indeed exceeds the actual value. In all likelihood, the MCF will be adjusted when the studies have been completed.

The emissions are determined as follows:

$$CH_4(cesspools\ and\ septic\ t.) = kg\ BOD_5\ /\ year\ x\ Bo\ x\ MCF$$

MCF = Methane correction factor, 0.5

B_o = Default – max. CH_4 formation capacity, 0.6 kg CH_4 / kg BOD_5

Calculation pursuant to Tier 3, as required for key categories, is not feasible, since the substance flows for cesspools and septic tanks are not separately recorded.

8.3.2.1.3 Uncertainties and time-series consistency (6.B.2 wastewater treatment)

Since the uncertainties of the method have not yet been estimated, the default values (conservative factors) given in UNFCCC Decision 20/CMP.1 (p. 39ff) are used.

The activity data for organic loads in cesspools and septic tanks are based on data from the Federal Statistical Office's Fachserie 19 Reihe 2.1 that were published in 1991, 1995, 1998, 2001, 2004 and 2007 (*STATISTISCHES BUNDESAMT (FEDERAL STATISTICAL OFFICE)*, Fachserie 19 Reihe 2.1). Every three years, the Federal Statistical Office conducts a survey – without determining the relevant uncertainties – of the numbers of inhabitants who are not connected to the public sewer system and whose wastewater is disposed of via cesspools and septic tanks. No other pertinent data sources are available. The results of such surveys may be considered very precise, since the surveys are exhaustive surveys. For production of a consistent time series, the activity data were linearly interpolated between 1991 and 1995, between 1995 and 1998, between 1998 and 2001, between 2001 and 2004 and between 2004 and 2007. The activity data for 1990, on the other hand, were extrapolated from the 1991 – 1995 time series. The activity data for 2008 – 2011 were extrapolated from the 2004 – 2007 time series.

Until 1995, data for the old and new Federal Länder were determined separately; since then, a single value for all of Germany has been determined in each case. This does not affect time-series consistency, however.

8.3.2.1.4 Source-specific quality assurance/ control and verification (6.B.2 wastewater treatment)

Quality control (pursuant to Tiers 1 + 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. The responsible experts have been unable to carry out quality assurance. The Single National Entity has carried out additional quality assurance.

The fact that aerobic wastewater treatment in relevant facilities produces no significant methane emissions can be confirmed in other countries (for example, Sweden).

8.3.2.1.5 Source-specific recalculations (6.B.2 wastewater treatment)

No recalculations are required.

8.3.2.1.6 Planned improvements (6.B.2 wastewater treatment)

No improvements are planned at present.

8.3.2.2 Methane emissions from municipal sludge treatment (6.B.2 sludge treatment)

8.3.2.2.1 Source category description (6.B.2 sludge treatment)

As a general rule, the treatment of municipal sewage sludge comprises two treatment stages:

- Dehydration, using: Mechanical processes (chamber-filter press, cyclone); evaporation in a sludge lagoon or drying beds
- Stabilisation: Aerobic stabilisation (open pool with oxygen input); stabilisation in digestion tower (anaerobic); (formerly: open sludge digestion)

With reference to population figures, *mechanical dehydration* + treatment in a digestion tower (with dehydration before and after the digestion-tower treatment) currently represents the main treatment method (some treatment is also carried out in small, rural sewage treatment plants). Moreover, sewage sludge is generally limed prior to subsequent use, which stabilises it still further.

Sludge stabilisation is carried out in order to prevent uncontrolled putrefaction. In facilities for fewer than 10,000 inhabitants, such stabilisation is usually carried out aerobically, with energy consumption, while in facilities for more than 30,000 inhabitants it normally is carried out anaerobically, with production of methane gas. The amount of methane gas produced depends especially on the composition of the sewage sludge, the temperature and the reaction conditions. Gas so produced is usually recovered for energy generation in combined heat/power generating systems (CHP). It is reported under 1.A.1. Where facilities are unable to use the methane gas cost-effectively in this manner, or when technical disruptions or overloads of attached CHPs occur, the methane gas may be flared off. In both treatment methods, no significant amounts of methane emissions are released into the environment.

In the early 1990s in eastern Germany, sludge was stabilised via open digestion, a process that produced methane emissions. Open sludge digestion is no longer practiced, however. It was phased out gradually, and was then completely discontinued in 1994.

In Germany, sewage sludge remaining after biological wastewater treatment is managed in the following ways (where applicable, after dehydration and stabilisation):

- Thermal disposal: no methane emissions occur. Thermal disposal requires energy inputs and thus is allocated to CRF 1.
- Recycling for substance recovery: the most important procedures for recycling sewage sludge for substance recovery include recycling in agriculture, pursuant to the Ordinance on Sewage Sludge (Klärschlammverordnung), and use in landscaping and other measures. Emissions from recycling for substance recovery are also not reported under wastewater and sludge treatment.

8.3.2.2.2 Methodological issues (6.B.2 sludge treatment)

Table 300 lists the emission factors for open sludge digestion and the methane emissions determined for that process.

Table 300: Methane emissions from open sludge digestion, in the new German Länder

	Units	1990	1991	1992	1993	1994
Emission factor	[kg CH_4/t TS]	210	210	210	210	210
Sewage-sludge production	[t TS]	247,190	140,952	72,762	37,524	0
Methane emissions	[t]	51,910	29,600	15,280	7,880	0

Emission factors derived from (UBA 1993)

An emission factor of 210 kg CH_4/t TS is used for open sludge digestion in eastern Germany, in keeping with the results of the study FHG ISI (UBA, 1993: p.15)[102]. The activity rates for the years 1990 to 1992 were communicated personally to the Federal Environment Agency by the Chief Inspector of the former GDR's water-processing plants.

In light of the fact that open sludge digestion is prohibited in the Federal Republic of Germany, it was assumed that use of that treatment method was gradually reduced in the new German Länder until 1994 and was no longer used at all as of 1994.

8.3.2.2.3 Uncertainties and time-series consistency (6.B.2 sludge treatment)

Since the uncertainties of the method have not yet been estimated, the default values (conservative factors) given in UNFCCC Decision 20/CMP.1 (p. 39ff) are used. The activity rates between 1990 and 1992 are based on a personal communication; those for 1993 are based on estimates of the Federal Environment Agency. As a result, a high degree of time-series consistency is not assured.

8.3.2.2.4 Source-specific quality assurance / control and verification (6.B.2)

Quality control (pursuant to Tiers 1 + 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. The responsible experts have been unable to carry out quality assurance. The Single National Entity has carried out additional quality assurance.

8.3.2.2.5 Source-specific recalculations (6.B.2 sludge treatment)

No recalculations are required.

8.3.2.2.6 Planned improvements (6.B.2)

At present, improvements seem neither necessary nor possible, since no further activity data can be obtained.

8.3.2.3 Nitrous oxide emissions from municipal wastewater (6.B.2 nitrous oxide emissions from municipal wastewater)

8.3.2.3.1 Source category description (6.B.2 nitrous oxide emissions from municipal wastewater)

Nitrous oxide (laughing-gas) emissions can occur as a by-product of municipal wastewater treatment, especially in connection with denitrification, in which gaseous end products – mainly, molecular nitrogen, however – are formed from nitrate.

102 The emission factor was determined via the difference between methane emissions from psychrophilic sludge stabilisation in the new German Länder and the total amount of sewage sludge produced.

The emissions trend is stable stagnation.

8.3.2.3.2 Methodological issues (6.B.2 nitrous oxide emissions from municipal wastewater)

Pursuant to the IPCC method, nitrous oxide emissions from household wastewater can be roughly determined via the average per-capita protein intake. The IPCC default values are used in each case for the nitrous-oxide emission factor per kg of nitrogen in wastewater, and for the nitrogen fraction in protein; the average per-capita protein intake and relevant population figures for Germany have to be determined on a country-specific basis.

The FAO's figures are used for determination of the average protein intake per person and day:

- For Germany and for the years 1989-91, the FAO (FAO Statistical Yearbook 2004) gives an average protein intake per person and day of 99 g.[103]
- In keeping with the FAO Statistical Yearbook 2007 – 2008(2010)[104] average protein intakes, per person and day, of 95 g (1994 – 1996), 97 g (1999 – 2001), 99 g (2003 – 2005) and 99 g (2005 – 2007) are given for Germany in the FAO Statistical Yearbook 2010[105].
- The values for the years 1992-1993 and 2002 are interpolated.
- The values for 1997-1998 represent the arithmetic mean from 1996-1999.
- The values for the years 2008-2010 are extrapolated (on the basis of 2003-2007).

The nitrous oxide emissions are determined on the basis of average protein intake and population figures (*FEDERAL STATISTICAL OFFICE*, Statistisches Jahrbuch 2010), and with the IPCC method.

$$N_2O_{(s)} = \mathrm{Pr}otein\ x\ Frac_{NPR}\, x\ NR_{PEOPLE}\, x\ EF_6$$

where

$$N_2O_{(s)} = N_2O\ emissions\ from\ human\ wastewater\ (kg\ N_2O - N/a)$$

$$\mathrm{Pr}otein = annual\ protein\ intake\ (kg/person/a)$$

$$NR_{PEOPLE} = Population\ of\ the\ country$$

$$EF_6 = emission\ factor\ (default\ 0.01\ (0.002 - 0.12)\ kg\ N_2O - N/kg\ produced\ wastewater - N)$$

$$Frac_{NPR} = Nitrogen\ fraction\ in\ protein\ (default = 0.16\ kg\ N/kg\ protein\ )$$

[103] www.fao.org/docrep/008/y5473m/y5473m00.HTM#Contents_en
FAO Statistical Yearbook 2004; Table D1 - Dietary energy protein and fat consumption 2004

[104] www.fao.org/economic/ess/ess-publications/ess-yearbook/fao-statistical-yearbook-2007-2008/d-consumption/en/; FAO Statistical Yearbook 2007-2008; Table D1 - Dietary energy protein and fat consumption

[105] www.fao.org/economic/ess/ess-publications/ess-yearbook/ess-yearbook2010/yearbook2010-consumption/en/
FAO Statistical Yearbook 2010; Table D1 - Dietary energy protein and fat consumption

8.3.2.3.3 Uncertainties and time-series consistency (6.B.2 nitrous oxide emissions from municipal wastewater)

Since the uncertainties for emissions determination have not yet been estimated, the default values (conservative factors) given in UNFCCC Decision 20/CMP.1 (p. 39ff) are used. The activity rates for 1989-1991 were taken from the FAO Statistical Yearbook 2004. The data for 1994-1996 and 1999-2001, and for 2003-2007, were taken from the FAO Statistical Yearbook 2007-2008 and 2010 Table D.1. As described in Chapter 8.3.2.3.2, lacking values were obtained via interpolation, extrapolation or calculation of the pertinent arithmetic mean.

Since the population-specific activity data increased by only about 4 % within 10 years (1995 – 2005), the error for the extrapolation as of 2006 is, at most, of the same order.

Calculations were based on the average daily protein requirements listed by the FAO database, to ensure that the time series is consistent and to prevent any need for extrapolation of individual values.

8.3.2.3.4 Source-category-specific quality assurance / control and verification (6.B.2 Nitrous oxide from municipal wastewater)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Analysis of the national inventory reports of other countries shows that most Annex I countries, like Germany, use the IPCC method for determining N_2O emissions.

Alternative data sources for the average protein intake per person and day include:

- The 1991 food table for practical applications (SENSER et al, 1991) lists an average protein intake of 94 g/inhabitant and day.
- The nutrition report of the German Nutrition Association (Deutsche Gesellschaft für Ernährung – DGE, 2008)[106] used estimated food-consumption data for 2005/2006 to estimate average daily protein intake (among other figures). From that data, an average value of about 79 g protein / person and day[107] was derived.

The FAO database in the Statistical Yearbooks 2004 (Vol.1/1), 2007-2008 and 2010 (table D.1) is used as a basis for determination of N_2O emissions from wastewater, since those sources constitute a consistent time series. It is internationally comparable, and it is regularly updated. In addition, the FAO has declared that the new Yearbook for 2007-2008 supplants the previous four FAO yearbook publications. The Federal Environment Agency has no information to the effect that the country-specific values in the food table and in the 2000 nutrition report are more precise or enjoy greater national acceptance. In addition, many countries use the FAO database; as a result, the emissions-determination process used by Germany is internationally comparable. An international comparison shows that the daily protein intake assumed for Germany lies within the middle of the overall range.

[106] The nutrition report is published every four years.
[107] This value was obtained with the help of the rough estimate that each population group in Germany consists of 50 % men (90.8 g/day) and 50% women (66.7 g/day).

8.3.2.3.5 Source-specific recalculations (6.B.2 Nitrous oxide from municipal wastewater)

No recalculations are required.

8.3.2.3.6 Planned improvements (6.B.2 Nitrous oxide from municipal wastewater)

No improvements are planned at present.

8.4 Waste incineration (6.C)

All waste incineration in Germany is carried out with energy recovery; for this reason, and in order to avoid double counting, the resulting emissions are reported in the energy section (CRF 1). No emissions (NO) from this energy use, therefore, are reported under 6.C.

8.5 Other areas (6.D)

In source category 6.D, emissions from composting systems (6.D.1) and from mechanical biological waste treatment (6.D.2) are reported.

CRF 6.D	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2011 Total emissions (Gg) & percentage (%)		Trend
Other	CH_4	-	-	49.8	(0.00%)	536.2	(0.06%)	977.25%
Other	N_2O	-	-	14.0	(0.00%)	323.1	(0.03%)	2210.8%

8.5.1 Other areas – composting facilities (6.D)

8.5.1.1 Source category description (6.D.1)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 1/CS	NS	CS
N_2O	Tier 1/CS	NS	CS

In Germany, annually increasing fractions of biodegradable waste are being managed in composting facilities. For this reason, the 2006 inventory included a first report on CH_4 and N_2O emissions from composting of municipal waste in composting facilities, along with a complete time series for these emissions. This category does not include composting of garden and household plant waste by households, in their own gardens. Such emissions are considered negligible, and no data regarding the relevant composted quantities are available.

8.5.1.2 Methodological issues (6.D.1)

Neither the "1996 IPCC Guidelines for National Greenhouse Gas Inventories" nor the IPCC report on "Good Practice Guidance" (2000) present any methods for calculating emissions from kitchen-waste composting. For this reason, a national method has been developed in which composted waste quantities are multiplied by emission factors from a national study (see below).

Activity data

Since 1980, the Federal Statistical Office has regularly collected and published data on waste quantities managed in composting facilities. Data on pertinent inputs of kitchen waste and plant waste (garden and park waste), and on waste inputs in composting and digestion facilities, have been separately collected and published since 2000.

The activity data for the current report year have to be estimated, since official waste statistics are published with a one-year time lag. For purposes of estimation, the waste-quantity figure from the previous year is used, unchanged.

Table 301: Quantities of waste placed in composting facilities

[in 1000 t]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Waste quantity	724	1,515	1,956	2,397	3,783	5,168	6,554	7,214	7,320	7,964
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Waste quantity	9,030	9,244	9,459	9,304	9,191	9,207	8,960	9,329	9,089	8,860
	2010	2011								
Waste quantity	8,699	8,699								

Emission factors

A research project carried out under commission to the Federal Environment Agency (IFEU 2003a) derived a method for calculating emission factors for the substances CH_4, N_2O and NH_3 from composting. The relevant database was provided by a study of Deutsche Bundesstiftung Umwelt (DBU 2002). In the pertinent method for determination of emission factors, average concentrations of carbon and nitrogen in kitchen waste and plant waste were assumed. In addition, estimates were made of the average decomposition rates during composting, as well as of distribution of carbon and nitrogen throughout the relevant emitted decomposition products.

For kitchen waste from households, the following emission factors resulted:

EF-N_2O = 83 g N_2O/Mg kitchen waste
EF-CH_4 = 2.5 kg CH_4/Mg kitchen waste

For plant waste, the same study obtained the following emission factors:

EF-N_2O = 60.3 g N_2O/Mg plant waste
EF-CH_4 = 3.36 kg CH_4/Mg plant waste

These national emission factors were used for the inventory calculations.

8.5.1.3 Uncertainties and time-series consistency (6.D.1)

Activity data

The uncertainties for the composted waste quantities are considered very small (2 %), since the relevant data were obtained via a complete-coverage survey, the reporting quality is good and operators have an interest in high-quality reporting.

Emission factors

The uncertainties for the emission factors are high. They depend on the type of facility/plant in question, on waste composition and on the effectiveness of the biofilters used. The pertinent figures from the literature and from other countries vary so widely that uncertainties of +60 % to -30 % for CH_4, and of at least +100 % to -50 % for N_2O, are assumed.

8.5.1.4 Source-specific quality assurance / control and verification (6.D.1)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

8.5.1.5 Source-specific recalculations (6.D.1)

Recalculations have to be carried out annually for the year prior to the previous year. For this NIR, recalculations have to be carried out for 2010, since the activity data of the Federal Statistical Office appear with a one-year time lag and thus the current report-year data have to be estimated. In each case, such estimates are replaced in the following year with the relevant figures from survey statistics. For the year 2010, the current recalculations yield a 4.5 % reduction of emissions from composting of kitchen waste and a 1.3 % increase in emissions from composting of plant waste. In the 2013 report, the total emissions for 2010 for this category have been corrected downward by 1.8 % with respect to the NIR 2012 (from 738 Gg CO_2 equivalent to 726 Gg CO_2 equivalent).

8.5.1.6 Planned improvements (6.D.1)

No further improvements are planned at present. An overview covering the planned improvements and their status can be found in Chapter 10.4 - Improvements in the inventory and Table 311 und Table 312.

8.5.2 Other areas – mechanical biological waste treatment (MBT) (6.D.2)

8.5.2.1 Source category description (6.D.2)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 1/CS	NS	CS
N_2O	Tier 1/CS	NS	CS

As of 1 June 2005, direct landfilling of organic and biodegradable waste is no longer permitted in Germany. Miscellaneous municipal waste, and other waste of similar composition, may thus be landfilled only following pre-treatment. In addition to thermal waste-treatment processes (waste incineration), mechanical biological processes are increasingly being used for this purpose.

Since the 1990s, mechanical biological processes have been used extensively in Germany for managing miscellaneous waste. Initially, relevant plants had relatively simple designs and were not fitted for waste-gas collection and treatment. As processes have improved, however, closed systems, with "biofilters" for waste-gas scrubbing, have gradually become the norm. While the waste-gas-scrubbing processes used by such plants have significantly reduced the plants' smell emissions, they have not reduced greenhouse-gas emissions.

In 2005, when all landfilling of untreated waste was terminated, capacities for mechanical biological waste treatment were considerably expanded. Pursuant to the 30th Ordinance on the Execution of the Federal Immission Control Act (30th BImSchV), as of 1 March 2001, new plants for mechanical biological waste treatment must fulfil strict technical requirements and conform to demanding standards for maximum permitted emissions. The transitional provisions for old plants call for such plants to be retroffited by no later than 1 March 2006.

Nearly all recently constructed new facilities were commissioned in 2005. Via expansions and operational upgrades, nearly all old facilities were brought into conformance with the 30th BImSchV by 2005. The transitional situation prevailing in 2005 can hardly be described with existing calculation models, since the relevant waste quantities cannot be correlated with the various relevant facility technologies. For the sake of simplicity, emissions through the year 2005 are calculated with the higher emission factors applying to the older-facility systems. For 2006, emissions are being calculated using the lower emission factors for the new facilities.

8.5.2.2 Methodological issues (6.D.2)

Since 1995, the Federal Statistical Office has regularly collected and published data on waste quantities managed in MBT systems. For the period 2007 through 2010, recent reports have used data from the research project "Facilities for mechanical and biological treatment of residual waste" ("Anlagen zur mechanisch-biologischen Restabfallbehandlung") (UBA, 2007). In connection with those earlier reports, there was doubt as to whether the data of the *Federal Statistical Office* cover all types of facilities that, in terms of their emissions behaviour, must be grouped with MBT facilities. As a conservative approach therefore, emissions calculation was carried out using the higher waste quantities determined by the research project. Via a number of discussions with the Federal Statistical Office, those doubts have since been eliminated. For the years 2007 through 2010, recalculation was carried out using the data of the Federal Statistical Office (DESTATIS, Fachserie 19, Reihe 1 of 12 July 2012).

Activity data

Since 1995, the Federal Statistical Office has regularly collected and published data on waste quantities managed in MBT systems.

Emission factors

In the 1990s, emissions from mechanical biological waste treatment were studied in a major collaborative research project supported by the Federal Ministry of Education and Research (BMBF). In a project carried out in 2003, the Institute for Energy and Environmental Research (IFEU) used the collaborative research project's findings to develop emission factors. In doing so, it differentiated between mechanical biological waste-treatment processes that were open (with no waste-gas collection and treatment) and processes that were closed (with waste-gas collection and treatment in biofilters). For methane, the emission factors for both types of processes were considered to be the same, since that substance is hardly broken down at all in biofilters. The N_2O emission factor for closed systems was considered to be higher than that for open systems, since N_2O also forms in biofilters, via oxidation of ammoniacal nitrogen.

Since June 2005, as a result of new legal provisions (30th BImSchV), all mechanical biological waste-treatment facilities are closed facilities, which have the more effective waste-gas-scrubbing processes. As of 2006, therefore, the emissions standards of the 30th BImSchV will be used as the emission factors for this area.

For open mechanical biological waste-treatment facilities, the following emission factors resulted:

EF-N_2O = 190 g N_2O/Mg waste
EF-CH_4 = 150 g CH_4/Mg waste

For closed mechanical biological waste-treatment facilities with biofilters, the same study obtained the following emission factors:

EF-N_2O = 375 g N_2O/Mg waste

EF-CH_4 = 150 g CH_4/Mg waste

For the period as of 2006, the emissions-load limitations imposed by the 30th BImSchV will be used as the applicable emission factors:

EF-N_2O = 100 g N_2O/Mg waste
EF-CH_4 = 55 g CH_4/Mg waste

All German MBT facilities reliably conform with those emissions standards, and in some cases their emissions are even considerably lower. Since in 2005 most MBT systems were equipped with waste-gas-treatment systems for minimising N_2O emissions, the emission factor for 2005 was estimated to be 169 g.

These national emission factors were used for the inventory calculations.

8.5.2.3 Uncertainties and time-series consistency (6.D.2)

The uncertainties for the mechanically-biologically treated waste quantities are considered to be very small (2 %) theoretically, since the relevant data were obtained via a complete-coverage survey, the reporting quality is good and operators have an interest in quality reporting. Nonetheless, it will be necessary, in order to rule out any possibility of underestimation of waste quantities, to consult with the Federal Statistical Office to determine which versions of "cold" waste-treatment processes are assigned to the MBT category. The uncertainties for the emission factors are high for the period before 2005. They depend on the type of facility/plant in question, on the type of process used at the relevant time and on the effectiveness of the biofilters used. The pertinent figures from the literature vary widely. For the period after 2005, it may be assumed that emissions easily comply with the standards of the 30th BImSchV or are even much lower than those standards. The only uncertainties are found in the question of the extent to which emissions during actual plant operations lie below the standards.

8.5.2.4 Source-specific quality assurance / control and verification (6.D.2)

Quality control (pursuant to Tier 1), in conformance with the requirements of the QSE manual and its associated applicable documents, has been carried out. The responsible experts have been unable to carry out quality assurance. The Single National Entity has carried out additional quality assurance.

8.5.2.5 Source-specific recalculations (6.D.2)

Recalculations were carried out for years 2007 through 2010. With the recalculations, the sector's emissions have now been determined throughout the entire time series, using data from official waste statistics (cf. also 8.5.2.2).

8.5.2.6 Planned improvements (6.D.2)

The emission factors used to date for methane and nitrous oxide are the emission limit values specified in the 30th BImSchV. The actual emissions of the facilities involved are considerably lower than those emission limit values. For future reporting, therefore, it will be necessary to evaluate the actual facility emissions and to review the pertinent emission factors.

9 OTHER (CRF SECTOR 7)

At present, no greenhouse gas emissions are calculated for Germany which cannot be allocated to one of the existing source categories.

10 RECALCULATIONS AND IMPROVEMENTS

In the following section, recalculations based on quantitatively effective inventory improvements are documented that occurred between between the 2011 Submission and the present 2012 Submission. Further information regarding the recalculations is provided in CRF tables Table 8(a) and Table 8(b) and in the present report's chapters on source-specific recalculations.

Pursuant to the aims of the *Good Practice Guidance*, emissions calculations should be based on the best available data, and efforts should be made to improve the inventories continuously. A continual improvement process results in annual recalculations. Recalculations become necessary when statistics are updated retroactively and the relevant changes are adopted in the inventories. Recalculations are also required when more precise data are included, when manual-transfer errors are corrected and when key-category analysis reveals a need to change methods for individual source categories. In addition, a range of factors in specialised/technical areas can necessitate recalculations.

The recalculations described in the following are thus based on the inventory data provided with the 2011 Submission.

10.1 Explanation and justification of the recalculations

10.1.1 Greenhouse-gas inventory

10.1.1.1 General procedure

There are a number of other reasons, in addition to the need for corrections, why recalculations and improvements can be necessary:

- Additional data become available that make it possible to close gaps in the inventory.
- A data source has changed.
- A method used for a source category has been adapted to provisions of the Good Practice Guidance.
- A source category has become a key category, thus necessitating a change of methods.
- New country-specific calculation procedures need to be used.
- Recommendations and results provided by reviews have been implemented.

In good practice, when methods change, the entire relevant time series should be consistently recalculated with the same method, to ensure that the same method is used each year and old values can be suitably replaced. Where the same method cannot be used every year, one of the following four recalculation procedures (IPCC Good Practice Guidance, 2000: Chapter 7) should be used:

- Overlapping procedure: For this method, the data for calculation pursuant to the old and new methods should be jointly available for at least one year.
- Replacement procedure: For this method, the EF and/or AD used to date should be highly similar to the newly available data.
- Interpolation procedure: The data previously used for recalculation cover only a few years of the time series, and the lacking data are interpolated.

- Extrapolation procedure: The data for the new method are not available for the beginning and/or end of the time series.

The QSE manual contains a guide to the above-outlined recalculation procedures. It also presents relevant examples.

10.1.1.2 Recalculations in the 2013 inventory, by source categories

This year's recalculations were necessitated by a range of methodological adjustments, some which led to significant changes in the affected source categories, as well as by further improvements in details. In addition, the Energy Balance was comprehensively revised with regard to the year 2010.

The inventories contain improvements in the following areas:

Energy (selection):

- Updating of activity data as a result of revision of the 2010 Energy Balance (1.A, 1.C)
- Correction of the EF(N_2O) for stationary combustion systems (1.A.1, 1.A.2.f, 1.A.3.e i)
- Revision of the activity data for waste incineration (for the period as of 2004) (1.A.1, 1.A.2)
- Adjustment of the EF(CO_2) for various types of lignite (2009) (1.A.1.c)
- Updating of the TREMOD-AV calculation module (1.A.3.a, 1.C.1.a)
- Revision of the intra-German / national and international shares of total kerosene use as of 2007, along with cross-checking of the pertinent activity data (1.A.3.a, 1.C.1.a)
- Adjustment of the activity data for diesel fuel and petrol, to bring them into line with the revised mineral-oil data of the Association of the German Petroleum Industry (MWV) (for the period as 2005) (1.A.3.b, c, d)
- Revision of the TREMOD calculation model with regard to LPG and CNG (1.A.3.b)
- Recalculation of the quantities of co-combusted lubricants, on the basis of revised mileage data (2008-2010) (1.A.3.b)
- Revision of the EF(CH_4) for diesel fuel and biodiesel (1.A.3.c)
- Recalculation of the activity data for added biofuels and co-combusted lubricants (for the period as of 2005) (1.A.3.c)
- Revision of quantities of co-combusted lubricants (2010) (1.A.3.d)
- Recalculation of the activity data for petrol (for the period as of 1995) (1.A.3.e ii, 1.A.4.c ii)
- Recalculation of the activity data for petrol (for the period as of 1995) (1.A.4.c ii)
- Adjustment of various items of activity data, in keeping with corrected net calorific values (2009, 2010) (1.A.5.a)
- Adjustments to carbon dioxide emissions, in keeping with the results of a research project (1.B.1)
- Adjustments to methane emissions, in keeping with the results of a research project in the area of natural gas storage (1.B.2)
- Updating of the activity data for heavy heating oil and co-combusted lubricants (2010) (1.C.1.b)

Industrial processes:

- Correction of the entire time series for CO_2 emissions from lime production (2.A.2)

- Correction of the CO_2 emissions from soda-ash use in the glass industry, following correction of the pertinent activity data (for the period as of 2007) (2.A.4.b)
- Reduction of F-gas emissions, in keeping with the introduction of new models for refrigeration and air conditioning (2.F.1)
- Correction of inputs of SF_6 as a tracer gas, from 150kg/a to 20kg/a (for the period as of 2007) (2.F.9)

Solvent and other product use: - no recalculations -

Agriculture:

- Updating of animal numbers within the category "other cattle" (cattle for fattening and for slaughter, which through the NIR 2012 were assigned to the "heifers" sub-category, have been reassigned to the "suckler cows" sub-category). (4.A, 4.B)
- Improvement of the dairy-cow model (CH_4-conversion factor for enteric fermentation; complete inclusion, within the N-flow concept, of nitrogen in hair and skin) (4.A, 4.B)
- Updating of animal performance data (dairy cattle, other cattle, swine, poultry) (4.A, 4.B)
- Introduction of national values for maximum CH_4-formation capacity B_o, and storage-specific methane conversion factors *MCF*, for cattle and swine (4.B)
- Introduction of a national N_2O-emission factor for solid manure (4.B)
- Updating of the N-flow concept with regard to inclusion of N_2O, NO and N_2 emissions from housing and storage (4.B)
- Inclusion of anaerobic digestion of slurry, including management of digested slurry (4.B)
- Changes in the nitrogen activity data for N_2O emissions from agricultural soils, as a result of the aforementioned changes in the area of animal husbandry (4.D)
- Updating of sewage-sludge quantities for 2010 (4.D)
- Updating of areas with organic soils (4.D)

Land use, land-use changes and forestry:

- Change in the basis for calculation of activity data (areas) 2009 – 2011 (5.A – 5.F)
- New ATKIS data for 2011 (5.A - 5.F)
- New emission factors (CO_2 and N_2O) for mineral soils in forests (5.A – 5.F);
- Complete data from the Forest Soil Inventory II (BZE II) (5.A – 5-F)
- New emission factors for litter (5.A - 5.F)
- Change in the methods for determining the below-ground biomass of woody grassland (5. A – 5.F)
- Correction in the biomass emission factors for cropland (5.A – 5.F)
- First-time use of B-DLM-based activity data for peat extraction (5. D, 5.E)

Waste and wastewater:

- Use of a new data source for methane collection at decommissioned landfills (ab 1999) (6.A.1)
- Updating of statistical input data for 2010 (6.D)

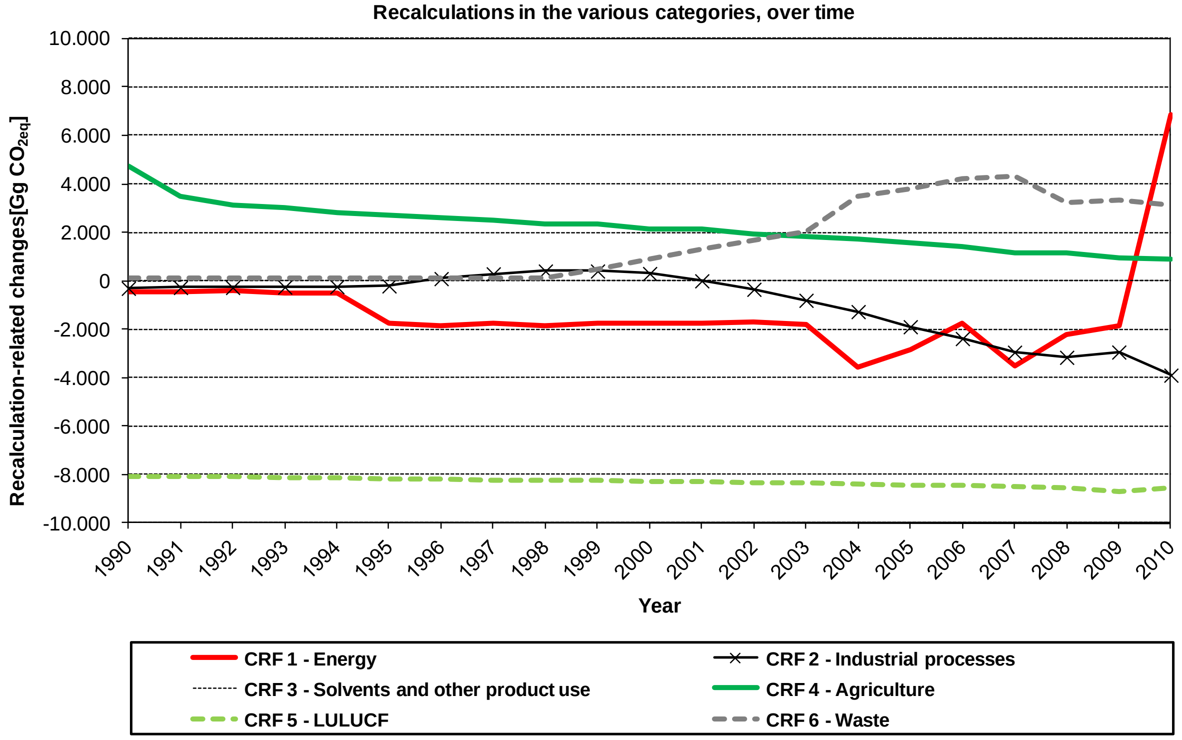


Figure 73: Change in total emissions, for all categories, and for the entire time series, in comparison to the relevant figures in the 2012 Submission

10.1.1.3 Recalculations in the 2013 inventory, by gases

Recalculations were carried out in the following source categories (cf. also the specifications in 10.1.1.2):

Table 302: Source categories in which new recalculations of the inventory, with regard to last year's report, were required

CRF	CO_2	CH_4	N_2O	F gases
1 – Energy	x	x	x	
2 – Industrial processes	x			x
3 – Solvent and other product use				
4 – Agriculture	x	x	x	
5 – LULUCF	x	x	x	
6 – Waste & wastewater		x		

Table 303: Percentage change, resulting from inventory recalculations, with respect to last year's report

	Base year (1990 / 1995)	2010
	Relative change	
Total (CO_2 equiv.)	0.33%	0.75%
CO_2	-0.02%	0.87%
CH_4	2.65%	5.64%
N_2O	1.79%	-0.15%
HFC, PFC, SF_6	0.70%	-17.90%

Emissions without LULUCF; Source: own calculations

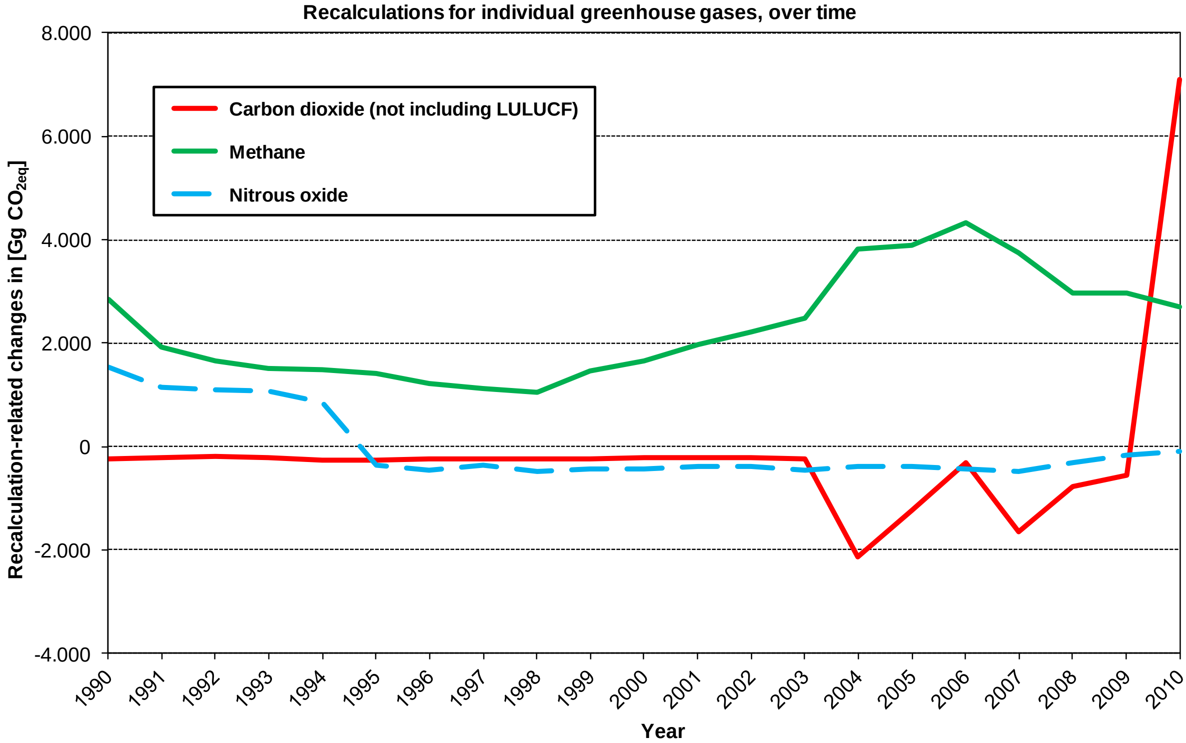


Figure 74: Recalculations of total emissions, for all source categories, and for the entire time series, in comparison to the relevant figures in the 2012 Submission

10.1.1.4 Recalculations carried out to implement results of the review process

With regard to the 2012 Submission, the following recalculations were carried out as a result of the review processes under UNFCCC and UNECE:

- Revision of methane collection at decommissioned landfills (for the period as of 1999) (6.A.1) – as a result of the UNFCCC 2010 In-Country Review
- Correction of the entire time series for CO_2 emissions from lime production (2.A.2) – as a result of the UNECE 2011 Centralized Review
- Use of new emission factors for mineral soils, on the basis of complete data from the Forest Soil Inventory II (BZE II) (5.A – 5.F)

10.1.2 KP-LULUCF inventory

10.1.2.1 General procedure

The methods used for recalculations under the Kyoto Protocol are the same as those used under the Convention. Detailed information on the general procedure is provided in Chapter 10.1.1.1.

10.1.2.2 Recalculations in the 2013 inventory, by source categories

- With regard to activity data, the current data records of the Basis-DLM (2011) were taken into account in derivation of the relevant areas. This necessitated recalculations for the years 2009 and 2010.
- For mineral soils, use of final BZE II data made it possible to derive different EF for afforestation and deforestation (KP 3.3) and for forest management (KP 3.4). Further pertinent information is provided in Chapter 7.2.4.4.

- The correction of biomass data yielded other emission factors (EF) for biomass as well, for previous uses in connection with afforestation and subsequent uses in connection with deforestation (KP 3.3) (cf. Chapter 7.1.7).
- The emission factors for the litter category were adjusted to take account of the available final data from the BZE II / BioSoil surveys, for afforestation and deforestation areas (KP 3.3) and for forest management (KP 3.4) (cf. Chapter 7.2.4.3).

10.1.2.3 Recalculations in the 2013 inventory, by gases

CO_2 recalculations were carried out for mineral soils, biomass and litter. No recalculations were required for nitrous oxide (N_2O) and methane (CH_4).

10.1.2.4 Recalculations carried out to implement results of the review process

- No review-related recalculations were carried out with respect to the 2012 Submission.

10.2 Impact on emissions levels

10.2.1 Greenhouse-gas inventory

The changes with respect to the 2012 Submission, at +0.3 % for 1990 and +0.75 % for 2010, are relatively small.

Table 306 and Table 307 show the changes in emissions as reported for 1990 and for 2010, for the various CRF sectors.

The inventory has been improved with regard to completeness and accuracy.

Table 304: Recalculations-related absolute and percentage changes in total national emissions, without CO_2 from LULUCF, with respect to last year's report

Year	2012 Submission [Gg CO_2 equivalent]	2013 Submission [Gg CO_2 equivalent]	Change, absolute	Change, relative
1990	1,246,407	1,250,529	4,122	0.33%
1991	1,200,651	1,203,512	2,861	0.24%
1992	1,150,852	1,153,405	2,554	0.22%
1993	1,141,686	1,144,075	2,390	0.21%
1994	1,122,050	1,124,201	2,151	0.19%
1995	1,117,698	1,118,588	890	0.08%
1996	1,136,625	1,137,527	902	0.08%
1997	1,100,494	1,101,613	1,118	0.10%
1998	1,074,642	1,075,665	1,023	0.10%
1999	1,040,323	1,041,792	1,470	0.14%
2000	1,039,264	1,040,857	1,593	0.15%
2001	1,054,025	1,055,681	1,656	0.16%
2002	1,032,891	1,034,424	1,533	0.15%
2003	1,031,084	1,032,353	1,269	0.12%
2004	1,019,509	1,019,838	328	0.03%
2005	997,544	998,194	650	0.07%
2006	999,164	1,000,653	1,490	0.15%
2007	977,257	976,209	-1,048	-0.11%
2008	976,233	975,257	-976	-0.10%
2009	912,064	911,578	-486	-0.05%
2010	936,798	943,791	6,992	0.75%

Source: own calculations

Table 305: Recalculations-related percentage changes, with respect to last year's report, in inventory data reported for informational purposes

	Relative change	
	1990	**2010**
Emissions from international transports	**0.00%**	**-0.20%**
Air transports	0.00%	-0.28%
Maritime transports	0.00%	0.00%
Multilateral missions	**NE**	**NE**
CO_2 emissions from biomass	**0.00%**	**12.81%**

Source: own calculations

10.2.1.1 Impacts on 1990 emissions levels

Total emissions (without CO_2 from LULUCF) for 1990 increased slightly, by a total of about 0.33 %, or 4,122 Gg (cf. Table 306).

The largest absolute change occurred in the *Agriculture* sector; it amounted to +4,752 Gg, or +5.7 %.

At -436 Gg (-0.04 %), -309 Gg (-0.33 %) and +119 Gg (+0.28 %), respectively, the changes made for 1990 in the areas *Energy*, Industrial processes and *Waste and wastewater* are small by comparison.

The emissions reported for the area *Solvents and other product use* have remained unchanged.

The reduction in the CH_4 and N_2O emissions reported for the *LULUCF* sector, amounting to nearly 3 Gg or 1.25 %, has only a slight impact on the inventory as a whole.

Other significant changes – among the changes that do not enter into the inventory – were made in this sector's CO_2 removals and emissions. In this area, recent, extensive methodological revision has resulted in a decrease in the emissions reported for 1990, amounting to about 8,000 Gg or nearly 29 %.

More detailed pertinent information, in addition to that provided in the following table, is available in CRF tables 8(a)s1 and 8(a)s2.

Table 306: Recalculation of CRF-specific total emissions, for all greenhouse gases in 1990

	Submission 2012 [Gg CO_2 equivalent]	Submission 2013 [Gg CO_2 equivalent]	Change, absolute	Change, relative
Total national emissions (not including CO_2 from LULUCF)	**1,246,407**	**1,250,529**	**4,122**	**0.33%**
1. Energy	1,020,759	1,020,323	-436	-0.04%
2. Industrial processes	94,580	94,271	-309	-0.33%
3. Solvent and other product use	4,477	4,477	0	0.00%
4. Agriculture	83,211	87,963	4,752	5.71%
5. Land-use changes and forestry	-27,699	-35,758	-8,059	-29.09%
CO_2 (net emissions / removals)	*-27,968*	*-36,024*	*-8,055*	*-28.80%*
N_2O + CH_4 (emissions)	*269*	*266*	*-3*	*-1.25%*
6. Waste and wastewater	43,111	43,230	119	0.28%

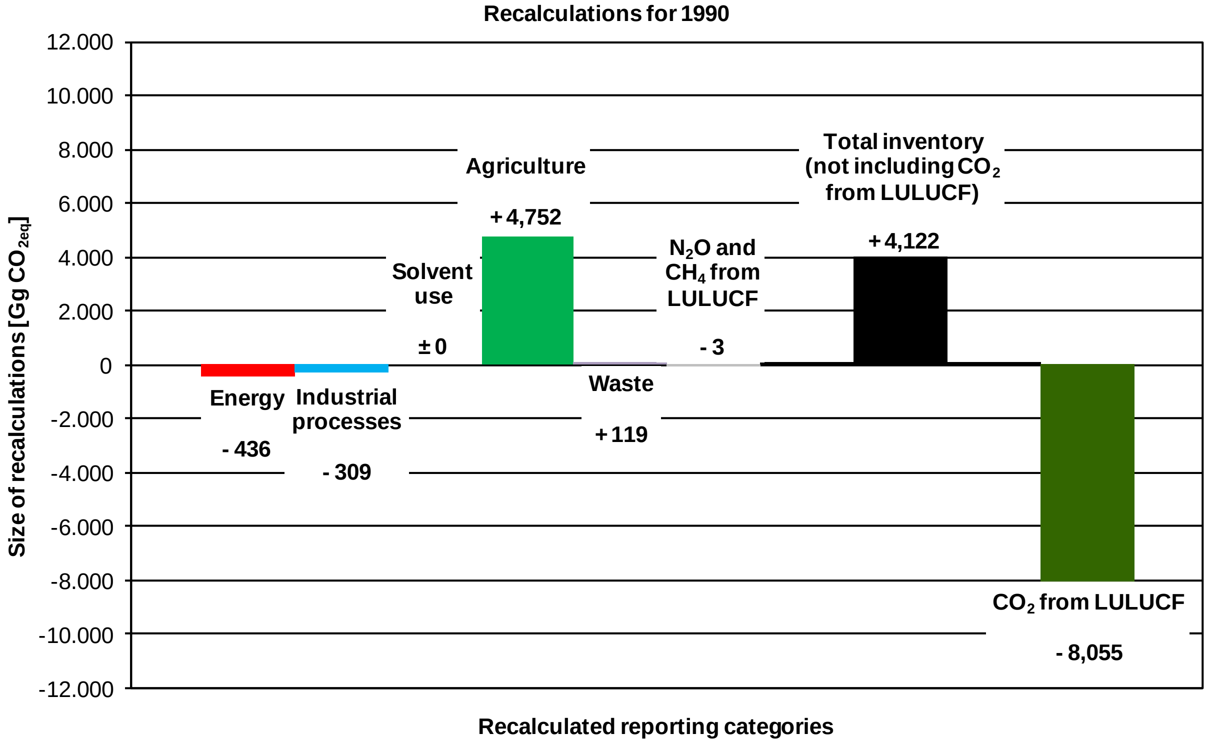


Figure 75: Recalculations of all greenhouse gases for 1990

10.2.1.2 Impacts on emissions levels of categories in 2010

The total emissions from LULUCF (not including CO_2) reported for 2010 have increased by 6,992 Gg, or 0.75 %, in comparison to the 2012 Submission (cf. Table 307).

The largest absolute changes in this area occurred in the *Energy* (+6,866 Gg) and *Industrial processes* (-3,893 Gg) sectors. For the CRF 1 sector, this is due especially to the revision of the 2010 Energy Balance. The comprehensive recalculations carried out in CRF 2 are listed in Chapter 10.1.1.2, and they are discussed in detail in the relevant source-category chapters.

The emissions reported for the area *Solvents and other product use* have remained unchanged, as they did for the year 1990.

The emissions reported for the *Agriculture sector*, increased further however, by +886 Gg, or +1.31 %.

Similarly large adjustments were carried out in the emissions reported for the *Waste & wastewater* sector; those adjustments amounted to +3,115 Gg, or +25.45 %.

The increase in the CH_4 and N_2O emissions reported for the *LULUCF* sector, amounting to nearly 3 Gg or 7 %, has only a slight impact on the inventory as a whole.

Other significant changes – among the changes that do not enter into the inventory – were made in that sector's CO_2 removals and emissions. In that area, the above-mentioned methodological revision has resulted in a considerable decrease in the emissions reported for 2010, amounting to nearly 8,600 Gg, or more than 50 %.

Additional information about recalculations is provided in CRF tables 8(a) and 8(b) and in the table below.

Table 307: Recalculation of CRF-specific total emissions, for all greenhouse gases in 2010

	2011 Submission [Gg CO_2 equivalent]	**Submission 2012 [Gg CO_2 equivalent]**	**Change, absolute**	**Change, relative**
Total national emissions (not including CO_2 from LULUCF)	**936,798**	**943,791**	**6,992**	**0.75%**
1. Energy	782,313	789,179	6,866	0.88%
2. Industrial processes	72,631	68,738	-3,893	-5.36%
3. Solvent and other product use	1,882	1,882	0	0.00%
4. Agriculture	67,479	68,365	886	1.31%
5. Land-use changes and forestry	17,283	8,721	-8,562	49.54%
CO_2 (net emissions / removals)	*17,028*	*8,448*	*-8,580*	*50.39%*
N_2O + CH_4 (emissions)	*255*	*272*	*18*	*7.02%*
6. Waste	12,239	15,354	3,115	25.45%

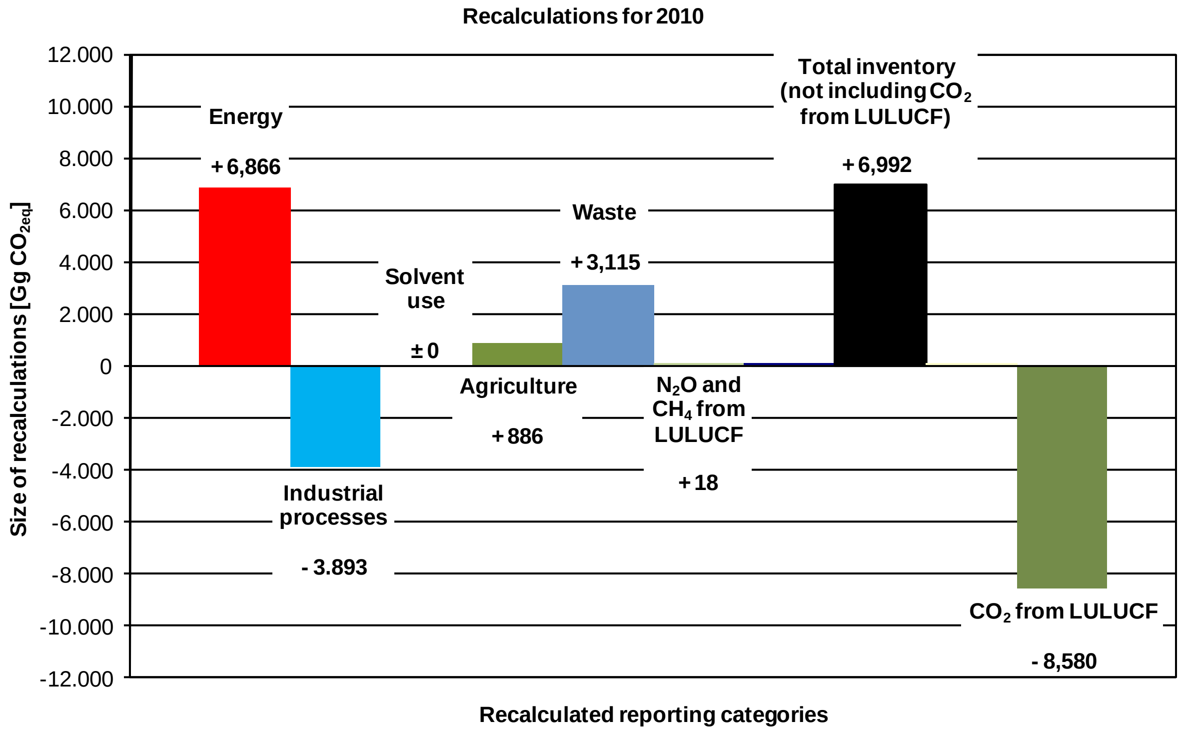


Figure 76: Recalculations of all greenhouse gases for 2010

10.2.2 KP-LULUCF inventory

10.2.2.1 Impacts on emissions levels of categories in 1990

The total sink for 1990 has increased by a total of about 13 %, as a result of methodological corrections and of first-time use of data for mineral soils in connection with forest management (cf. Table 308). To a degree of 99 %, that change is due to the changes in forest management; to a degree of 1 %, it is due to afforestation or deforestation.

Table 308: Recalculation of total KP-LULUCF emissions, for all gases in 1990

	Submission 2012 [Gg CO_2 equivalent]	Submission 2013 [Gg CO_2 equivalent]	Change, absolute [Gg CO_2 equivalent]	Change, relative [%]
Afforestation (KP3.3)	1,139	1,173	34	2.98%
Deforestation (KP3.3)	2,102	2,038	-64	-3.04%
Forest management (KP3.4)	-69,326	-77,758	-8,432	12.16%
Total	**-66,085**	**-74,547**	**-8,462**	**12.80%**

10.2.2.2 Impacts on emissions levels of categories in 2010

The total removals for 2010 have increased by 32 % in comparison to the 2012 Submission. This is due primarily to first-time use of data for mineral soils in connection with forest management.

Table 309: Recalculation of total KP-LULUCF emissions, for all gases in 2010

	Submission 2012 [Gg CO_2 equivalent]	Submission 2013 [Gg CO_2 equivalent]	Change, absolute [Gg CO_2 equivalent]	Change, relative [%]
Afforestation (KP3.3)	-5,945	-5,700	245	4.12%
Deforestation (KP3.3)	120	112	-8	-6.67%
Forest management (KP3.4)	-19,410	-27,697	-8,287	42.69%
Total	**-25,235**	**-33,285**	**-8,050**	**31.90%**

10.3 Impacts on emissions trends and on time-series consistency

10.3.1 Greenhouse-gas inventory

The time-series consistency has improved as a result of the recalculations.

As a result, the trend for total national emissions (not including CO_2 from LULUCF) shows a reduction of 27 % with respect to the current base year.

Following a recent considerable increase, pure CO_2 emissions, at -3.4 %, are considerably lower than they were in the post-crisis year 2010. CH_4 emissions decreased by similarly large amount, with the change amounting to -3.1 %. Nitrous oxide emissions, on the other hand, increased markedly from their 2010 levels; the increase amounted to 4.1 %. The trends for HFC, PFC and SF_6 emissions have been diverging from each other: With respect to 2010, HFC emissions are up by 2.4 %, while PFC emissions are down by 19.5 %. SF_6 emissions have increased by 4 %.

10.3.2 KP LULUCF inventory

The time series remained consistent, thanks to recalculations. A significant improvement in emission estimation was achieved, especially via first-time use of data for mineral soils in connection with forest management. Overall, that improvement has led to emissions adjustments for afforestation, deforestation and cultivated areas (cf. Chapter 10.2.2).

10.4 Improvements in the inventory

10.4.1 Greenhouse-gas inventory

The following table summarises the improvements made in greenhouse-emissions reporting on the basis of the ERT's references and remarks in past reviews under the UN Framework Convention on Climate Change and the Kyoto Protocol. The table lists only aspects that were not already successfully addressed during the Review.

Table 310: Compilation of the review recommendations that have been successfully addressed and that are documented in the IP

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR Chapter
National Systme	ARR 2008 § 21a; ARR 2011 §15	ERT recommended that Germany should continue its efforts to complete and strengthen the well developed national system, i.e. Full implementation of the QA/QC plan; securing the timely completion of the energy balance; archiving agreement between Destatis and vTI regarding confidentiality issues and availability of agricultural statistics; eliminating data problems relating to railway transport; reaching agreement with Eurocontrol on data exchange; and developing an integrated concept for LULUCF sector.	With the conclusion on the integrated concept for LULUCF by the German Ministry for Agriculture and Consumer Protection all issues from this recommendation have been established, beside the agreement with Eurocontrol, which will be negotiated by the European Commission for all MS	
QA / QC	ARR 2010 § 16e, 46d	Include information on the results of the QA / QC procedures in the NIR	Descriptions of the results of QA/QC procedures aure included in respective NIR chapters	
Key Category Analysis	ARR 2011 § 19	Germany has also conducted a key category assessment for activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol, following the IPCC good practice guidance for LULUCF. However, all KP-LULUCF activities (CO2) are identified as key categories according to CRF table NIR 3, while annex 1 to the NIR included only afforestation/reforestation and forest management (CO2) as key categories. The ERT recommends that Germany ensure consistency of its reported key category analysis results in its next annual submission.	Germany has corrected the inconsistency in its 2013 submission	Chapter 17.1
Key Category Analysis	ARR 2011 § 18	The ERT welcomes this plan to improve the key category analysis in Germany and recommends that Germany document the criteria the key category analysis it uses in its next annual submission.	Germany has included qualitative criteria in its key category analysis in the submission 2012	Chapter 17.1.2
Uncertainties	ARR 2011 § 21	The ERT noted some inconsistencies in the NIR explaining the tier applied. The tier 2 analysis is performed every three years (most recently for the 2010 submission). However, in some places in the NIR it is mentioned that tier 1 is applied for the 2011 submission, and elsewhere references are made to tier 2. The ERT recommends that Germany enhance the QC of the NIR before submission in order to avoid inconsistencies of information.	Germany revised the respective chapter and corrected the inconsistency	
Recalculation	ARR 2011 §22	The rationale and impact of these recalculations is generally provided in the NIR and in CRF table 8(b). However, the ERT noted that in some cases further documentation of the recalculations is needed (see paras. 36, 55, 63, 67 and 79 below) and recommends that Germany improve the transparency of its recalculations at the category level in its next annual submission.	Germany has improved the detail of information provided regarding rationales and impacts of recalculations in both CRF tables and NIR	Chapter 10.1
1.	ARR 2009 §§ 43, 45d	ERT reiterates the recommendation from previous reviews the effective improvement of the timeliness of the availability of the energy balance.	The NIR chapter 18 contains a justification on why the timeliness of the availability of the energy balance can not further imporoved	Chapter 18
1.	ARR 2011 § 43	Quantitative uncertainties for AD and EFs for several subcategories in manufacturing industries and construction (e.g. iron and steel) are not available in the NIR, but are available only as combined	Germany included AD and EFs uncertainties in the respective NIR chapter on uncertainties	Chapter 23

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR Chapter
		uncertainties reported as per cent of national total emissions. ..To increase the transparency of the inventory, the ERT recommends that Germany include this information in its next annual submission, preferably briefly in the category sections, but also as a whole in an annex to the NIR		
1.A.	ARR 2010 § 64; ARR 2011 § 45	CO2 emissions from fuel combustion were estimated using the reference approach and the sectoral approach. ... The ERT also noted large differences between inventory data and corresponding IEA data. The ERT recommends that Germany explain the reasons for these differences in the reference approach and the sectoral approach in the CRF documentation box and in the NIR and, to the extent possible, also explain the differences between its data and the corresponding IEA data.	As the data source for the joint annual questionnaire of the IEA has changed the inventory data and the corresponding ÎEA from 2010 onwards are consistent in the meantime.	
1.A.	ARR 2010 § 67; ARR 2011 §47	The ERT noted that the reporting of feedstocks includes the coke oven coke input of blast furnaces and that the carbon storage fractions used differed significantly from the defaults contained in the Revised 1996 IPCC Guidelines. Germany did not provide proper justification for these departures from the Revised 1996 IPCC Guidelines. The ERT recommends that the Party provide justification or reconsider the methodology and storage fractions used.	Germany uses the IPCC 1996 default values since the submission 2012	Chapter 20 Annex 4
1.A.	ARR 2008 §27; ARR 2011 § 24	ERT encourages Germany to correct the discrepancies between CRF tables 1.C and 1.A(b) for gas/diesel and residual fuel oil for 2005 and 2006	The respective data have been revised and corrected, hence no discrepancies occur	
1.B.1	Initial Review § 60	The ERT recommends that Germany add transparency to its calculation by providing the number of decommissioned mines, potential emissions and gas recovery per year in its NIR		
4.	ARR 2010 §§ 100, 105	The ERT recommends that Germany use country-specific EFs in inventory development and document the rationale for using these accordingly and in line with the IPCC good practice guidance. The ERT also recommends that Germany review its reasoning and justification (i.e. argumentation) on the use of the 2006 IPCC Guidelines.	The respective chapters have been reviesed and updated	Various chapters
4.B.	ARR 2011 § 75	The N excretion rate for dairy cattle (131.5 kg N/head/year) for 2009 is the highest reported by Parties (range 68–131.5 kg N/head/year) and above the IPCC default range (60–100 kg N/head/year). During an internal review, Germany found that the N excretion rates used for dairy cattle are too high due to an overestimation of the N content in the feed. The ERT recommends that Germany correct this in its next annual submission.	Germany corrected the N excretion rate for dairy cattle in the submission 2012	Chapter 6.3
5.	ARR 2010 § 10	ERT identified a need for improvement in the quality of reporting under Article 3, paragraphs 3 and 4, of the Kyoto Protocol. There were numerous deficiencies and errors, which meant that the ERT was not able to assess the accuracy of the reporting. Germany was requested by the ERT to provide an action plan outlining how it plans to resolve the issues identified by the ERT. Germany provided this plan on 5 November 2010. The ERT recommends that Germany implement the planned improvements set out in this action	The Action Plan on resolutions of issues identified in the LULUCF sector has been completely implemented in this submission	Various chapters

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR Chapter
		plan as far as possible and to report thereon in its 2011 annual submission, and to provide information from its action plan in the national inventory report (NIR). In response to the draft annual review report,		
5.	ARR 2010 § 24c, 25, 39	The ERT noted several errors and mistakes in the reporting, especially in the LUUCF sector, and concluded that the implementation of the QA/QC procedures needs to be strengthened.	According to the complete implementation of the action plan the QA/QC procedures are strengthend.	
5.	ARR 2011 § 86	The ERT reiterates the recommendation in the previous review report that Germany include subdivisions, such as extracted peatlands and natural or re-established wetlands, to improve transparency.	Germany revised and improved the respective chapters	Chapter 7
5.A.1	ARR 2009; §90	ERT recommends that Germany either report information supporting the underlying assumption that carbon stocks are in an equilibrium or provide estimates of emissions and removals for this category in ist next submission	Germany provide in this submission estimates of emissions and removals	Chapter 7.2.4.4

All measures are aimed at achieving complete consistency with the UNFCCC report guidelines and the IPCC Guidelines and at preventing any adjustments under the Kyoto Protocol.

The following tables summarise the information, as provided in the various source-category chapters of the past three inventory reports, relative to planned improvements. The information entries, which are organised by processing status, include details on resulting needs for further action and various kinds of additional information.

Table 311: Summary of the planned improvements mentioned in the NIR source-category chapters

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
1.	Energy	In future, CO2 verification will have to be improved especially via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). In the process, reference data from detailed emissions calculation (primarily, activity data) are to be compared more closely with aggregated data from emissions trading. Initial pertinent results are presented in the relevant source category chapters.	Verifiability of CO2 emissions is to be improved via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). To that end, comparison of a) reference data from detailed emissions calculation (primarily, activity data) and b) aggregated data from emissions trading is to be intensified.	2012		Chap. 3.2.1.2.3	2012
1.A	Fuel Combustion Activities	In future, CO2 verification is to be improved especially via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). In the process, reference data from emissions calculation (primarily, activity rates) are to be compared more closely with aggregated data from emissions trading.	Cross-checking of calculated emissions data against aggregated emissions-trading data provided by the German Emissions Trading Authority (DEHSt) needs to be intensified.	2011		Chap. 3.2.1.2.3	2011
1.A.1.a	Public electricity and Heat Production	In addition, plans call for further improvement of the methods for calculating activity data for waste incineration.	Methods for calculating activity data for waste incineration have to be improved further.	2011		Chap. 3.2.6.6	2011
1.A.3.a	Civil Aviation	The Federal Environment Agency continues to seek an agreement with Eurocontrol regarding the provision of original Eurocontrol data.	An agreement needs to be reached with Eurocontrol relative to provision of original Eurocontrol data.	2011	By now under the auspices of the EU. Therefore no task for the UBA any more.	Chap. 3.2.10.1.6	2011
1.A.3.a	Civil Aviation	As soon as Eurocontrol provides data from the AEM 3 model, such data can be used in reporting. With such data, the applicable share for national air transports, the breakdown of kerosene consumption by the two relevant flight phases and NOx, HC and CO emissions data would all be based on calculations pursuant to Tier 3b.	As soon as an agreement between the EU and EUROCONTROL, concerning the availability of data (AEM 3 data), has been achieved, Eurocontrol data have to be integrated within the inventory	2011	Will become part of the inventory plan, at the time when an agreement between EU and EUROCONTROL is achived.	Chap. 3.2.10.1.6	2011
1.A.3.c	Railways	A project is determining the quantities of coal and coke, and of all other fuels in addition to diesel fuel and biodiesel, used since 1990 .	After the project's completion, data for all fuels should be updated where necessary.	2012		Chap. 3.2.10.3.6	2012
1.A.3.d	Navigation	In a project, the basic data used in the TREMOD module for inland shipping are being extensively revised.	After the project's completion, the basic data used for inland shipping have to be updated.	2012		Chap. 3.2.10.4.6	2012
1.A.3.e	Other Transportation	In future, emissions from construction-sector transports will be reported under 1A.2.f ii. No additional improvements are planned at present.	Emissions calculations relative to construction-related transports have to be reported under 1A.2.f ii.	2011	The planned re-allocation of emissions from mobile sources in construction	Chap. 3.2.10.5.6	2011

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
					activities currently reported under 1.A.3.e ii to CRF sub-category 1.A.2.f ii in order to achieve comparability to the UNECE NFR structure and with the goal to meet likely new requirements according to the draft 2006 reporting guidelines was cancelled as the final 2006 reporting guidelines as well as the corresponding CRF tables do not incorporate these changes.		
1.B.1.c	Solid Fuels: Abandoned Mining	Scientific estimates of the relevant quantities of fugitive methane emissions from decommissioned sections of mines are now available. To date, experts have placed these emissions at 300 million m³ and assumed that some 5 million m³ of these escape into the atmosphere. Since this figure is subject to large uncertainties, a research project on "Potential for release and use of pit gas" is working to improve it. Fugitive releases at ground surface amount to no more than 0.02 ‰ of total gas releases.	Results from the project have to be integrated within the inventory.	2011		Chap. 3.3.1.3.6	2011
1.B.1.c	Solid Fuels: Abandoned Mining	Scientific estimates of the relevant quantities of fugitive methane emissions from decommissioned sections of mines are now available. To date, experts have placed these emissions at about 260 million m³ and assumed that some 0.5 million to 1 million m³ of these escape into the atmosphere. Fugitive releases at ground surface amount to no more than 0.02 ‰ of total gas releases. The determined emissions have been verified, via research projects, to the year 2009. Plans call for the estimates for subsequent years to be verified as well.	For years as of 2010, estimates relative to the levels of fugitive methane emissions from decommissioned sections of mines need to be verified.	2012		Chap. 3.3.1.3.6	2012
1.B.2	Oil and Natural Gas	The results produced by a research project of Müller-BBM (2009a) include an analysis of the source categories 1.B.2.a.iii-vi, which need to be improved. Additional studies will be carried out in order to obtain still-lacking emission factors	Lacking emission factors and activity data have to be determined.	2011		Chap. 3.3.2.2	2011

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
		and activity rates for these categories.					
1.B.2	Oil and Natural Gas	The results produced by a research project of Müller-BBM (2009a) include an analysis of the source categories 1.B.2.a.i-vi, which need to be improved. Additional studies will be carried out in order to obtain still-lacking emission factors and activity data for these categories.	Lacking emission factors and activity data have to be determined.	2012		Chap. 3.3.2.2	2012
1.B.2	Oil and Natural Gas	Research projects are underway to verify emission factors for storage of natural gas.	Emission factors for storage of natural gas need to be verified.	2012		Chap. 3.3.2.2	2012
1.B.2	Oil and Natural Gas	Plans also call for verification of emission factors for gas distribution.	Emission factors for distribution of natural gas need to be verified.	2012		Chap. 3.3.2.2	2012
2.A.2	Lime Production	The emission factors determined, in the framework of a research project, on the basis of emissions declarations of German lime works (including works producing dolomite) are only of limited use for verification of the figures in the CSE. The completion of that project has been delayed.	Results from the project have to be integrated within the inventory.	2011		Chap. 4.2.2.6	2011
2.A.7.(a)	Mineral Products: Other - Glass Production	At present, review of various items of information relative to cullet input is planned. Such review could lead to improvements and slight changes in the relevant emissions level.	The figures relative to cullet inputs need to be reviewed. This should include research into data sources – possibly, carried out via the National Co-ordinating Committee. (cf. also "additional need for action")	2011		Chap. 4.2.7.6	2011
2.A.7.(a)	Mineral Products: Other - Glass Production	At present, review of various items of information relative to cullet input is planned. Such review could lead to improvements and slight changes in the relevant emissions level.	The figures relative to cullet inputs need to be reviewed. This should include research into data sources – possibly, carried out via the National Co-ordinating Committee.	2012		Chap. 4.2.7.6	2012
2.C.1	Iron and Steel Production	The plausibility of the consistent statistical figures, net calorific values and emission factors required for the carbon balance for primary steel production is to be reviewed via discussions among experts.	Expert discussions need to be carried out to review the plausibility of the statistical data, net calorific values and emission factors required for the carbon balance for primary steel production.	2011		Chap. 4.4.1.6	2011
2.C.1	Iron and Steel Production	The plausibility of the consistent statistical figures, net calorific values and emission factors required for the carbon balance for primary steel production is to be reviewed via discussions among experts.	Expert discussions need to be carried out to review the plausibility of the statistical data, net calorific values and emission factors required for the carbon balance for primary steel production.	2012		Chap. 4.4.1.6	2012
2.C.3	Aluminium Production	Determination of uncertainties continues, with the involvement of the industry association. The correct PFC emissions for 2009 will be submitted later.	The "correct" PFC emissions for 2009 need to be incorporated, and the relevant uncertainties need to be determined.	2011		Chap. 4.4.3.6	2011
2.C.4	SF6 Used in Aluminium and Magnesium Foundries	For some time now, discussions have been underway with users with the aim of determining how realistic it is to assume that the emission factor for the aluminium industry is "1". We expect such discussion to produce concrete results by the next round of reporting. In all likelihood, such results will lead to correction of the emission factor.	The emission factor needs to be corrected on the basis of discussions with the "users".	2011		Chap. 4.4.4.6	2011
2.D.1	Pulp and Paper	The CO2 emissions from caustification in sulphate pulp production are of biogenic origin; thus, they do not have to be reported. In future, CO2 of biogenic origin may also be reported, in the interest of enhancing transparency.	Review of whether CO2 of biogenic origin should be reported in future.	2012		Chap. 4.5.1.6	2012
2.F.1	Refrigeration and Air Conditioning equipment	The refrigerant models being used are to be reviewed for currentness.	The refrigerant models used need to be reviewed for currentness.	2012		Chap. 4.7.1.5	2012

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
4.A	Enteric Fermentation	At the recommendation of the ERT of the in-country review of September 2010, an effort is being made to derive a national methane-conversion factor for dairy cows.	A national methane-conversion factor for dairy cows needs to be derived.	2012		Chap. 6.2.6	2012
4.B	Manure Management	In 2010, the Federal Statistical Office conducted an extensive survey of agricultural data ("Landwirtschaftliche Zählung 2010" ("agricultural census 2010"), LZ2010). Analysis of the LZ2010, with regard to data of relevance for the inventory, is being carried out as of the end of 2010, in co-operation with the Federal Statistical Office.	The results of LZ 2010 have to be integrated within the inventory.	2011		Chap. 6.3.2.6	2011
4.B	Manure Management	At the recommendation of the ERT of the in-country review of September 2010, an effort is being made to determine methane-conversion factors (MCF), for the storage procedures commonly used in Germany, that adequately represent national circumstances and are consistent with pertinent measurements. Since the methane-conversion factor MCF and the maximum methane-formation capacity Bo have to be set in relation to one another, efforts are also being made to derive national values for Bo. The results will be reviewed by the newly created KTBL working group on climate protection (sub- working group on manure management).	A national methane-conversion factor for storage procedures in Germany needs to be derived.	2012		Chap. 6.3.2.6	2012
4.B	Manure Management	The fact that part of the liquid manure is processed in biogas systems is currently not being taken into account in the inventory, due to a lack of representative activity data. KTBL is currently carrying out a project aimed at supporting collection of required activity data and emission factors for future reports. In addition, a number of research projects on the same topic are being carried out in Germany.	The results of the KTBL project relative to liquid manure in biogas systems need to be integrated within the inventory.	2012		Chap. 6.3.2.6	2012
4.B	Manure Management	The national N2O emission factors currently being used by Germany are to be reviewed by the newly created newly created KTBL working group on climate protection (sub- working group on manure management) (KTBL = Association for Technology and Structures in Agriculture).	The national N2O emission factors need to be reviewed. The inventory should then be revised, if necessary, in light of the results.	2012		Chap. 6.3.4.6	2012
4.D	Agricultural Soils	In 2010, the Federal Statistical Office conducted an extensive survey of agricultural data ("Landwirtschaftliche Zählung 2010" ("agricultural census 2010"), LZ2010). Analysis of the LZ2010, with regard to data of relevance for the inventory, is being carried out as of the end of 2010, in co-operation with the Federal Statistical Office.	The results of LZ 2010 have to be integrated within the inventory.	2011		Chap. 6.5.6	2011
4.D	Agricultural Soils	In March 2011, the Federal Statistical Office plans to carry out a special survey of data relative to application of farm manure. The results of that survey will have an impact on the NH3 and NO emissions of relevance for indirect N2O emissions.	The Federal Statistical Office's special survey "Data on manure spreading" ("Daten zur Wirtschaftsdünger-Ausbringung") has to be integrated within the inventory.	2011		Chap. 6.5.6	2011
4; 5	Agriculture; LULUCF	Improvement of the QA/QC concept (cf. the answer to ERT: Action plan for resolving issues identified by the ERT regarding KP LULUCF).	Completion of the QA/QC concept.	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5.A	Forest Land	Land-use changes In the new German Länder, the relevant areas and land-use changes were determined with the help of the data from the GSE FM-INT project. Forest-land parcels with an area of at least 0.5 hectares were categorised. That categorisation produced some discrepancies with forest areas as determined in accordance with the definition of "forest" used in the National Forest Inventory (BWI). A project is to	Initiation of a project to determine whether, with the help of additional data sources, the relevant areas in the new German Länder can be determined more precisely for the period 1990 to 2005.	2011	Not necessary anymore. For the reason see NIR 2012 chapter 7.1.3.2.1.	Chap. 7.2.8.1	2011

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
		be carried out with the aim determining whether, with the help of additional data sources, the relevant areas in the new German Länder can be determined more precisely for the period 1990 to 2005 (cf. also Chapter 19.5.1.1.3).					
5.A	Forest Land	Litter and mineral soils Still-lacking Länder data records are to be collected for purposes of future evaluations. To date, it has been possible to calculate carbon stocks for only about half of the BZE II soil-survey points. Inclusion of the currently lacking data will make it possible to carry out evaluations on a basis that is statistically more reliable. The approach chosen, involving main soil units, offers potential for more-detailed evaluation, since the analyses have not yet taken account of covariables (texture, precipitation, temperature, inclination, exposition).	The still-lacking Länder data sets needed for calculation of carbon stocks need to be obtained from the Länder. The approach chosen (cf. the relevant individual objective) needs to be further improved.	2011		Chap. 7.2.8.2	2011
5.A	Forest Land	Still-lacking Länder data records are to be collected for purposes of future evaluations. To date, it has been possible to calculate carbon stocks for only about 75% of the BZE II survey points. Inclusion of the currently lacking data will make it possible to carry out evaluations on a basis that is statistically more reliable. The approach chosen, involving dominant soil units, offers potential for more-detailed evaluation, since the analyses have not yet taken account of covariables (texture, precipitation, temperature, inclination, exposition). Furthermore, the BÜK map data are currently being revised. They will soon be published with a higher level of precision (scale of 1:200.000).	The still-lacking Länder data sets needed for calculation of carbon stocks need to be obtained from the Länder. The approach chosen needs to be further improved.	2012		Chap. 7.2.8.2	2012
5.A; 5.B; 5.C; 5.D	Forest Land, Cropland, Grassland, Wetland	The area-identification process, for all categories, will be converted to an approach that uses a point raster and that is consistent for purposes of reporting forest categories and reporting in the KP-LULUCF framework. In addition, that method will simplify use of other data/sources, such as data from the European LUCAS grid, and satellite/aerial photos, etc., thereby making it possible for backward projections to 1990 to draw on additional data sources.	Preparation of a consistent land-use matrix (cf. also the relevant Action Plan), on the basis of a consistent sampling network.	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6; ActPl	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	The point raster will ensure that reporting for the "cropland" category is spatially and chronologically consistent, and it will make it possible to reconstruct actual land use between 1990 and 2000 in a consistent manner.	Reconstruction of a contradiction-free land-use matrix for 1990 (cf. also Action Plan, Chapter 1).	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6; ActPl	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Changes in the system for reporting emissions from mineral soils: Derivation of typical, use-dependent carbon stocks in mineral soils, weighted by soil type and area, for all of Germany Development of a new system for describing carbon-stock changes as a function of land use	Improvement of the procedure for estimating C-stock changes in mineral soils, for all land-use categories, by making a methodological transition to a symmetric approach (cf. also Action Plan Chapter 1).	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6; ActPl	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Change in the system for determining carbon-stock changes in biomass: Reduction in the total number of emission factors, via calculation of area-weighted mean values for all of Germany. An increase, over the number used to date, in the number of plant species that enter into area-weighted mean values	Reduction of the EF used to date, by calculating area-weighted means for all Germany and by including more plant species.	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Change in the system for determining carbon-stock changes in biomass: Separate calculation of carbon stocks for above-ground and below-ground biomass	Calculation of carbon stocks separately for above-ground and below-ground biomass, and determination of new, country-specific default factors for carbon stocks in wood	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6	2011

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
		New country-specific default factors for carbon stocks in wood plantations outside of forests	stands outside of forests (cf. also the Action Plan).				
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Complete, GPG-conformal uncertainties calculation	Requirements-conformal calculation of uncertainties for all land-use categories.	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5.E	Settlements	Planned source-specific improvements for this sector include determination of country-specific emission factors for vegetation cover in cities and settlements and along transport infrastructure. A preliminary study has been commissioned to this end. The project will determine carbon stocks, and their changes, in urban trees. (cf. Chapter 19.5.2.6).	Country-specific emission factors need to be determined for vegetated areas in cities, in settlements and along transport infrastructure. The inventory needs to be revised on the basis of the results of the pilot study and of the pertinent subsequent projects.	2011	Planned improvement has been devided in 2012 Reporting into two improvements.	Chap. 7.6.8	2011
5.E	Settlements	Two pilot projects are currently underway for development of methods for determining wood biomass in settlements. The pilot projects are studying two German cities in this regard.	Country-specific emission factors need to be determined for vegetated areas in cities, in settlements and along transport infrastructure. In addition, such factors must explicitly include hedges. The inventory needs to be revised on the basis of the results of the pilot studies and of the pertinent subsequent projects.	2012		Chap. 7.6.8	2012
6.A.1	Controlled landfilling of waste	An experts' assessment (Wasteconsult international, 2009) has quantified the low residual gas emissions from landfilling of mechanically and biologically treated waste. The assessment confirms that emissions contributions of MBT systems' waste are very low in comparison to total landfill-gas emissions. The assessment also shows that the chronological emissions progression for stored MBT waste cannot be adequately described with the FOD model. The kinetics of landfill-gas formation in MBT waste are to be examined, in a further study, and then described in an improved model.	The results from the project have to be integrated within the inventory.	2011		Chap. 8.2.1.6	2011
6.A.1	Controlled landfilling of waste	In future, the Federal Statistical Office plans to collect data on landfill-gas collection and use also from landfills in their after-closure phases. It is expected that in 2012 environmental statistics will include, for the first time, data on landfill-gas collection that have been collected in a consistent manner, from all relevant landfills.	If environmental statistics in 2012 include consistently collected data on collection of landfill gas, for all landfills, then the inventory needs to be revised accordingly on the basis of the new data.	2011		Chap. 8.2.1.6	2011
6.A.1	Controlled landfilling of waste	An experts' assessment (Wasteconsult international, 2009) has quantified the low residual gas emissions from landfilling of mechanically and biologically treated waste. The assessment confirms that emissions contributions of MBT systems' waste are very low in comparison to total landfill-gas emissions. The assessment also shows that the chronological emissions progression for stored MBT waste cannot be adequately described with the FOD model. The kinetics of landfill-gas formation in MBT waste are to be examined, in a further study, and then described in an improved model. The results of the study are to be used to describe, more precisely, and quantify the expected methane emissions from MBT waste, so that the emissions values derived via expert assessment in the aforementioned study (WASTECONSULT INTERNATIONAL, 2009) can be replaced with the improved data. The study was awarded in October 2011 in the framework of a public	The inventory needs to be improved on the basis of the study results. The study results need to be documented.	2012		Chap. 8.2.1.6	2012

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
		invitation to tender.					
6.A.1	Controlled landfilling of waste	In future, the Federal Statistical Office plans to collect data on landfill-gas collection and use also also from landfills in their after-closure phases. It is expected that in 2012 environmental statistics will include, for the first time, data on landfill-gas collection that have been collected in a consistent manner, from all relevant landfills.	The data on landfill-gas formation that the Umweltstatistik 2012 (2012 environmental statistics) completed need to be integrated within the inventory.	2012		Chap. 8.2.1.6	2012
6.D.1	Composting	Currently, a research project is underway, under commission to the Federal Environment Agency, with the aim of improving the database for the emission factors for CH4 and N2O. The project includes both research, to obtain pertinent literature data, and measurements of composting and fermentation facilities. The project aim is to produce emission factors based on measured emissions from real systems. This project, when completed, is expected to yield new emission factors for both gases.	The results from the project have to be integrated within the inventory.	2011		Chap. 8.5.1.6	2011
6.D.1	Composting	Currently, a research project is underway, under commission to the Federal Environment Agency, with the aim of improving the database for the emission factors for CH4 and N2O. The project includes both research, to obtain pertinent literature data, and measurements of composting and fermentation facilities. The project aim is to produce emission factors based on measured emissions from real systems. The project is expected to yield new emission factors, for both gases, that will then need to be integrated within the inventory.	The results from the project have to be integrated within the inventory.	2012		Chap. 8.5.1.6	2012
6.D.2	Other: MBT	The Federal Environment Agency plans to urge the Federal Statistical Office to take account, in its data collection, of versions of MBT systems that have not been included to date.	The Federal Statistical Office needs to be requested to gather data on types of waste-incineration plants that have not been included in surveys to date. The inventory then has to be revised accordingly.	2011		Chap. 8.5.2.6	2011
6.D.2	Other: MBT	The Federal Environment Agency plans to urge the Federal Statistical Office to take account, in its data collection, of versions of MBT systems that have not been included to date. To that end, a joint discussion involving the MBT operators and the Federal Statistical Office is planned.	The Federal Statistical Office needs to be requested to gather data on types of waste-incineration plants that have not been included in surveys to date. The inventory then has to be revised accordingly.	2012		Chap. 8.5.2.6	2012
1.	Energy	In future, CO2 verification will have to be improved especially via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). In the process, reference data from detailed emissions calculation (primarily, activity data) are to be compared more closely with aggregated data from emissions trading. Initial pertinent results are presented in the relevant source category chapters.	Verifiability of CO2 emissions is to be improved via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). To that end, comparison of a) reference data from detailed emissions calculation (primarily, activity data) and b) aggregated data from emissions trading is to be intensified.	2012		Chap. 3.2.1.2.3	2012
1.A	Fuel Combustion Activities	In future, CO2 verification is to be improved especially via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). In the process, reference data from emissions calculation (primarily, activity rates) are to be compared more closely with aggregated data from emissions trading.	Cross-checking of calculated emissions data against aggregated emissions-trading data provided by the German Emissions Trading Authority (DEHSt) needs to be intensified.	2011		Chap. 3.2.1.2.3	2011

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
1.A.1.a	Public electricity and Heat Production	In addition, plans call for further improvement of the methods for calculating activity data for waste incineration.	Methods for calculating activity data for waste incineration have to be improved further.	2011		Chap. 3.2.6.6	2011
1.A.3.a	Civil Aviation	The Federal Environment Agency continues to seek an agreement with Eurocontrol regarding the provision of original Eurocontrol data.	An agreement needs to be reached with Eurocontrol relative to provision of original Eurocontrol data.	2011	By now under the auspices of the EU. Therefore no task for the UBA any more.	Chap. 3.2.10.1.6	2011
1.A.3.a	Civil Aviation	As soon as Eurocontrol provides data from the AEM 3 model, such data can be used in reporting. With such data, the applicable share for national air transports, the breakdown of kerosene consumption by the two relevant flight phases and NOx, HC and CO emissions data would all be based on calculations pursuant to Tier 3b.	As soon as an agreement between the EU and EUROCONTROL, concerning the availability of data (AEM 3 data), has been achieved, Eurocontrol data have to be integrated within the inventory	2011	Will become part of the inventory plan, at the time when an agreement between EU and EUROCONTRO L is achived.	Chap. 3.2.10.1.6	2011
1.A.3.c	Railways	A project is determining the quantities of coal and coke, and of all other fuels in addition to diesel fuel and biodiesel, used since 1990 .	After the project's completion, data for all fuels should be updated where necessary.	2012		Chap. 3.2.10.3.6	2012
1.A.3.d	Navigation	In a project, the basic data used in the TREMOD module for inland shipping are being extensively revised.	After the project's completion, the basic data used for inland shipping have to be updated.	2012		Chap. 3.2.10.4.6	2012
1.A.3.e	Other Transportation	In future, emissions from construction-sector transports will be reported under 1A.2.f ii. No additional improvements are planned at present.	Emissions calculations relative to construction-related transports have to be reported under 1A.2.f ii.	2011	The planned re-allocation of emissions from mobile sources in construction activities currently reported under 1.A.3.e ii to CRF sub-category 1.A.2.f ii in order to achieve comparability to the UNECE NFR structure and with the goal to meet likely new requirements according to the draft 2006 reporting	Chap. 3.2.10.5.6	2011

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
					guidelines was cancelled as the final 2006 reporting guidelines as well as the corresponding CRF tables do not incorporate these changes.		
1.B.1.c	Solid Fuels: Abandoned Mining	Scientific estimates of the relevant quantities of fugitive methane emissions from decommissioned sections of mines are now available. To date, experts have placed these emissions at 300 million m³ and assumed that some 5 million m³ of these escape into the atmosphere. Since this figure is subject to large uncertainties, a research project on "Potential for release and use of pit gas" is working to improve it. Fugitive releases at ground surface amount to no more than 0.02 ‰ of total gas releases.	Results from the project have to be integrated within the inventory.	2011		Chap. 3.3.1.3.6	2011
1.B.1.c	Solid Fuels: Abandoned Mining	Scientific estimates of the relevant quantities of fugitive methane emissions from decommissioned sections of mines are now available. To date, experts have placed these emissions at about 260 million m³ and assumed that some 0.5 million to 1 million m³ of these escape into the atmosphere. Fugitive releases at ground surface amount to no more than 0.02 ‰ of total gas releases. The determined emissions have been verified, via research projects, to the year 2009. Plans call for the estimates for subsequent years to be verified as well.	For years as of 2010, estimates relative to the levels of fugitive methane emissions from decommissioned sections of mines need to be verified.	2012		Chap. 3.3.1.3.6	2012
1.B.2	Oil and Natural Gas	The results produced by a research project of Müller-BBM (2009a) include an analysis of the source categories 1.B.2.a.iii-vi, which need to be improved. Additional studies will be carried out in order to obtain still-lacking emission factors and activity rates for these categories.	Lacking emission factors and activity data have to be determined.	2011		Chap. 3.3.2.2	2011
1.B.2	Oil and Natural Gas	The results produced by a research project of Müller-BBM (2009a) include an analysis of the source categories 1.B.2.a.i-vi, which need to be improved. Additional studies will be carried out in order to obtain still-lacking emission factors and activity data for these categories.	Lacking emission factors and activity data have to be determined.	2012		Chap. 3.3.2.2	2012
1.B.2	Oil and Natural Gas	Research projects are underway to verify emission factors for storage of natural gas.	Emission factors for storage of natural gas need to be verified.	2012		Chap. 3.3.2.2	2012
1.B.2	Oil and Natural Gas	Plans also call for verification of emission factors for gas distribution.	Emission factors for distribution of natural gas need to be verified.	2012		Chap. 3.3.2.2	2012
2.A.2	Lime Production	The emission factors determined, in the framework of a research project, on the basis of emissions declarations of German lime works (including works producing dolomite) are only of limited use for verification of the figures in the CSE. The completion of that project has been delayed.	Results from the project have to be integrated within the inventory.	2011		Chap. 4.2.2.6	2011
2.A.7.(a)	Mineral Products: Other - Glass	At present, review of various items of information relative to cullet input is planned. Such review could lead to improvements and slight changes in the relevant	The figures relative to cullet inputs need to be reviewed. This should include research into data sources – possibly,	2011		Chap. 4.2.7.6	2011

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
	Production	emissions level.	carried out via the National Co-ordinating Committee. (cf. also "additional need for action")				
2.A.7.(a)	Mineral Products: Other - Glass Production	At present, review of various items of information relative to cullet input is planned. Such review could lead to improvements and slight changes in the relevant emissions level.	The figures relative to cullet inputs need to be reviewed. This should include research into data sources – possibly, carried out via the National Co-ordinating Committee.	2012		Chap. 4.2.7.6	2012
2.C.1	Iron and Steel Production	The plausibility of the consistent statistical figures, net calorific values and emission factors required for the carbon balance for primary steel production is to be reviewed via discussions among experts.	Expert discussions need to be carried out to review the plausibility of the statistical data, net calorific values and emission factors required for the carbon balance for primary steel production.	2011		Chap. 4.4.1.6	2011
2.C.1	Iron and Steel Production	The plausibility of the consistent statistical figures, net calorific values and emission factors required for the carbon balance for primary steel production is to be reviewed via discussions among experts.	Expert discussions need to be carried out to review the plausibility of the statistical data, net calorific values and emission factors required for the carbon balance for primary steel production.	2012		Chap. 4.4.1.6	2012
2.C.3	Aluminium Production	Determination of uncertainties continues, with the involvement of the industry association. The correct PFC emissions for 2009 will be submitted later.	The "correct" PFC emissions for 2009 need to be incorporated, and the relevant uncertainties need to be determined.	2011		Chap. 4.4.3.6	2011
2.C.4	SF6 Used in Aluminium and Magnesium Foundries	For some time now, discussions have been underway with users with the aim of determining how realistic it is to assume that the emission factor for the aluminium industry is "1". We expect such discussion to produce concrete results by the next round of reporting. In all likelihood, such results will lead to correction of the emission factor.	The emission factor needs to be corrected on the basis of discussions with the "users".	2011		Chap. 4.4.4.6	2011
2.D.1	Pulp and Paper	The CO2 emissions from caustification in sulphate pulp production are of biogenic origin; thus, they do not have to be reported. In future, CO2 of biogenic origin may also be reported, in the interest of enhancing transparency.	Review of whether CO2 of biogenic origin should be reported in future.	2012		Chap. 4.5.1.6	2012
2.F.1	Refrigeration and Air Conditioning equipment	The refrigerant models being used are to be reviewed for currentness.	The refrigerant models used need to be reviewed for currentness.	2012		Chap. 4.7.1.5	2012
4.A	Enteric Fermentation	At the recommendation of the ERT of the in-country review of September 2010, an effort is being made to derive a national methane-conversion factor for dairy cows.	A national methane-conversion factor for dairy cows needs to be derived.	2012		Chap. 6.2.6	2012
4.B	Manure Management	In 2010, the Federal Statistical Office conducted an extensive survey of agricultural data ("Landwirtschaftliche Zählung 2010" ("agricultural census 2010"), LZ2010). Analysis of the LZ2010, with regard to data of relevance for the inventory, is being carried out as of the end of 2010, in co-operation with the Federal Statistical Office.	The results of LZ 2010 have to be integrated within the inventory.	2011		Chap. 6.3.2.6	2011
4.B	Manure Management	At the recommendation of the ERT of the in-country review of September 2010, an effort is being made to determine methane-conversion factors (MCF), for the storage procedures commonly used in Germany, that adequately represent national circumstances and are consistent with pertinent measurements. Since the methane-conversion factor MCF and the maximum methane-formation capacity Bo have to be set in relation to one another, efforts are also being made to derive national values for Bo. The results will be reviewed by the newly created KTBL working group on climate protection (sub- working group on manure	A national methane-conversion factor for storage procedures in Germany needs to be derived.	2012		Chap. 6.3.2.6	2012

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
		management).					
4.B	Manure Management	The fact that part of the liquid manure is processed in biogas systems is currently not being taken into account in the inventory, due to a lack of representative activity data. KTBL is currently carrying out a project aimed at supporting collection of required activity data and emission factors for future reports. In addition, a number of research projects on the same topic are being carried out in Germany.	The results of the KTBL project relative to liquid manure in biogas systems need to be integrated within the inventory.	2012		Chap. 6.3.2.6	2012
4.B	Manure Management	The national N2O emission factors currently being used by Germany are to be reviewed by the newly created newly created KTBL working group on climate protection (sub- working group on manure management) (KTBL = Association for Technology and Structures in Agriculture).	The national N2O emission factors need to be reviewed. The inventory should then be revised, if necessary, in light of the results.	2012		Chap. 6.3.4.6	2012
4.D	Agricultural Soils	In 2010, the Federal Statistical Office conducted an extensive survey of agricultural data ("Landwirtschaftliche Zählung 2010" ("agricultural census 2010"), LZ2010). Analysis of the LZ2010, with regard to data of relevance for the inventory, is being carried out as of the end of 2010, in co-operation with the Federal Statistical Office.	The results of LZ 2010 have to be integrated within the inventory.	2011		Chap. 6.5.6	2011
4.D	Agricultural Soils	In March 2011, the Federal Statistical Office plans to carry out a special survey of data relative to application of farm manure. The results of that survey will have an impact on the NH3 and NO emissions of relevance for indirect N2O emissions.	The Federal Statistical Office's special survey "Data on manure spreading" ("Daten zur Wirtschaftsdünger-Ausbringung") has to be integrated within the inventory.	2011		Chap. 6.5.6	2011
4; 5	Agriculture; LULUCF	Improvement of the QA/QC concept (cf. the answer to ERT: Action plan for resolving issues identified by the ERT regarding KP LULUCF).	Completion of the QA/QC concept.	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5.A	Forest Land	Land-use changes In the new German Länder, the relevant areas and land-use changes were determined with the help of the data from the GSE FM-INT project. Forest-land parcels with an area of at least 0.5 hectares were categorised. That categorisation produced some discrepancies with forest areas as determined in accordance with the definition of "forest" used in the National Forest Inventory (BWI). A project is to be carried out with the aim determining whether, with the help of additional data sources, the relevant areas in the new German Länder can be determined more precisely for the period 1990 to 2005 (cf. also Chapter 19.5.1.1.3).	Initiation of a project to determine whether, with the help of additional data sources, the relevant areas in the new German Länder can be determined more precisely for the period 1990 to 2005.	2011	Not necessary anymore. For the reason see NIR 2012 chapter 7.1.3.2.1.	Chap. 7.2.8.1	2011
5.A	Forest Land	Litter and mineral soils Still-lacking Länder data records are to be collected for purposes of future evaluations. To date, it has been possible to calculate carbon stocks for only about half of the BZE II soil-survey points. Inclusion of the currently lacking data will make it possible to carry out evaluations on a basis that is statistically more reliable. The approach chosen, involving main soil units, offers potential for more-detailed evaluation, since the analyses have not yet taken account of covariables (texture, precipitation, temperature, inclination, exposition).	The still-lacking Länder data sets needed for calculation of carbon stocks need to be obtained from the Länder. The approach chosen (cf. the relevant individual objective) needs to be further improved.	2011		Chap. 7.2.8.2	2011
5.A	Forest Land	Still-lacking Länder data records are to be collected for purposes of future evaluations. To date, it has been possible to calculate carbon stocks for only about 75% of the BZE II survey points. Inclusion of the currently lacking data will make it possible to carry out evaluations on a basis that is statistically more reliable. The	The still-lacking Länder data sets needed for calculation of carbon stocks need to be obtained from the Länder. The approach chosen needs to be further improved.	2012		Chap. 7.2.8.2	2012

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
		approach chosen, involving dominant soil units, offers potential for more-detailed evaluation, since the analyses have not yet taken account of covariables (texture, precipitation, temperature, inclination, exposition). Furthermore, the BÜK map data are currently being revised. They will soon be published with a higher level of precision (scale of 1:200.000).					
5.A; 5.B; 5.C; 5.D	Forest Land, Cropland, Grassland, Wetland	The area-identification process, for all categories, will be converted to an approach that uses a point raster and that is consistent for purposes of reporting forest categories and reporting in the KP-LULUCF framework. In addition, that method will simplify use of other data/sources, such as data from the European LUCAS grid, and satellite/aerial photos, etc., thereby making it possible for backward projections to 1990 to draw on additional data sources.	Preparation of a consistent land-use matrix (cf. also the relevant Action Plan), on the basis of a consistent sampling network.	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6; ActPl	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	The point raster will ensure that reporting for the "cropland" category is spatially and chronologically consistent, and it will make it possible to reconstruct actual land use between 1990 and 2000 in a consistent manner.	Reconstruction of a contradiction-free land-use matrix for 1990 (cf. also Action Plan, Chapter 1).	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6; ActPl	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Changes in the system for reporting emissions from mineral soils: Derivation of typical, use-dependent carbon stocks in mineral soils, weighted by soil type and area, for all of Germany Development of a new system for describing carbon-stock changes as a function of land use	Improvement of the procedure for estimating C-stock changes in mineral soils, for all land-use categories, by making a methodological transition to a symmetric approach (cf. also Action Plan Chapter 1).	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6; ActPl	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Change in the system for determining carbon-stock changes in biomass: Reduction in the total number of emission factors, via calculation of area-weighted mean values for all of Germany. An increase, over the number used to date, in the number of plant species that enter into area-weighted mean values	Reduction of the EF used to date, by calculating area-weighted means for all Germany and by including more plant species.	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Change in the system for determining carbon-stock changes in biomass: Separate calculation of carbon stocks for above-ground and below-ground biomass New country-specific default factors for carbon stocks in wood plantations outside of forests	Calculation of carbon stocks separately for above-ground and below-ground biomass, and determination of new, country-specific default factors for carbon stocks in wood stands outside of forests (cf. also the Action Plan).	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Complete, GPG-conformal uncertainties calculation	Requirements-conformal calculation of uncertainties for all land-use categories.	2011		Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5.E	Settlements	Planned source-specific improvements for this sector include determination of country-specific emission factors for vegetation cover in cities and settlements and along transport infrastructure. A preliminary study has been commissioned to this end. The project will determine carbon stocks, and their changes, in urban trees. (cf. Chapter 19.5.2.6).	Country-specific emission factors need to be determined for vegetated areas in cities, in settlements and along transport infrastructure. The inventory needs to be revised on the basis of the results of the pilot study and of the pertinent subsequent projects.	2011	Planned improvement has been devided in 2012 Reporting into two improvements.	Chap. 7.6.8	2011
5.E	Settlements	Two pilot projects are currently underway for development of methods for determining wood biomass in settlements. The pilot projects are studying two German cities in this regard.	Country-specific emission factors need to be determined for vegetated areas in cities, in settlements and along transport infrastructure. In addition, such factors must explicitly include hedges. The inventory needs to be	2012		Chap. 7.6.8	2012

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
			revised on the basis of the results of the pilot studies and of the pertinent subsequent projects.				
6.A.1	Controlled landfilling of waste	An experts' assessment (Wasteconsult international, 2009) has quantified the low residual gas emissions from landfilling of mechanically and biologically treated waste. The assessment confirms that emissions contributions of MBT systems' waste are very low in comparison to total landfill-gas emissions. The assessment also shows that the chronological emissions progression for stored MBT waste cannot be adequately described with the FOD model. The kinetics of landfill-gas formation in MBT waste are to be examined, in a further study, and then described in an improved model.	The results from the project have to be integrated within the inventory.	2011		Chap. 8.2.1.6	2011
6.A.1	Controlled landfilling of waste	In future, the Federal Statistical Office plans to collect data on landfill-gas collection and use also from landfills in their after-closure phases. It is expected that in 2012 environmental statistics will include, for the first time, data on landfill-gas collection that have been collected in a consistent manner, from all relevant landfills.	If environmental statistics in 2012 include consistently collected data on collection of landfill gas, for all landfills, then the inventory needs to be revised accordingly on the basis of the new data.	2011		Chap. 8.2.1.6	2011
6.A.1	Controlled landfilling of waste	An experts' assessment (Wasteconsult international, 2009) has quantified the low residual gas emissions from landfilling of mechanically and biologically treated waste. The assessment confirms that emissions contributions of MBT systems' waste are very low in comparison to total landfill-gas emissions. The assessment also shows that the chronological emissions progression for stored MBT waste cannot be adequately described with the FOD model. The kinetics of landfill-gas formation in MBT waste are to be examined, in a further study, and then described in an improved model. The results of the study are to be used to describe, more precisely, and quantify the expected methane emissions from MBT waste, so that the emissions values derived via expert assessment in the aforementioned study (WASTECONSULT INTERNATIONAL, 2009) can be replaced with the improved data. The study was awarded in October 2011 in the framework of a public invitation to tender.	The inventory needs to be improved on the basis of the study results. The study results need to be documented.	2012		Chap. 8.2.1.6	2012
6.A.1	Controlled landfilling of waste	In future, the Federal Statistical Office plans to collect data on landfill-gas collection and use also also from landfills in their after-closure phases. It is expected that in 2012 environmental statistics will include, for the first time, data on landfill-gas collection that have been collected in a consistent manner, from all relevant landfills.	The data on landfill-gas formation that the Umweltstatistik 2012 (2012 environmental statistics) completed need to be integrated within the inventory.	2012		Chap. 8.2.1.6	2012
6.D.1	Composting	Currently, a research project is underway, under commission to the Federal Environment Agency, with the aim of improving the database for the emission factors for CH4 and N2O. The project includes both research, to obtain pertinent literature data, and measurements of composting and fermentation facilities. The project aim is to produce emission factors based on measured emissions from real systems. This project, when completed, is expected to yield new emission factors for both gases.	The results from the project have to be integrated within the inventory.	2011		Chap. 8.5.1.6	2011
6.D.1	Composting	Currently, a research project is underway, under commission to the Federal Environment Agency, with the aim of improving the database for the emission	The results from the project have to be integrated within the inventory.	2012		Chap. 8.5.1.6	2012

Category	Category Name	Planned improvement	Need for action	IP [year]	Comment	Source reference	Reporting year
		factors for CH4 and N2O. The project includes both research, to obtain pertinent literature data, and measurements of composting and fermentation facilities. The project aim is to produce emission factors based on measured emissions from real systems. The project is expected to yield new emission factors, for both gases, that will then need to be integrated within the inventory.					
6.D.2	Other: MBT	The Federal Environment Agency plans to urge the Federal Statistical Office to take account, in its data collection, of versions of MBT systems that have not been included to date.	The Federal Statistical Office needs to be requested to gather data on types of waste-incineration plants that have not been included in surveys to date. The inventory then has to be revised accordingly.	2011		Chap. 8.5.2.6	2011
6.D.2	Other: MBT	The Federal Environment Agency plans to urge the Federal Statistical Office to take account, in its data collection, of versions of MBT systems that have not been included to date. To that end, a joint discussion involving the MBT operators and the Federal Statistical Office is planned.	The Federal Statistical Office needs to be requested to gather data on types of waste-incineration plants that have not been included in surveys to date. The inventory then has to be revised accordingly.	2012		Chap. 8.5.2.6	2012

Table 312: Summary of the planned improvements mentioned in the NIR source-category chapters, status: incomplete

Category	Category Name	Planned improvement	Need for action	IP [year]	Source reference	Reporting year
1.A.1.a	Public electricity and Heat Production	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO2) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N2O-emissions behaviour of combustion and gas-turbine systems and the CH4-emissions behaviour of gas-turbine systems.	Results from the project have to be integrated within the inventory.	2011	Chap. 3.2.6.6	2011
1.A.1.a	Public electricity and Heat Production	Following the completion of the research project begun at the end of 2008 (FICHTNER et al. 2011) the emission factorsfor NOx and SO2 were updated. Updating of the emission factors for CH4 and N2O is currently in progress.	The project's results for CH4 and CO2 need to be integrated within the inventory.	2012	Chap. 3.2.6.6	2012
1.A.1.b	Petroleum Refining	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO2) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N2O-emissions behaviour of combustion and gas-turbine systems and the CH4-emissions behaviour of gas-turbine systems. The research project also covers power stations and bottom-heating systems in petroleum refineries.	Results from the project have to be integrated within the inventory.	2011	Chap. 3.2.7.6	2011
1.A.1.b	Petroleum Refining	Following the completion of the research project begun at the end of 2008 (FICHTNER et al. 2011) the emission factorsfor NOx and SO2 were updated. Updating of the emission factors for CH4 and N2O is currently in progress.	The project's results for CH4 and CO2 need to be integrated within the inventory.	2012	Chap. 3.2.7.6	2012
1.A.1.c	Manufacture of Solid Fuels and Other energy Industries	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO2) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N2O-emissions behaviour of combustion and gas-turbine systems and the CH4-emissions behaviour of gas-turbine systems. The research project also covers power stations and other combustion systems of the mining sector.	Results from the project have to be integrated within the inventory.	2011	Chap. 3.2.8.6	2011
1.A.1.c	Manufacture of Solid Fuels and Other energy Industries	Following the completion of the research project begun at the end of 2008 (FICHTNER et al. 2011) the emission factorsfor NOx and SO2 were updated. Updating of the emission factors for CH4 and N2O is currently in progress.	The project's results for CH4 and CO2 need to be integrated within the inventory.	2012	Chap. 3.2.8.6	2012
1.A.1.c	Manufacture of Solid Fuels and Other energy Industries	Upon completion of the emissions calculation, the AGEB made a number of corrections in the Energy Balance; those corrections will be integrated within the inventory for the next submission.	AGEB-corrections of the energybalance are to be integrated into the Inventory.	2013	Chap. 3.2.8.6	2013
1.A.2.f	Manufacturing Industries and Construction: Other	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO2) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N2O-emissions behaviour of combustion and gas-turbine systems and the CH4-emissions behaviour of gas-turbine systems. The research project also covers power stations and other combustion systems of the manufacturing sector – other energy production.	Results from the project have to be integrated within the inventory.	2011	Chap. 3.2.9.11.6	2011
1.A.2.f	Manufacturing Industries and Construction: Other	Following the completion of the research project begun at the end of 2008 (FICHTNER et al. 2011) the emission factorsfor NOx and SO2 were updated. Updating of the emission factors for CH4 and N2O is currently in progress.	The project's results for CH4 and CO2 need to be integrated within the inventory.	2012	Chap. 3.2.9.11.6	2012
1.A.2.f.(a)	Manufacturing Industries and Construction: Lime	Fuel allocations to the areas cement, lime and plaster is to be reviewed.	The allocation of fuels used for cement, lime and plaster shall be inspected. The result has to be integrated into the inventory, where appropriate.	2013	Chap. 3.2.9.10.6	2013
1.A.2.f.(b)	Manufacturing Industries and Construction: Cement	Fuel allocations to the areas cement, lime and plaster is to be reviewed.	The allocation of fuels used for cement, lime and plaster shall be inspected. The result has to be integrated into the	2013	Chap. 3.2.9.7.6	2013

			inventory, where appropriate.			
1.A.3.d	Navigation	Currently, the greenhouse-gas inventory for sea transports, including transports between German seaports, is being thoroughly revised. The findings and results from that effort will enter into future reporting on source category 1.A.3.d.	Results from revision of the greenhouse-gas inventory relative to sea transports have to be integrated within the inventory.	2011	Chap. 3.2.10.4.6	2011
1.A.3.d	Navigation	Currently, the greenhouse-gas inventory for sea transports, including transports between German seaports, is being thoroughly revised. The findings and results from that effort will enter into future reporting on source category 1.A.3.d.	Results from revision of the greenhouse-gas inventory relative to sea transports have to be integrated within the inventory.	2012	Chap. 3.2.10.4.6	2012
1.A.3.d	Navigation	In another project (FKZ 363 01 403), the basic data used in the TREMOD inland-shipping module for the year 2010 were reviewed and confirmed, to provide an example of such work. Additional such review is planned, along with any resulting necessary adjustments in the time series for the emission factors.	Where appropriate, emissionfactors for inland navigation shall be updated after finalization of project.	2013	Chap. 3.2.10.4.6	2013
1.A.3.e	Other Transportation	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO2) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N2O-emissions behaviour of combustion and gas-turbine systems and the CH4-emissions behaviour of gas-turbine systems. The research project also covers gas turbines in natural gas compressor stations.	Results from the project have to be integrated within the inventory.	2011	Chap. 3.2.10.5.6	2011
1.A.3.e	Other Transportation	Natural-gas-compressor stations: Following the completion of the research project begun at the end of 2008 (FICHTNER et al. 2011) the emission factorsfor NOx and SO2 were updated. Updating of the emission factors for CH4 and N2O is currently in progress.	The project's results for CH4 need to be integrated within the inventory.	2012	Chap. 3.2.10.5.6	2012
1.A.4	Other Sectors	The current survey of consumption and emissions of German high-seas fisheries, which is based on a number of highly simplified and conservative assumptions, is to be revised in the medium term.	The assumptions relative to consumption and emissions of German high-seas fisheries have to be revised (cf. the relevant individual objective).	2011	Chap. 3.2.11.6	2011
1.A.4	Other Sectors	Currently, the greenhouse-gas inventory for sea transports, including transports between German seaports, is being thoroughly revised. The findings and results from that effort will enter into future reporting on source category 1.A.4.c iii.	The findings and results from the relevant project on maritime transports, FKZ 3709 43 111 / 01, need to be integrated within the inventory.	2012	Chap. 3.2.11.6	2012
1.A.4	Other Sectors	Upon completion of the emissions calculation, the AGEB made a number of corrections in the Energy Balance; those corrections will be integrated within the inventory for the next submission.	AGEB-corrections of the energybalance are to be integrated into the Inventory.	2013	Chap. 3.2.11.6	2013
1.B.2	Oil and Natural Gas	A research project is currently underway with the aim of studying emissions from the gas network. The project's initial results indicate that the emissions figures reported to date have been much too high, since the emission factors used are based on a high assumed frequency of damage and since the materials used in pipelines have been considerably improved with regard to gas tightness.	Project results are to be integrated into the inventory.	2013	Chap. 3.3.2.2	2013
1.B.2.a.v	Distribution of oil products	A research project will be carried out to update data for cleaning of railway tank cars (UBA 2004b) and to obtain data for other cleaning areas, such as cleaning of inland-waterway tanker ships and road tankers.	The data on cleaning of railway tanker cars (UBA 2004b), and data for other areas of cleaning such as inland-waterway tanker ships and road trankers, need to be updated / determined via the research project. The inventory then has to be revised accordingly.	2012	Chap. 3.3.2.3.5.6	2012
1.B.2.d	Oil and Natural Gas: Distribution/Production	Even though the quantities involved are expected to be very small, plans call for quantification of gas releases from exploratory drilling in cases in which no blow-out preventers are used (in the near-surface range to depths of 400 m).	Gas releases from exploratory wells in which no "blow-out preventers" have been used have to be quantified (cf. the relevant individual objective).	2011	Chap. 3.3.2.5.6	2011
1.B.2.d	Oil and Natural Gas:	Even though the quantities involved are expected to be very small, plans call for quantification of gas	Gas releases from exploratory wells in	2012	Chap. 3.3.2.5.6	2012

	Distribution/Production	releases from exploratory drilling in cases in which no blow-out preventers are used (in the near-surface range to depths of 400 m).	which no "blow-out preventers" have been used have to be quantified.			
1.B.2.d	Oil and Natural Gas: Distribution/Production	In a departure from the standard concept for such processes, use of fluorinated substances to enhance the efficiency of geothermal electricity and heat generation in low-temperature thermal power stations is currently being tested. The implications of such technical developments, relative to safety and emissions, are being determined by the Federal Environment Agency (UBA). In a workshop ("Effektivität und Umweltverträglichkeit in geothermischen Niedertemperatur-Kreisprozessen"; "Effectiveness and environmental compatibility in low-temperature geothermal circuit processes") held at the Deutscher Bundeskongress Geothermie (a national congress on geothermal energy) that took place in November 2011, such implications were presented and discussed.	Collection of data relative to F gases in the geothermal sector has to be assured.	2012	Chap. 3.3.2.5.6	2012
1.C.1.B	Marine Bunkers	A study is currently gathering AIS- based ship-movement data. The resulting bunkering-quantities data will then be used, in combination with also-updated specific emission factors, for description of the emissions to be assigned to Germany.	Results from the AIS project have to be integrated within the inventory.	2011	Chap.3.2.2.3.6	2011
1.C.1.b	Marine Bunkers	In the framework of a study, ship-movement data are currently being determined via the Automatic Identification System (AIS; a radio-based and satellite-based system for transmission of ship data such as size, load, speed, route, etc.). The resulting bunkering-quantities data will then be used, in combination with also-updated specific emission factors, for description of the emissions to be assigned to Germany.	Results from the AIS project have to be integrated within the inventory.	2012	Chap. 3.2.2.3.6	2012
1.C.1.b	Marine Bunkers	In 2013 or later, use will begin of LNG bunkered in Germany. Such use will duly be taken into account in future reports.	LNG bunkered in germany shall be included into the inventory.	2013	Chap. 3.2.2.3.6	2013
2.A.4	Soda Ash Production and Use	No specific improvements are planned at present. In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method needs to be verified.	In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method needs to be verified.	2011	Chap. 4.2.4.6	2011
2.A.4	Soda Ash Production and Use	In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method still needs to be verified.	In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method needs to be verified.	2012	Chap. 4.2.4.6	2012
2.A.5	Asphalt Roofing	The VDD plans to carry out additional considerations relative to export-import offsetting.	A new relevant expert (Fachverantwortlicher) will have to re-study the data relative to correction of foreign-trade statistics – possibly, via the National Co-ordinating Committee. (cf. also "additional need for action")	2011	Chap. 4.2.5.6	2011
2.A.5	Asphalt Roofing	The VDD plans to carry out additional considerations relative to export-import offsetting.	A new relevant expert (Fachverantwortlicher) will have to re-study the data relative to correction of foreign-trade statistics – possibly, via the National Co-ordinating Committee.	2012	Chap. 4.2.5.6	2012
2.A.6	Road Paving with Asphalt	Relevant findings currently available from a research project are to be used for specific evaluation of emission factors.	The emission factors need to be evaluated on the basis of the existing project report.	2011	Chap. 4.2.6.6	2011
2.A.6	Road Paving with Asphalt	Relevant findings currently available from a research project are to be used for specific evaluation of emission factors.	The emission factors need to be evaluated on the basis of the existing project report.	2012	Chap. 4.2.6.6	2012
2.D.1	Pulp and Paper	The CO2 emissions from caustification in sulphate pulp production are of biogenic origin; thus, they do	Review of whether CO2 of biogenic origin	2011	Chap. 4.5.1.6	2011

		not have to be reported. In future, CO2 of biogenic origin may also be reported, in the interest of enhancing transparency.	should be reported in future.			
4.A	Enteric Fermentation	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2011	Chap. 6.2.6	2011
4.A	Enteric Fermentation	Efforts to improve modelling of feeding of swine continue. To date, the required highly detailed data have been obtained, nationwide, via surveys of experts, and they have been evaluated (Dämmgen et al., 2011b). The next planned next work step is to process the data for GAS-EM inventory model. Possibly, findings from official survey of protein inputs in swine fattening during the period November 2010 to October 2011, which took place in fall 2011, can enter into the model. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH4 emissions from enteric fermentation.	Modelling of feeding of swine needs to be improved. The validity of the model calculation needs to be made transparent.	2012	Chap. 6.2.6	2012
4.A	Enteric Fermentation	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2012	Chap. 6.2.6	2012
4.A (b)	Enteric Fermentation - Cattle, Swine, Sheep, Horses	Efforts are currently underway to improve modelling of feeding of swine. The improved model is to include data from a survey to be carried out by the Federal Statistical Office, in November 2011, of protein inputs in swine feeding. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH4 emissions from enteric fermentation.	Modelling of feeding of swine needs to be improved. The validity of the model calculation needs to be made transparent.	2011	Chap. 6.2.6	2011
4.B	Manure Management	Efforts are currently underway to improve modelling of feeding of swine. The improved model is to include data from a survey to be carried out by the Federal Statistical Office, in November 2011, of protein inputs in swine feeding. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH4 emissions from enteric fermentation.	Modelling of feeding of swine needs to be improved.	2011	Chap. 6.3.2.6	2011
4.B	Manure Management	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2011	Chap. 6.3.2.6	2011
4.B	Manure Management	With regard to planned improvements, the reader's attention is called to Chapter 6.3.2.6. The improvement in modelling of feeding of swine is expected to also influence the results for N2O emissions from manure management.	If improvement of the model for feeding of swine affects N2O emissions from (farm) manure management, then the pertinent impacts need to be integrated within the inventory.	2011	Chap. 6.3.4.6	2011
4.B	Manure Management	The method used for calculation of GG emissions from slurry digestion was unable to take account of small amounts of slurry (cf. Chapter 6.1.3.6.5). The calculation method is to be revised to enable inclusion of such amounts of slurry.	Due to conceptional restrictions small amounts of slurry are not taken into emission calculation. To corecct this ommision the calculation method shall be adjusted. Results are to be integrated into the inventory.	2013	Chap. 6.3.2.6 + 6.3.4.6	2013
4.B	Manure Management	Efforts to improve modelling of feeding of swine continue. To date, the required highly detailed data have been obtained, nationwide, via surveys of experts, and they have been evaluated (Dämmgen et al., 2011b). The next planned next work step is to process the data for GAS-EM inventory model. Possibly, findings from official survey of protein inputs in swine fattening during the period November 2010 to	Modelling of feeding of swine needs to be improved.	2012	Chap. 6.3.2.6	2012

		October 2011, which took place in fall 2011, can enter into the model. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH4 emissions from enteric fermentation.				
4.B	Manure Management	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2012	Chap. 6.3.2.6	2012
4.B	Manure Management	The improvement, referred to in Chapter 6.3.2.6, of modelling of feeding of swine, and collection of data on N-reduced feeding of swine, are expected to influence the results for N2O and NO emissions from manure management.	If improvement of the model for feeding of swine affects N2O/NO emissions from (farm) manure management, then the pertinent impacts need to be integrated within the inventory.	2012	Chap. 6.3.4.6	2012
4.D	Agricultural Soils	Currently, efforts to improve modelling of feeding of swine are underway. In addition, the Federal Statistical Office plans to conduct a survey of protein inputs in swine fattening. The model changes are also expected to affect the results for NH3 emissions from farm-manure management, which are of relevance with regard to indirect N2O emissions from agricultural soils. In co-operation with the Federal Statistical Office, efforts are being made to produce a reliable estimate of Germany's net imports of farm manure.	Modelling of feeding of swine needs to be improved. The validity of the model calculation needs to be made transparent.	2011	Chap. 6.5.6	2011
4.D	Agricultural Soils	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2011	Chap. 6.5.6	2011
4.D	Agricultural Soils	Efforts to improve modelling of feeding of swine continue (DÄMMGEN et al., 2011b). Possibly, findings from official survey of protein inputs in swine fattening during the period November 2010 to October 2011, which took place in fall 2011, can enter into the model. Improved modelling of feeding of swine will affect data on N excretions and, thus, on the N quantities entering the soil via manure management.	Modelling of feeding of swine needs to be improved. The validity of the model calculation needs to be made transparent.	2012	Chap. 6.5.6	2012
4.D	Agricultural Soils	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2012	Chap. 6.5.6	2012
5.	Land Use, Land-Use Change and Forestry	Mineral soils: Agricultural soil inventory: generation of national measurements of C stocks in cropland and grassland; gradual revision of the database for mineral soils.	Results of the "BZE-Agriculture" are to be integrated into the inventory, to serve the derivation of more precise emissionsfactors.	2013	Chap. 19.5.2.3	2013
5.A	Forest Land	Land-use changes The National Forest Inventory 3 (Bundeswaldinventur 3; BWI 3), which is currently being prepared, will make it possible to determine relevant areas and land-use changes in a consistent manner for the entire territory of Germany. The results of BWI 3, which is being carried out from 2011 to 2012, will make it possible to estimate the areas and land-use changes for all LULUCF land categories for the period 2002 through 2012.	Estimation of the applicable land areas, and relevant changes, for all LULUCF land categories, for the period 2002 to 2012, on the basis of the National Forest Inventory 3 (BWI 3).	2011	Chap. 7.2.8.1	2011
5.A	Forest Land	The BÜK map data are currently being revised. They will soon be published with a higher level of precision (scale of 1:200.000).	Once the BÜK soil map has been revised, it must be determined whether that map's high level of precision has an impacts on emission calculations. The inventory then	2011	Chap. 7.2.8.2	2011

			has to be revised accordingly.			
5.A	Forest Land	Litter and mineral soils Evaluation of the data relative to changes in organic carbon in the upper 30 cm of mineral soil shows that sandy soils in particular, soils whose distribution is concentrated in northern Germany, have accumulated carbon since the BZE I survey. A study is already underway, with regard to the BZE, to determine the reasons for the carbon increase. A comparison with a regional soil inventory carried out on long-term study areas (KONOPATZKY 2009) indicates that changes have taken place primarily in recent years. On the other hand, a study carried out in the framework of the BZE has concluded that significant changes of carbon stocks in mineral soil take at least 10 years to become apparent in surveys (MELLERT et al. 2007). It is thus necessary to determine the relevant rate of change via a follow-on inventory. The time for that inventory will be determined after evaluation of the BZE II survey has been completed.	Once the Forest Soil Inventory II (BZE II) has been evaluated, a follow-on inventory needs to be initiated to determine changes in organic carbon in the top 30cm of mineral soils (cf. the relevant individual objective).	2011	Chap. 7.2.8.2	2011
5.A	Forest Land	The National Forest Inventory 3 (Bundeswaldinventur 3; BWI 3) that is currently being carried out will add, to the sample-based information system, an important database for determination of activity data. The results of BWI 3, which is being carried out from 2011 to 2012, are expected to make it possible, in 2013, to estimate the areas and land-use changes for all categories of conversion from and to forest land, and for forest land remaining forest land, for the period 2002 through 2012. The high quality of the pertinent data is expected to make highly precise conclusions possible with regard to forest land areas and pertinent changes.	Estimation of the applicable land areas, and relevant changes, for categories of changes to and from forest, and for forest land remaining forest land, for the period 2002 to 2012, on the basis of the National Forest Inventory 3 (BWI 3).	2012	Chap. 7.2.8.1	2012
5.A	Forest Land	Evaluation of the data relative to changes in organic carbon in the upper 30 cm of mineral soil shows that sandy soils in particular, soils whose distribution is concentrated in northern Germany, have accumulated carbon since the BZE I survey. A study is already underway, with regard to the BZE, to determine the reasons for the carbon increase. A comparison with a regional soil inventory carried out on long-term study areas (KONOPATZKY 2009) indicates that the changes have taken place primarily in recent years. On the other hand, a study carried out in the framework of the BZE has concluded that significant changes of carbon stocks in mineral soil take at least 10 years to become apparent in surveys (MELLERT et al. 2007). It is thus necessary to determine the relevant rate of change via a follow-on inventory. The time at which that inventory is to be carried out will not be decided until after the BZE II inventory has been evaluated.	Once the Forest Soil Inventory II (BZE II) has been evaluated, a follow-on inventory needs to be initiated to determine changes in organic carbon in the top 30cm of mineral soils.	2012	Chap. 7.2.8.2	2012
5.A, 5.B, 5.C	Forest Land, Cropland, Grassland	The values listed in the above chapters are the best data now available in complete-coverage form. Major inventories for determination of the carbon and nitrogen stocks in mineral soils have been carried out, and are being carried out, in Germany, with a view to improving such data: • The Forest Soil Inventory II (Bodenzustandserhebung II Wald), for all forest soils (currently being evaluated) • The Agricultural Soil Inventory (Bodenzustandserhebung Landwirtschaft), for cropland and grassland soils These two major inventories cover some 84 % of Germany's total area, an area which corresponds to about 88 % of its mineral-soil area. • The results of the inventories are gradually being used for determination of precise emission factors. • As part of integration of the results of the major inventories, the reporting system for mineral soils (Berichtssystem Mineralboden) is to be converted from a soil depth of 30 cm to a depth of 1 m.	The results of the major inventories (BZE II Wald (Forest Soil Inventory II), BZE LaWi-Acker-Grünl. (inventory of agricultural, cultivated and grassland soils) need to be integrated within the inventory, and pertinent reporting for mineral soils needs to cover a soil depth of 1 m (i.e. a transition needs to be made from current 30 cm coverage).	2012	Chap. 19.5.2.2.6	2012
5.B, 5.C	LULUCF	A sample-based information system was introduced for determination of area data throughout the entire LULUCF sector. With the data available for the relevant years, each sample point can be assigned a land-use category, tied to a quality level. The land-use categories for each year have been derived from such assignations. In addition, records have been kept of the number of points that are considered	Improvement of the proportion of validated points for the year 1990. That proportion is to be improved via integration of new data sources (in particular, 1990 maps derived	2012	Chap. 7.2.8.1	2012

		validated as a result of agreement with respect to LULUCF categories, on the various quality levels. The percentage of points in 1990 that have not yet been validated is still high. Plans call for that percentage to be considerably improved via integration of new data sources (in particular, 1990 maps derived from ColorInfraRed data) (cf. also Chapter 7.1.3.3).	from ColorInfraRed data).			
5.B, 5.C	Cropland, Grassland	Improvement of the area data for organic soils under cultivation: ongoing research project.	The area data for organic soils on cropland need to be improved.	2012	Chap. 7.3.8	2012
5.B, 5.C	Cropland, Grassland	Mineral soils: Agricultural soil inventory: generation of national measurements of C stocks, for cropland and grassland.	On the basis of the Agricultural Soil Inventory, data on C stocks in mineral soils need to be derived for cropland and grassland, and the inventory has to be improved accordingly.	2012	Chap. 7.3.8	2012
5.B, 5.C	Cropland, Grassland	Mineral soils: Agricultural Soil Inventory: gradual revision of the database for mineral soils.	The database for mineral soils needs to be revised on the basis of the Agricultural Soil Inventory, and the inventory has to be improved accordingly.	2012	Chap. 7.3.8	2012
5.B, 5.C	Cropland, Grassland	Organic soils: Greenhouse gas measurements for improvement and validation of the relevant emission factors: ongoing research project.	The national emission factors for organic soils need to be improved and validated with the help of greenhouse-gas measurements.	2012	Chap. 7.3.8	2012
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	New emission factors, differentiated by soil type and soil use, for organic soils	Determination of differentiated EF for organic soils.	2011	Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5.C	Grassland	Furthermore, the previously used provisional emission factor for tree/shrub biomass has been improved, via inclusion of results from ten tree/shrub plantations in addition to the results from previously studied plantations.	The preliminary emissionfactor shall be revised and the inventory be updated.	2013	Chap. 7.4.8	2013
5.D	Wetland	In the wetlands category, an effort is being made to derive country-specific emission factors for emissions of the greenhouse gases CO2, N2O and CH4 from peat extraction. To this end, measurements are being carried out, in the framework of the project "Organic Soils", that cover all phases of this form of land use (cf. Chapter 19.5.2.6). The results will be used for parametrisation and validation of mathematical models, and for determination of country-specific, regional default factors. As soon as they become available, the results of this project will enter into national reporting.	The results from the project have to be integrated within the inventory.	2011	Chap. 7.5.8	2011
6.A.1	Managed Waste Disposal on Land	In 2011/12, the residual-gas emissions from landfill storage of mechanically and biologically treated waste were quantified in an expert opinion (IFAS, 2012). The opinion confirms that emissions calculations to data have been correct in applying low emissions contributions from landfilling of MBT waste. In addition, with regard to the progression of methane formation, the opinion provides indications of higher fractions of waste components with shorter half-lives in decomposition. This issue is being reviewed at present. The half-lives / reaction constants for MBT waste may be adjusted as a result.	The inventory shall be improved on the basis of the surveys results. The survey and its results shall be documented.	2013	Chap. 8.2.1.6	2013
6.A.1	Managed Waste Disposal on Land	In an international comparison, collection rates of landfill gas, at about 20 %, seem very low. They also seem low in that nearly all German landfills have gas-collection facilities and that the technical characteristics of German landfills would seem to provide a comparatively good basis for high collection rates. This apparent contradiction will need to be cleared up for future reports.	The causes for the high differences between statistical data and estimated amount of landfill gas shall be determined.	2013	Chap. 8.2.1.6	2013
6.B.1	Industrial Wastewater	Plans call for review of the possibility of determining the COD values for the sector-specific wastewater streams.	Check wether CSB-values for branchspecific wastewater flows can be determined. Where appropriate the inventory shall be revised.	2013	Chap. 8.3.1.2.6	2013

6.D.2	Other: MBT	The emission factors used to date for methane and nitrous oxide are the emission limit values specified in the 30th BImSchV. The actual emissions of the facilities involved are considerably lower than those emission limit values. For future reporting, therefore, it will be necessary to evaluate the actual facility emissions and to review the pertinent emission factors.	Until now emission thresholds based on the 30. BImSchV are used as emission factors for CH4 and N2O. Real plant emissions are assumed to be far below these thresholds. Actual plant emissions shall be evaluated, the emission factors be checked and the inventory be updated.	2013	Chap. 8.5.2.6	2013

10.4.2 KP & LULUCF

The improvements described in the Convention inventory for the LULUCF sector in areas 5.A and 5.B.2.1 through 5.F.2.1 are also to be applied to the KP-LULUCF inventory (cf. Chapter 10.4.1).

11 Supplementary information required under Article 7, Paragraph 1 of the Kyoto Protocol

11.1 General information

11.1.1 The definition of forest, and any other criteria

The National Forest Inventory is the main data source used for determination of activity data and emission factors. Its forest definition, which serves as a basis for the report, is presented in Chapter 7.2.3.1.

In keeping with Germany's initial report under the Kyoto Protocol (UNFCCC 2007), Germany has defined the following specific parameters for its national forest definition:

Table 313: Definition of "forest" in Germany

Parameter	Range	Selected value
Minimum area of land	0.05 – 1.00 ha	0.1 ha
Tree crown cover or equivalent stocking level	10 – 30 %	(10 %)
Potential tree height at maturity	2 – 5 m	5 m

Within the range defined by the Marrakesh Accords (c.f. the above range), these parameters are the ones that come closest to the definition used in the National Forest Inventory. As comparative studies have shown, the differences between different activity-data calculations carried out in accordance with the aforementioned parameters are negligible.

The first National Forest Inventory does not include data for the new German Länder. The project GSE Forest Monitoring (GSE 2003, GSE 2006, GSE 2007, GSE 2009) was carried out to compensate for that gap. Working on the basis of maps, it determined forest cover, and its changes, between 1990 and 2002 and between 1990 and 2005/2006. The forest definition used within GSE was based on the internationally accepted definition of the FAO, however, which specifies a minimum area of land of 0.5 ha (cf. also OEHMICHEN et al. (2011b)). The original data available to the Johann Heinrich von Thünen Institute (TI) include land areas and land-use changes smaller than the 0.5 ha threshold, and down to a pixel size of 25m x 25m. Such smaller units may be considered similar to the "minimum mapping units" used in the National Forest Inventory (cf. also Chapter 7.1.3.2.1).

Pursuant to UNFCCC (1998), areas are to be assigned to the categories afforestation and deforestation if they have been afforested / deforested since 1990. Such areas remain in those assigned categories until the end of the commitment period. As a result, the areas of said categories increase constantly. For afforested areas, so GPG LULUCF (IPCC 2003), a further distinction must be made between a) areas that have not been harvested, or deforested via natural disturbances (subject to Art. 3.3) and b) areas that have been harvested, or deforested via natural disturbances followed by re-establishment of forest (subject to Art. 3.3 that would otherwise be subject to Art. 3.4). Germany has no areas, however, that have been afforested since 1990 and already harvested again. In the context of greenhouse-gas reporting, short-rotation coppices are not included as forest (cf. Chapter 7.2.3.1).

In general, reforestation requirements apply in Germany (cf. Art. 11 (1) p. 2 Federal Forest Act (BWaldG), meaning that clear-cut forest areas and thinned forest stands have to be reforested or replenished. Areas that have been afforested since 1990, but temporarily have no forest cover as a result of natural disasters, continue to fall within the definition of forest and must be reforested. No deforestation as a result of natural disasters takes place in Germany.

11.1.2 Elected activities under Article 3 Paragraph 4 of the Kyoto Protocol

In keeping with its initial report under the Kyoto Protocol, Germany has elected the option of crediting forest management pursuant to Article 3 (4) of the Kyoto Protocol.

11.1.3 Description of how the definitions of each activity under Article 3.3, and each elected activity under Article 3.4, have been implemented and applied consistently over time

The definitions used by Germany for afforestation, reforestation and deforestation are in accordance with the Marrakesh Accords (MA). Pursuant to the MA, afforestation is defined as "the direct human-induced conversion of land that has not been forested for a period of at 50 years to forested land through planting, seeding and / or the human-induced promotion of natural seed sources[108]." Reforestation differs from afforestation solely with regard to the time since the area was last forested and, pursuant to the IPCC, occurs on land that has not been forest since 31 December 1989[109]. Since the reporting period for Germany begins with base year 1990, and since adequate data for differentiation of land-use forms are available only for the period as of 1970, afforestation and reforestation are considered together in the present context (and hereafter are both referred to as afforestation). Afforestation means the establishment of trees on abandoned land, if the relevant rejuvenation suffices for producing forest in accordance with the national forest definition. In general, the time of afforestation is the time at which the first activity in the relevant regeneration process was carried out. In the case of spontaneous regeneration of trees, the time of afforestation is considered to be the time at which the national criteria for the forest definition have been met, i.e. when the natural forest cover has reached an average age of five years, and a crown cover of at least 50 % (cf. Chapter 7.2.3.1).

The afforestation category corresponds to the following categories in reporting under the UN Framework Convention on Climate Change:

108 Annex A Paragraph 1 lit. b to Decision 16/CMP.1 (FCCC/KP/2005/8/Add.3, page 5).

109 IPCC LULUCF GPG (2003), Section 4.2.5.1.

Table 314: Afforestation in KP and UNFCCC categories

Category for KP reporting	Category pursuant to UNFCCC	
Afforestation under Art. 3.3 KP	5.A.2.1 Cropland converted to forest land	
	5.A.2.2. Grassland converted to forest land	5.A.2.2.1 Grassland (in a strict sense – i.t.s.s.) converted to forest land
		5.A.2.2.2 Woody grassland converted to forest land
	5.A.2.3. Wetlands converted to forest land	5.A.2.3.1 Wetlands (terrestrial) converted to forest land
		5.A.2.3.2 Waters converted to forest land
	5.A.2.4. Settlements converted to forest land	
	5.A.2.5. Other land converted to forest land	

The IPCC defines deforestation as "the direct human-induced conversion of forested land to non-forested land"[110]. In accorance with the provisions of the IPCC, harvest that is followed by regeneration is not considered deforestation, since harvest is a forest-management activity pursuant to Art. 3.4. This definition does not include "forest cover loss resulting from natural disturbances, such as wildfires, insect epidemics or wind storms", since "in most cases these areas will regenerate naturally or with human assistance"[111]. Such areas also fall within the category of managed land pursuant to Art. 3.4 or, if the areas are afforested land, within the category of afforestated land pursuant to Art. 3.3.

Where, since 1990, human activities have taken place on such areas temporarily without forest cover – activities such as road construction, settlement construction or other forms of land use (management of grassland or wetlands) – with the result that forest regeneration is prevented, then, so the IPCC, the areas must be considered deforested.

The deforestation category corresponds to the following categories in reporting under the UN Framework Convention on Climate Change (NO = not occurring):

[110] Annex A No 1 lit. d FCCC/CP/2001/15/Add.1, page 58

[111] Cf. IPCC LULUCF GPG (2003), Section 4.2.6.1.

Table 315: Deforestation in KP and UNFCCC categories

Category in KP reporting	Category pursuant to UNFCCC	
Deforestation under Art. 3.3 KP	5.B.2.1. Forest land converted to cropland	
	5.C.2.1. Forest land converted to grassland	5.C.2.1.1 Forest land converted to grassland (i.t.s.s.)
		5.C.2.1.2 Forest land converted to woody grassland
	5.D.2.1. Forest land converted to wetlands	5.D.2.1.1 Forest land converted to wetlands (terrestrial)
		5.D.2.1.2 Forest land converted to waters
	5.E.2.1. Forest land converted to settlements	
	5.F.2.1. Forest land converted to other land	(NO)

In Germany, all forest areas that have been forest since 1990 are considered managed within the meaning of the Marrakesh Accords[112] and are reported under *forest management* pursuant to Art. 3.4 KP. A detailed pertinent description is presented in Chapter 11.5.1.

Table 316: Forest management in KP and UNFCCC categories

Category in KP reporting	Category pursuant to UNFCCC
Forest management pursuant to Art. 3.4 KP	5.A.1 Forest land remaining forest land

Since every land-use change to forest is considered afforestation, every land-use change from forest land to a different land-use category is considered deforestation, and all forest areas not afforested are subject to forest management, there is no possibility that the manner in which the relevant definitions are applied could change over time.

11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, how they have been consistently applied in determining how land was classified

Since Germany has elected only the activity *forest management* under Art. 3.4 KP, no hierarchy needs to be defined. Pursuant to the provisions of GPG LULUCF (2003)[113], forest management can take place only on lands that meet the definition of forest. The forest areas reported under FM are the forest areas reported, under the Convention, under *forest land remaining forest land*. All German forest lands are considered managed within the meaning of the provisions of the Marrakesh Accords. The definition of forest management is broadly interpreted (cf. for a detailed discussion Chapter 11.5.1).

11.2 Land-oriented information

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

The method used to derive activity data (areas) is described in Chapter 7.1.3. It corresponds to report method 1 pursuant to the GPG for LULUCF (IPCC 2003). The area reference unit is Germany. The areas in the "forest" land-use form, and their additions and removals, are

[112] Paragraph 1 lit. f of Annex A of Decision 16/CMP.1
[113] IPCC LULUCF GPG (2003), Section 4.1.2

derived primarily from the point data of the National Forest Inventories (BMELV 2005). For the new German Länder, the National Forest Inventory (BWI) data have been supplemented with data from the project GSE FM-INT (GSE 2003, GSE 2006, GSE 2007, GSE 2009) (cf. also Chapters 7.2.2 and 7.2.3).

11.2.2 Method used to develop the land-transition matrix

The method used to define forest areas, and to derive areas for the "change" classes, is described in detail in Chapters 7.1.3 and 7.2.3.2. Table 317 provides an overview of land-use changes leading to forest land (afforestation), of land-use changes leading away from forest land (deforestation), and of managed areas (forest management) for the period 1990 to 2011. Conversion areas remain in their relevant conversion classes until the end of the commitment period for the 2012 Kyoto Protocol. As a result, the annual areas accumulate. In Table 317, the column for the accumulated areas lists those areas as they are reported. An adjacent column shows the corresponding annual areas.

Table 317: Areas in the categories afforestation, deforestation and forest management, 1990 to 2011

Year	Afforestation/ Reforestation (KP 3.3) [kha]		Deforestation (KP 3.3) [kha]		Forest Management (KP 3.4) [kha]	
	[kha]	Annual areas	[kha]	Annual areas	[kha]	Annual areas
1990	28.086	28.086	15.142	15.142	10,738.559	10,738.559
1991	56.173	28.086	30.284	15.142	10,723.418	10,751.504
1992	84.259	28.086	45.426	15.142	10,708.276	10,764.448
1993	112.346	28.086	60.568	15.142	10,693.134	10,777.393
1994	140.432	28.086	75.710	15.142	10,677.992	10,790.338
1995	168.519	28.086	90.852	15.142	10,662.850	10,803.282
1996	196.605	28.086	105.994	15.142	10,647.708	10,816.227
1997	224.692	28.086	121.136	15.142	10,632.566	10,829.171
1998	252.778	28.086	136.278	15.142	10,617.424	10,842.116
1999	280.865	28.086	151.420	15.142	10,602.282	10,855.060
2000	308.951	28.086	166.562	15.142	10,587.140	10,868.005
2001	318.630	9.679	170.166	3.604	10,583.536	10,892.487
2002	328.309	9.679	173.769	3.604	10,579.932	10,898.562
2003	337.988	9.679	177.373	3.604	10,576.328	10,904.637
2004	347.667	9.679	180.977	3.604	10,572.724	10,910.712
2005	357.346	9.679	184.581	3.604	10,569.121	10,916.787
2006	363.117	5.771	187.963	3.382	10,565.738	10,923.084
2007	368.889	5.771	191.345	3.382	10,562.356	10,925.473
2008	374.660	5.771	194.728	3.382	10,558.974	10,927.862
2009	376.019	1.359	196.516	1.788	10,557.185	10,931.845
2010	377.378	1.359	198.305	1.788	10,555.397	10,931.416
2011	378.737	1.359	200.093	1.788	10,553.608	10,930.986

11.2.3 Maps and/or databases to identify the geographical locations, and the system of identification codes for the geographical locations

The following data sources were used in determination of activity data:

- National Forest Inventory 1 (Bundeswaldinventur; BWI 1)

- National Forest Inventory 2 (Bundeswaldinventur; BWI 2)
- Inventory Study 2008 (Inventurstudie; IS08)
- Datenspeicher Waldfonds (DSW)
- Forest Soil Inventory I (Bodenzustandserhebung im Wald I; BZE I)
- Forest Soil Inventory II (Bodenzustandserhebung im Wald II; BZE II)
- Soil-inventory data from the project BioSoil (BioSoil)
- GSE Forest Monitoring: Inputs for national greenhouse-gas reporting (GSE FM-INT)
- Official topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem; ATKIS®)
- CORINE Land Cover (CLC)
- Soil map for the Federal Republic of Germany 1:1,000,000 (Bodenübersichtskarte der Bundesrepublik Deutschland; BÜK 1000)
- Forest-fire statistics of the Federal Republic of Germany
- Fertiliser statistics of the Federal Statistical Office

Detailed descriptions of the data sources are presented in Chapters 7.2.2 and 7.1.3.2.1.

11.3 Activity-specific information

11.3.1 Methods for carbon stock change, greenhouse gas emission and removal estimates

11.3.1.1 Description of methodologies and the underlying assumptions used

11.3.1.1.1 Summary

Most of the descriptions of methods are presented in Chapter 7, which discusses the issue of reporting for the UN Framework Convention on Climate Change. As described in Chapter 11.1.3, the categories forest management and afforestation in the Kyoto Protocol are equivalent to the categories 5.A.1 Forest Land remaining Forest Land and 5.A.2 Land converted to Forest Land, respectively. For this reason, in the following chapters methodological information relative to these categories is usually provided via referencing to Chapter 7; additional methodological descriptions are provided largely only for the area of deforestation.

For the period 1987 to 2002 in the old German Länder, and for the period 2002 to 2008 in all German Länder, up-scaling was carried out for this category on the basis of individual-tree data from the National Forest Inventories and from the Inventory Study (samples, Tier 2). In addition, the C stocks for deforested areas were estimated (cf. Chapter 11.3.1.1.2). The C stocks of the old German Länder, in this category for the period from 1987 to 2002, were applied to the "forest land converted to other land" areas in the new German Länder, since the Datenspeicher Waldfonds forest database does not provide any information in this regard. The C emissions that are assigned to these areas are higher, as a result of their stock accumulations, than C binding by new forest lands. All in all, carbon stocks of some -32.63 Mg ha^{-1} were lost from biomass (not including the biomass of the converted land) in this category in 2011. As a simplification, it was assumed that C stocks are emitted into the atmosphere in the year in which the land was converted.

The emission factors derived from biomass losses, and from the areas calculated for each relevant year since 1987, decreased continuously, for purposes of reporting under the Kyoto

Protocol, from 1990 to 2011. This is due solely to the fact that the relevant areas remain in the deforestation category as of 1990, with the result that the total area increases in each report year. Table 318 illustrates this effect with the example of decreasing above-ground biomass in connection with deforestation.

Table 318: Annual and accumulated deforested areas, and annual and implied emission factors for above-ground forest biomass; positive: C sink; negative: C emissions

	1990	2000	2005	2008	2011
Area of annual deforestation [ha]	15,142	15,142	3,604	3,382	1,788
Annual emission factor [MgC/ha]	-26.8920	-26.8920	-23.8482	-23.8482	-23.8482
Accumulated deforested area [ha]	15,142	166,562	184,581	194,728	200,093
Implied emission factor [MgC/ha]	-26.8920	-2.4447	-0.4656	-0.4142	-0.2132

The C-stock differences between the five "forest land converted to other land" LULUCF categories (5.B.1 through 5.F.1) were not studied in detail, since too few sampling elements are available for that purpose. Such study, in other words, would provide illusory precision, i.e. "precision" that would disappear within sampling errors and in the other error categories. For this reason, a single emission factor, based on total carbon stocks and the total deforested area, is used for biomass decreases for all land-use categories.

In addition to losses of biomass in connection with conversion of forest land, other types of losses must be considered as well, including losses in the areas of dead wood, litter, mineral soils and organic soils. In the case of biomass, dead wood and litter, it is assumed that the pertinent losses take the form of emissions in the year of conversion. Emissions from organic soils take place each year on the entire deforested area. For mineral soils, a transition time of 20 years is assumed. Table 319 provides an overview of carbon-stock losses, for deforestation, for the period as of 2008. The decreases in carbon stocks in biomass, dead wood and litter between 2008 and 2009 result from the decreases in the area of annual deforestation.

Table 319: Deforested areas and carbon-stock losses from biomass (including the biomass of the converted land), dead wood, litter and mineral and organic soils, for deforestation as of 2008; positive: C sink; negative: C emissions

Pool	**Carbon-stock loss [Gg]**			
	2008	**2009**	**2010**	**2011**
Biomass	-54.331	-19.618	-19.700	-19.624
Dead wood	-10.977	-5.972	-6.140	-6.307
Litter	-59.799	-31.531	-31.442	-31.352
Mineral soils	85.435	85.788	78.382	71.140
Organic soils	-51.150	-51.356	-51.532	-51.669
Total	**-90.822**	**-22.689**	**-30.431**	**-37.811**
	Deforested area [ha]			
Annual	3,382	1,788	1,788	1,788
Accumulated	194,728	196,516	198,305	200,093

11.3.1.1.2 Biomass

Information on methods used for calculating carbon stocks, and carbon-stock changes, in above-ground and below-ground biomass is presented in the following chapters:

- Forest Land remaining Forest Land, cf. Chapter 7.2.4.1.1.
- Land converted to Forest Land cf. Chapter 7.2.4.1.2.

Deforested areas:

With regard to deforested areas, an individual-tree calculation was carried out on the basis of the BWI (NFI) 1, BWI 2 and IS08 inventories. For the period between the BWI 1 and BWI 2 inventories, only trees in the old German Länder were considered, since the BWI 1 inventory was carried out only there. The wood-stocks data for the old German Länder were applied to the new German Länder. The emission factor for the period 1990 through 2001, for the decreasing above-ground and below-ground biomass, is 34.86 Mg C ha^{-1}. For the period as of 2002, an individual-tree calculation, spanning the BWI 2 and IS08 inventories, was carried out for Germany as a whole. The emission factor for the period 2002 through 2011, for the decreasing above-ground and below-ground biomass, is 32.63 Mg C ha^{-1}. The stocks of subsequent final-use classes were deducted – and thus taken into account. The carbon stocks released upon deforestation are counted, completely, as "emissions" in the same year.

Additional methodological descriptions are presented in the following chapters:

- Derivation of individual-tree biomass, cf. Chapter 7.2.4.1.3.
- Conversion to above-ground individual-tree biomass, cf. Chapter 7.2.4.1.4.
- Conversion to below-ground biomass, cf. Chapter 7.2.4.1.5.
- Conversion of individual-tree biomass to carbon, cf. Chapter 7.2.4.1.6
- Procedures for scaling up to relevant states in 1987, 2002 and 2008, cf. Chapter 7.2.4.1.7.
- Up-scaling procedures for obtaining changes between 1987 and 2002, and between 2002 and 2008 (derivation of stock changes via the "stock-change method"), cf. Chapter 7.2.4.1.8.
- Interpolation of time periods, to obtain annual-change estimates, cf. Chapter 7.2.4.1.9.

11.3.1.1.3 Dead wood

Information on methods used for calculating carbon stocks and carbon-stock changes in dead wood is presented in the following chapters:

- Forest Land remaining Forest Land, cf. Chapter 7.2.4.2.1.
- Land converted to Forest Land cf. Chapter 7.2.4.2.2.

<u>Deforested areas:</u>

The C stocks in dead wood were calculated with data of the BWI 2 survey and the Inventurstudie 2008 (IS08). According to those calculations, the average carbon stocks in dead wood amounted to 2.68 Mg ha^{-1} in 2002 (BWI 2) and to 3.25 Mg ha^{-1} in 2008 (IS08). For the years 2003 to 2007, the stocks were derived by interpolating the status data for the years 2002 and 2008. For the period 1990 to 2001, and for the period as of 2009, the stocks were derived via extrapolation of the same status data. In each case of deforestation, the carbon stocks in dead wood, for the relevant year, were taken into account immediately as C emissions.

11.3.1.1.4 Litter

Information on methods used for calculating carbon stocks and carbon-stock changes in litter is presented in the following chapters:

- Forest Land remaining Forest Land, cf. Chapter 7.2.4.3.1.

- Land converted to Forest Land cf. Chapter 7.2.4.3.2.

Deforested areas:

Calculations relative to the litter ground cover were carried out with the status data of BZE I (Forest Soil Inventory I) and the status data of the BZE II / BioSoil soil inventories. According to the relevant calculations, the average carbon stocks in litter amounted to 18.58 Mg ha^{-1} in 1990 (BZE I) and to 17.78 Mg ha^{-1} in 2006 (BZE II / BioSoil). For the years 1991 through 2005, the stocks were derived by interpolating the status data for the years 1990 and 2006. For the period as of 2007, the stocks were obtained via extrapolation. In each case of deforestation, the carbon stocks in litter, for the relevant year, were taken into account immediately as C emissions.

Additional methodological descriptions are presented in the following chapters:

- Derivation of litter carbon stocks in 1990 (BZE I) and 2006 (BZE II/BioSoil), cf. Chapter 7.2.4.3.3.
- Derivation of carbon-stock changes in litter in the period from 1990 (BZE I) to 2006 (BZE II/Biosoil), cf. Chapter 7.2.4.3.4.

11.3.1.1.5 Mineral soils

- Information on methods used for calculating carbon stocks and carbon-stock changes in mineral soils of the "Forest Land remaining Forest Land" area is provided in Chapter 7.2.4.4.1.

Afforested and deforested areas:

For each land-use-change category, the carbon-stock changes in mineral soils as a result of land-use changes are calculated as the difference between the carbon stocks of the final-use category and the carbon stocks of the original category. Pursuant to IPCC Default (IPCC 1996b, 2003, 2006), the total changes are linearly distributed over a period of 20 years (cf. Chapter 7.1.5). For afforested and deforested areas, the carbon-stock changes in mineral soils were calculated in keeping with the procedures in Table 320 and Chapter 19.5.2. For each relevant year, the forest-soil carbon stocks were calculated via linear interpolation of the C stocks given in the forest-soil surveys.

Table 320: Implied emission factors (IEF) [Mg C ha^{-1} a^{-1}] for mineral soils in the source categories afforestation and deforestation (negative = emission, positive = removal)

[MgC ha^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
KP 3.3 Afforestation/Reforestation	-0.56574	-0.55901	-0.55228	-0.54555	-0.53882	-0.53209	-0.52537	-0.51864	-0.51191	-0.50518
KP 3.3 Deforestation	0.54149	0.53490	0.52831	0.52172	0.51513	0.50854	0.50195	0.49536	0.48877	0.48218
[MgC ha^{-1} a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
KP 3.3 Afforestation/Reforestation	-0.4984	-0.49066	-0.48292	-0.47525	-0.46763	-0.46005	-0.45749	-0.45480	-0.45198	-0.45130
KP 3.3 Deforestation	0.47559	0.47438	0.47296	0.47134	0.46954	0.46757	0.46686	0.46594	0.46485	0.46248
[MgC ha^{-1} a^{-1}]	2010	2011								
KP 3.3 Afforestation/Reforestation	-0.40864	-0.36722								
KP 3.3 Deforestation	0.41870	0.37659								

Additional methodological descriptions are presented in the following chapters:

- Derivation of carbon stocks and carbon-stock changes, cf. Chapter 7.2.4.4.3.
- Results of derivation of carbon stocks and carbon-stock changes, cf. Chapter 7.2.4.4.4.

11.3.1.1.6 Organic soils

Information on methods used for calculating carbon stocks and carbon-stock changes in organic soils is presented in the following chapters:

- Forest Land remaining Forest Land, cf. Chapter 7.2.4.5.1.
- Land converted to Forest Land cf. Chapter 7.2.4.5.2.

Deforested areas:

- For land converted to forest land, the carbon-stock changes in organic soils were calculated in keeping with the procedures in Table 321 and Chapter 7.1.6. The area-weighted emission factor for deforestation in 2011 is -4.619 Mg C ha^{-1}. It is important to remember that these calculations do not yield the carbon-stock difference between forest land and the subsequent use; they yield the emissions for the new use, in keeping with drainage intensity. Organic soils under forest already emit 0.68 MgC ha^{-1} a^{-1}.

Table 321: Emission factors for organic soils of deforestation categories (negative = loss; positive = sink)

Land-use change	Emission factor [MgC ha^{-1} a^{-1}]
Forest land converted to cropland	-11.00
Forest land converted to grassland	-5.00
Forest Land converted to woody gl.	-0.68
Forest land converted to wetlands	0.00
Forest land converted to water	0.00
Forest land converted to settlements	-5.00
Forest land converted to other land	0.00

11.3.1.1.7 Other greenhouse-gas emissions from forests

Information relative to calculations of other greenhouse-gas emissions from forests is presented in the following chapters:

- Liming, cf. Chapter 7.2.4.6.1.
- Wildfires, cf. Chapter 7.2.4.6.2.
- Drainage, cf. Chapter 7.2.4.6.3.
- Land-use changes from forest land to cropland, cf. Chapter 7.2.4.6.4.

11.3.1.2 Justification when omitting any carbon pool or of greenhouse-gas emissions / removals from activities under Article 3.3 and elected activities under Article 3.4

No dead wood occurs on new forest land. Since the dead wood pool thus cannot be a source, NO (not occurring) is entered in the CRF tables. A detailed justification for this approach is presented in Chapter 7.2.4.2.2.

No fertilisation of forest areas, with mineral fertilisers, takes place in Germany. For this reason, fertilisation with mineral fertilisers is listed as NO (not occurring) in the CRF tables.

No areas with mineral soils that are subject to drainage are known; for this reason, NO (not occurring) is entered for this category in the CRF tables (cf. Chapter 7.2.4.6.3).

11.3.1.3 Information on whether or not indirect and natural greenhouse gases and removals have been factored out

No indirect or natural greenhouse-gas emissions or sinks were taken into account.

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

In the report, new data sources and methods were taken into account, and recalculations were carried out for selected time series. The following changes have been made: With regard to activity data, the current data records of the Basis-DLM (2011) were taken into account in derivation of the relevant areas. This necessitated recalculations for the years 2009 and 2010. The resulting area changes, and a comparison with the corresponding areas as reported in the 2012 Submission, are shown in Table 322. All area changes in the categories afforestation, deforestation and forest management were smaller than 1 %. Detailed descriptions of the methods used to prepare the land-use matrix are provided in Chapter 7.1.3.

Table 322: Comparison of the changes, as reported in the 2012 and 2013 submissions, in the land-area matrix used for purposes of reporting under the Kyoto Protocol [kha]

[kha]	2009	2010
Afforestation, 2013	376.019	377.378
Afforestation, 2012	375.802	376.944
Deforestation, 2013	196.516	198.305
Deforestation, 2012	195.767	196.806
Forest management, 2013	10,557.185	10,555.397
Forest management, 2012	10,557.935	10,556.895

For the land-use category afforestation and deforestation (3.3.A.2), recalculations were carried out for the following pools:

- The emission factors for mineral soils were adjusted to take account of the final data from the Forest Soil Inventory (BZE). Further pertinent information is provided in Chapter 7.2.4.4.
- With regard to the biomass pool, while the emission factors for decreases / increases on forest land did not change, adjustment of the biomass emission factors for the relevant initial / final land-use categories still made recalculations necessary (cf. Chapter 7.1.7).
- For the current submission, the final BZE data were available for the litter pool, as well as for the mineral soils pool. For this reason, the pertinent time series was recalculated here as well. Details relative to the data and the method used are provided in Chapter 7.2.4.3.

For afforestation, Table 323 compares the time series in the current submission with those from the previous year's submission, while Table 324 presents such a comparison for deforestation.

Table 323: Comparison of emissions [Gg CO_2], as reported in 2012 and 2013 submissions, from afforestation A/R (KP 3.3)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mineral soils, 2013	54.642	107.983	160.025	210.768	260.210	308.353	355.196	400.740	444.983	487.927
Mineral soils, 2012	29.369	58.738	88.107	117.475	146.844	176.213	205.582	234.951	264.320	293.689
Above-ground biomass, 2013	858.524	546.170	214.992	-85.378	-416.302	-730.684	-1,043.685	-1,360.190	-1,682.863	-1,996.701
Above-ground biomass, 2012	857.959	545.551	214.281	-85.903	-416.920	-731.239	-1,044.233	-1,360.668	-1,683.292	-1,997.117
Below-ground biomass, 2013	303.124	196.385	85.423	-17.054	-126.740	-233.163	-339.492	-445.895	-553.981	-660.200
Below-ground biomass, 2012	297.170	190.376	79.380	-23.030	-132.747	-239.143	-345.482	-451.845	-559.901	-666.126
Litter, 2013	-47.836	-95.414	-142.735	-189.799	-236.605	-283.154	-329.445	-375.479	-421.255	-466.774
Litter, 2012	-49.973	-99.720	-149.243	-198.540	-247.612	-296.458	-345.079	-393.475	-441.646	-489.591
[Gg CO_2 a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mineral soils, 2013	529.571	537.917	545.807	553.240	560.216	566.736	572.891	578.774	584.383	585.672
Mineral soils, 2012	323.058	329.952	336.391	342.327	347.702	352.451	356.370	360.027	363.377	361.868
Above-ground biomass, 2013	-2,320.017	-3,402.777	-3,520.380	-3,639.153	-3,728.643	-3,844.246	-3,874.817	-3,938.552	-4,001.059	-4,236.063
Above-ground biomass, 2012	-2,320.363	-3,402.853	-3,520.484	-3,639.533	-3,728.726	-3,844.341	-3,874.891	-3,938.592	-4,001.096	-4,247.744
Below-ground biomass, 2013	-768.720	-1,143.159	-1,182.004	-1,221.300	-1,253.310	-1,291.102	-1,301.287	-1,322.965	-1,344.220	-1,421.635
Below-ground biomass, 2012	-774.602	-1,143.780	-1,182.628	-1,222.060	-1,253.940	-1,291.726	-1,302.591	-1,324.255	-1,345.511	-1,426.381
Litter, 2013	-512.035	-526.616	-541.108	-555.511	-569.826	-584.052	-591.821	-599.536	-607.199	-607.678
Litter, 2012	-537.311	-552.866	-568.344	-583.744	-599.066	-614.311	-622.776	-631.195	-639.568	-640.011
[Gg CO_2 a^{-1}]	2010									
Mineral soils, 2013	532.255									
Mineral soils, 2012	333.215									
Above-ground biomass, 2013	-4,252.181									
Above-ground biomass, 2012	-4,261.574									
Below-ground biomass, 2013	-1,426.964									
Below-ground biomass, 2012	-1,430.919									
Litter, 2013	-608.144									
Litter, 2012	-640.444									

Table 324: Comparison of emissions [Gg CO_2-eq.], as reported in 2012 and 2013 submissions, from deforestation D (KP 3.3)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mineral soils, 2013	-28.367	-56.044	-83.031	-109.327	-134.932	-159.848	-184.073	-207.607	-230.451	-252.605
Mineral soils, 2012	-14.943	-29.885	-44.828	-59.771	-74.714	-89.656	-104.599	-119.542	-134.484	-149.427
Above-ground biomass, 2013	746.292	742.651	748.196	738.706	744.127	741.475	738.150	736.534	737.928	735.011
Above-ground biomass, 2012	746.460	742.845	748.435	738.854	744.320	741.638	738.309	736.659	738.030	735.106
Below-ground biomass, 2013	187.012	186.697	188.442	186.046	187.169	186.699	186.183	185.703	186.045	185.475
Below-ground biomass, 2012	191.036	190.747	192.509	190.080	191.218	190.735	190.224	189.725	190.052	189.485
Litter, 2013	1,031.572	1,028.796	1,026.020	1,023.244	1,020.468	1,017.692	1,014.916	1,012.140	1,009.364	1,006.588
Litter, 2012	1,077.654	1,075.225	1,072.796	1,070.367	1,067.938	1,065.509	1,063.080	1,060.651	1,058.222	1,055.793
[Gg CO_2 a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mineral soils, 2013	-274.068	-279.323	-284.423	-289.367	-294.156	-298.790	-303.760	-308.584	-313.262	-314.557
Mineral soils, 2012	-164.370	-168.162	-171.980	-175.829	-179.713	-183.635	-187.974	-192.455	-197.105	-198.349
Above-ground biomass, 2013	736.720	241.139	201.532	202.243	200.523	200.970	145.429	145.344	145.206	50.562
Above-ground biomass, 2012	736.780	241.143	201.539	202.272	200.527	200.976	145.432	145.346	145.208	20.806
Below-ground biomass, 2013	186.028	62.509	73.477	73.667	73.253	73.318	54.058	54.042	54.007	21.370
Below-ground biomass, 2012	190.017	63.022	73.990	74.192	73.766	73.831	54.855	54.837	54.803	10.145
Litter, 2013	1,003.812	238.250	237.589	236.928	236.268	235.607	220.502	219.882	219.262	115.613
Litter, 2012	1,053.364	250.126	249.548	248.970	248.391	247.813	232.036	231.493	230.950	70.789
[Gg CO_2 a^{-1}]	2010									
Mineral soils, 2013	-287.399									
Mineral soils, 2012	-184.270									
Above-ground biomass, 2013	50.811									
Above-ground biomass, 2012	20.957									
Below-ground biomass, 2013	21.422									
Below-ground biomass, 2012	10.176									
Litter, 2013	115.286									
Litter, 2012	70.622									

In the forest management category (KP 3.4), recalculation was required only with regard to the litter pool. As for afforestation and deforestation, the applicable emission factors (EF) were adjusted in light of the final BZE data. As a result, the EF (1990-2011) for litter changed from 0 (2012 Submission) to -0.05 Mg C ha^{-1}. The final BZE data made it possible, for the first time, to enter values for the mineral soils pool into the CRF tables. The EF (1990-2011) for mineral soils is 0.27 Mg C ha^{-1}. Further information relative to litter is presented Chapter 7.2.4.3, while additional information on mineral soils is provided in Chapter 7.2.4.4.

11.3.1.5 Estimation of uncertainties

For purposes of the Kyoto Protocol (KP) – Article 3.3 Afforestation/Deforestation and 3.4 Forest Management – uncertainties were determined pursuant to the provisions of IPCC (2000; IPCC – Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories). The uncertainty statistics commonly given for a normal distribution include the 95 % confidence interval, ± half of the 95 % confidence interval and 1.96 x the standard error, in % of the mean. For asymmetric distributions – in the present context, usually consisting of data sets with a logarithmic normal distribution – the relevant deviations are described as upper and lower bounds, expressed as % values of the pertinent position scale. Pursuant to the IPCC (2000), in such cases propagation of uncertainties is to be calculated via a conservative estimation in which the distance between the extreme value of the sloping axis section and the position scale is defined as half of the 95 % confidence interval. Table 325 shows the results of uncertainties calculation for all pools and sub-categories of the KP 3.3/3.4 inventory. The total uncertainty is ± 22.15 %.

Further information relative to uncertainties is provided as follows: for estimation of land-use-change areas, in Chapter 7.2.5.1; for above-ground and below-ground biomass, in Chapter 11.3.1.5.1; for litter and mineral soils, in Chapter 11.3.1.5.2; and summarised for the LULUCF sector overall, in Chapter 19.5.4.

Table 325: Uncertainties for greenhouse-gas reporting under the Kyoto Protocol, Articles 3.3 and 3.4

A Source category	Pool	B Gas	C Base year emissions [CO_2-eq.] Gg a^{-1}	D Year 2011 emissions [CO_2-eq.] Gg a^{-1}	E Activity data uncertainty (half the 95% confidence interval) %	F Emission factor uncertainty (half the 95% confidence interval) %	G Combined uncertainty (half the 95% confidence interval) %	H Combined uncertainty as % of total national emissions in year 2011 %
KP 3.3 Afforestation/Reforestation	Mineral soil	CO2	54.64	480.07	6.08	26.49	27.18	0.32
KP 3.3 Afforestation/Reforestation	Organic soil	CO2	4.35	55.35	6.08	180.88	180.98	0.25
KP 3.3 Afforestation/Reforestation	Above-ground biomass	CO2	858.52	-4267.06	6.08	98.07	98.26	10.37
KP 3.3 Afforestation/Reforestation	Below-ground biomass	CO2	303.12	-1432.03	6.08	78.60	78.84	2.79
KP 3.3 Afforestation/Reforestation	Litter	CO2	-47.84	-608.60	6.08	3.64	7.09	0.11
KP 3.3 Afforestation/Reforestation	Dead wood	CO2	0	0	0	0	0	0
KP 3.3 Deforestation	Mineral soil	CO2	-28.37	-260.85	8.36	26.49	27.78	0.18
KP 3.3 Deforestation	Organic soil	CO2	15.01	189.45	8.36	30.26	31.39	0.15
KP 3.3 Deforestation	Above-ground biomass	CO2	746.29	50.58	8.36	58.93	59.52	0.07
KP 3.3 Deforestation	Below-ground biomass	CO2	187.01	21.37	8.36	51.14	51.82	0.03
KP 3.3 Deforestation	Litter	CO2	1031.57	114.96	8.36	3.64	9.12	0.03
KP 3.3 Deforestation	Dead wood	CO2	86.50	23.13	8.36	6.12	10.36	0.01
KP 3.3 Deforestation - disturbance	Mineral soil	N2O	0	0.04	9.75	83.83	84.39	0.00
KP 3.4 Forest Management	Mineral soil	CO2	-10400.89	-10228.02	1.34	65.33	65.35	16.53
KP 3.4 Forest Management	Organic soil	CO2	579.97	554.21	1.34	180.88	180.89	2.48
KP 3.4 Forest Management	Above-ground biomass	CO2	-47664.87	-12762.96	1.34	15.71	15.76	4.98
KP 3.4 Forest Management	Below-ground biomass	CO2	-18746.05	-3683.13	1.34	24.22	24.26	2.21
KP 3.4 Forest Management	Litter	CO2	1968.74	1934.83	1.34	125.4	125.41	6.00
KP 3.4 Forest Management	Dead wood	CO2	-3691.29	-3627.72	1.34	60.43	60.45	5.42
KP 3.4 Forest Management - drainage	Organic soil	N2O	67.99	64.97	1.34	264.71	264.71	0.43
KP 3.4 Forest Management - wildfires	Wildfires	CH4	9.08	1.32	15.00	35.00	38.08	0.00
KP 3.4 Forest Management - wildfires	Wildfires	N2O	2.08	0.30	15.00	35.00	38.08	0.00
KP 3.4 Forest Management - liming	Liming	CO2	116.78	64.32	5.00	2.95	5.80	0.01
Total			**-74547.63**	**-33315.47**				**22.15**

11.3.1.5.1 *Estimation of uncertainties in emission factors for biomass*

Table 326 shows the uncertainties that result for the calculation of C stock changes in living biomass, as carried out in keeping with the information provided in Chapter 7.2.5.2. The following should be noted in this regard:

- It was not possible to derive emission factors for KP Afforestation/Reforestation and KP Deforestation for the new German Länder for the period 1993 – 2002, since the Datenspeicher Wald forest database does not contain the data necessary for such derivation. Consequently, the emission factors for the old German Länder have been used for that period.
- The 2008 Inventory Study did not include any survey of afforestation areas. The database for the pertinent deforestation points lacks reliability. For this reason, the emission factors for the period 1987 – 2002 have also used for the period 2002 – 2008.

Table 326: Total error budget for estimation of C changes in biomass for the inventory periods of the National Forest Inventory, 1987 – 2002 and 2002 – 2008; se = standard deviation, vef = volume-expansion factor, rd = bulk density

LULUCF category	area error [%]	se [%]	above-ground vef [%]	rd [%]	error total [%]	below-ground se [%]	root-shoot ratio [%]	error total [%]	carbon carbon error [%]	error total [%] above-ground	below-ground
1987 – 2002	**Old German Länder**										
KP Forest Management	0.93	2.70	2.06	6.29	7.15	2.50	17.38	17.55	2.00	7.48	17.69
KP Afforestation	5.50	8.35	2.70	6.96	11.20	8.01	24.79	26.05	2.00	12.64	26.70
KP Deforestation	5.96	11.13	2.14	8.21	14.00	11.05	23.09	25.60	2.00	15.35	26.36
1993 – 2002	**New German Länder**										
KP Forest Management	1.12	5.77	1.57	21.66	22.47	5.76	19.34	20.18	2.00	22.59	20.31
2002-2008	**Germany**										
KP Forest Management	1.79	28.18	1.23	4.95	28.64	24.47	13.30	27.86	2.00	28.77	27.98
KP Deforestation	26.44	82.42	2.14	8.21	82.85	63.02	23.09	67.12	2.00	86.99	72.16

For the KP categories Afforestation and Deforestation, the errors in the biomass figures for the initial-use / final-use category, in addition to the errors in determination of forest biomass, have to enter into the error calculation for the emission factors. Table 327 shows the uncertainties of the 95 % confidence interval for Forest Land, and for the relevant initial-use and final-use categories, as well as the total uncertainty for each emission factor.

Table 327: Uncertainties for the emission factors for biomass

LULUCF category	Uncertainty above-ground Forest land [%]	LUC [%]	Total [%]	Uncertainty below-ground Forest land [%]	LUC [%]	Total [%]
1990 – 2011			**Germany**			
KP Forest Management	15.71		15.71	24.22		24.22
KP Afforestation	24.77	131.12	98.07	52.33	102.68	78.60
KP Deforestation	43.49	131.12	58.93	52.63	102.68	51.14

11.3.1.5.2 *Estimation of uncertainties in emission factors for mineral soils and litter*

The following uncertainties result for the emission factors for mineral soils and litter, as carried out in keeping with the information provided in Chapter 7.2.5.3 (cf. Table 328):

Table 328: Error budget for the emission factors for mineral soils and litter; se = standard deviation of the mean value; C 90, C 06 = laboratory error in carbon-stocks determination, BZE I and BZE II; FE = error in determination of the fine-earth fraction

LULUCF category	Pool	Emission factor					
		se [%]	C 90 [%]	C 06 [%]	FE [%]	Error total [%]	Uncertainty [%]
KP Forest Management	Litter	61.3	17.4	9.0		62.7	125.4
KP Forest Management	Mineral soil	16.5	12.2	4.5	19.1	33.3	65.3

11.3.1.6 Information on other methodological issues

11.3.1.6.1 Comparison with results of neighbouring countries

A by-country comparison of afforestation-related carbon-stock changes in living above-ground and below-ground biomass (Table 329) shows that Germany has the largest carbon sink. The lowest carbon-storage results are seen in Denmark. In the area of deforestation, Germany shows far and away the lowest carbon losses for the pools above-ground and below-ground biomass. The largest losses in the area of above-ground biomass are seen in Switzerland, followed by Belgium, the UK and the Czech Republic. In the below-ground biomass category, the largest losses occurred in Belgium and the Czech Republic. In the forest management category, Germany's carbon sink is among the lowest. In the category of living above-ground biomass, only Switzerland has a smaller sink. Denmark has the largest sink in this category.

Germany's litter-related carbon-sink value (Table 330) in the area of afforestation ranks in the middle of the range for all countries being compared. The highest values – and, thus, the largest C sinks – are seen in Austria. Denmark is the only country to have a carbon source in this category. In the area of deforestation, Germany has the lowest carbon losses, followed by France and Denmark. The highest emissions from deforestation occurred in the Netherlands and in Austria. Forest management produces a slight carbon source in Germany. Denmark and the UK have sinks in this category.

Germany's deforestation-related carbon losses in the dead-wood (Table 331) category are among the smallest, after those of Denmark. The largest C losses in this category, far and away, are found in Switzerland. In the forest management category, Germany, Denmark, Switzerland and the Czech Republic all have small carbon sinks. Only France has carbon losses (small) in this category.

Germany is the only country with afforestation-related carbon losses in the mineral soils category (Table 332) The largest carbon sinks in this category are found in Poland, Belgium and Austria, while the other countries chosen for comparison have only small sinks. On the other hand, Germany is the only country with a carbon sink in the deforestation category. The smallest C losses are found in the Czech Republic, while the largest C losses, far and away, are seen in Poland, followed by Switzerland. In the forest management category, Germany occupies a mid-range position in the area of carbon sinks.

In the area of organic soils (Table 333), Germany has carbon losses in all three categories. The Netherlands have far and away the largest losses via afforestation. A carbon sink in this category is seen only in the UK. All comparable countries also show deforestation-related carbon losses in organic soils. Germany has the third-largest losses, after the Netherlands and Switzerland. In the area of forest management, Germany and Switzerland have the largest carbon losses. The UK is the only country with a C sink in this category.

Table 329: Carbon-stock changes in living biomass (Germany, for 2011; other countries, for 2010)

Country[114]	Afforestation / Reforestation [Mg C ha^{-1}]		Deforestation [Mg C ha^{-1}]		Forest Management [Mg C ha^{-1}]	
	Above-ground	Below-ground	Above-ground	Below-ground	Above-ground	Below-ground
AUT	1.00	0.18	-0.72	-0.19	NA	NA
BEL	1.92	0.38	-3.99	-0.80	NA	NA
CHE	2.16	IE	-5.63	IE	0.17	IE
CZE	1.59	0.32	-3.22	-0.64	0.59	0.12
DNK	0.19	0.05	-0.88	-0.19	1.95	0.40
FRA	0.85	0.40	-2.07	-0.46	0.46	0.18
GBR	2.42	IE	-3.65	IE	0.45	IE
GER	**3.07**	**1.03**	**-0.07**	**-0.03**	**0.33**	**0.10**
NLD	2.13	0.78	-2.57	-0.47	NA	NA
POL	1.92	0.54	-2.61	-0.52	0.56	0.23

Source: UNFCCC 2012

Table 330: Carbon-stock changes in litter (Germany, for 2011; other countries, for 2010)

Country[114]	Afforestation / Reforestation [Mg C ha^{-1}]	Deforestation [Mg C ha^{-1}]	Forest Management [Mg C ha^{-1}]
AUT	1.19	-1.23	NA
BEL	NO	-0.31	NA
CHE	NO	-1.13	NO
CZE	IE	IE,NA	NE,NO
DNK	-0.18	-0.20	0.52
FRA	0.27	-0.19	0
GBR	0.09	IE	0.49
GER	**0.44**	**-0.16**	**-0.05**
NLD	NE	-1.29	NA
POL	IE	IE	IE

Source: UNFCCC 2012

Table 331: Carbon-stock changes in dead wood (Germany, for 2011; other countries, for 2010)

Country[114]	Afforestation / Reforestation [Mg C ha^{-1}]	Deforestation [Mg C ha^{-1}]	Forest Management [Mg C ha^{-1}]
AUT	NO	IE	NA
BEL	NO	-0.08	NA
CHE	NO	-0.32	0.03
CZE	NO	-0.08	NO
DNK	-0.20	-0.02	0.06
FRA	0.04	-0.08	-0.06
GBR	IE	IE	IE
GER	**0**	**-0.03**	**0.09**
NLD	NE	-0.06	NA
POL	0.02	-0.08	0.02

Source: UNFCCC 2012

[114] AUT = Austria, BEL = Belgium, CHE = Switzerland, CZE = Czech Republic, DNK = Denmark, FRA = France, GBR = UK, GER = Germany, NLD = the Netherlands, POL = Poland

Table 332: Carbon-stock changes in mineral soils (Germany, for 2011; other countries, for 2010)

Country[114]	Afforestation / Reforestation [Mg C ha^{-1}]	Deforestation [Mg C ha^{-1}]	Forest Management [Mg C ha^{-1}]
AUT	0.68	-0.94	NA
BEL	1.38	-1.61	NA
CHE	0.17	-1.78	NO
CZE	0.15	-0.07	NE,NO
DNK	0.15	-0.20	NA,NR
FRA	0.20	-0.98	0
GBR	0.21	-1.14	0.56
GER	**-0.37**	**0.38**	**0.27**
NLD	0.18	-0.19	NA
POL	1.88	-2.21	0.53

Source: UNFCCC 2012

Table 333: Carbon-stock changes in organic soils (Germany, for 2011; other countries, for 2010)

Country[114]	Afforestation / Reforestation [Mg C ha^{-1}]	Deforestation [Mg C ha^{-1}]	Forest Management [Mg C ha^{-1}]
AUT	NO	NO	NA
BEL	NO	NO	NA
CHE	-0.68	-5.73	-0.68
CZE	NO	NO	0.00
DNK	-0.34	-2.53	-0.34
FRA	NO	NO	NO
GBR	0.45	IE	0.58
GER	**-0.68**	**-4.62**	**-0.68**
NLD	-6.46	-5.75	NA
POL	NO	NA	NO

Source: UNFCCC 2012

11.3.1.7 The year of the onset of an activity, if after 2008

Table 334 shows the interpolated area sizes for KP 3.3 activities that began after 2008. The activity Forest Management (KP 3.4) is included only for those areas that have been forest since 1990. As the table indicates, there are no areas on which forest management began after 2008.

Table 334: Relevant area sizes for activities that began after 2008.

KP 3.3 Activity	Year of onset		
	2009	**2010**	**2011**
Afforestation/Reforestation [ha]	1359	1359	1359
Deforestation [ha]	1788	1788	1788

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are directly human-induced

As described in Chapter 7.1.3, the procedure for determining land-use changes from and to forest land identifies area changes as of 1970, while the methods used for purposes of reporting under the Kyoto Protocol take account only of changes as of 1990. Currently, the third National Forest Inventory is in progress; it is referenced to 2012. That inventory will provide the database for recalculations at the end of the first commitment period. All included activities in this context thus fall within the period 1 January 1990 to 31 December 2012.

While each land-use change from and to forest land is recorded primarily via the National Forest Inventory (Bundeswaldinventur; BWI), such changes are also recorded in additional data sets. The relevant sampling points form a grid that covers all of Germany. Via repeated surveying of the sample points, all changes can be mapped on a large scale. If a point is mapped as forest that was mapped as non-forest in the previous inventory, it represents a specific area of afforestation. The BWI differentiates between afforestation via planting / sowing and afforestation via natural rejuvenation. However, an area afforested via natural rejuvenation is classified as *afforested* only when the relevant stand has an average age of five years and crown cover of at least 50 % (cf. Chapter 7.2.3.1).

Agricultural land can change from (managed) cropland to unmanaged land and, via spontaneous establishment of trees (natural rejuvenation), into forest land. Pursuant to GPG (IPCC 2003), afforestation may be reported only if it is "directly human-induced". "It is *good practice* to provide documentation that all afforestation and reforestation activities included (…) are directly human-induced. Relevant documentation includes forest management records or other documentation that demonstrates that a decision had been taken to replant or to allow forest regeneration by other means."[115] German law requires a "permit from the competent authority under the law of the Länder" (Art. 10 (1) Federal Forest Act (BWaldG)) for each afforestation. Pursuant to Para. 2, no permit is required only in those cases in which, for the area to be afforested, "afforestation has been mandated in a legally binding way, on the basis of other public legal provisions, or the requirements of regional planning and Land (state) planning are not affected". Germany is a densely populated, intensively managed country in which all areas nation-wide are subject to land-use plans. In addition, Germany has different planning levels, ranging from large-scale planning (e.g. regional planning) to specific small-scale planning (e.g. landscape plans, operational plans for forest management). Preparation of, and compliance with, plans is monitored by the relevant competent authorities in each case, including authorities of the Federal Government, of the Länder and of individual municipalities. Thus it may be assumed that all afforested areas fulfill the "directly human-induced" requirement, since the act of permission, as well as the act of mandating in a legally binding manner and the preparation and establishment of regional and landscape plans all presuppose active decisions by humans.

11.4.2 Information on how harvesting forest disturbance that is followed by re-establishment of forests is distinguished from deforestation

Pursuant to Art. 11 (1) Federal Forests Act (BWaldG), "forests (…) (should) be properly and sustainably managed, in the framework of their defined purposes. Länder laws are to be enacted that set forth obligations for all forest owners whereby clear-cut or degraded forest areas

1. are to be reforested, or
2. replenished, in cases in which natural regrowth remains incomplete,

within a reasonable period of time, unless conversion to another type of use has been approved or is otherwise permitted."

[115] Cf. IPCC LULUCF GPG (2003), Section 4.2.5.2.

In general, reforestation is called for on all forest areas that are to remain in use as forest land. That is a legal requirement, and it is the customary practice in the German forestry sector. Forest land that is temporarily unstocked thus continues to fall within the scope of required reporting on forest management pursuant to Art. 3.4 KP. The situation is different in cases in which forest land becomes unstocked and planning calls for subsequent use of the land to fall within the category "non-forest land". Such land is to be considered deforested land, with the relevant deforestation directly human-induced, regardless of whether the deforestation was caused by harvesting or by natural disturbances.

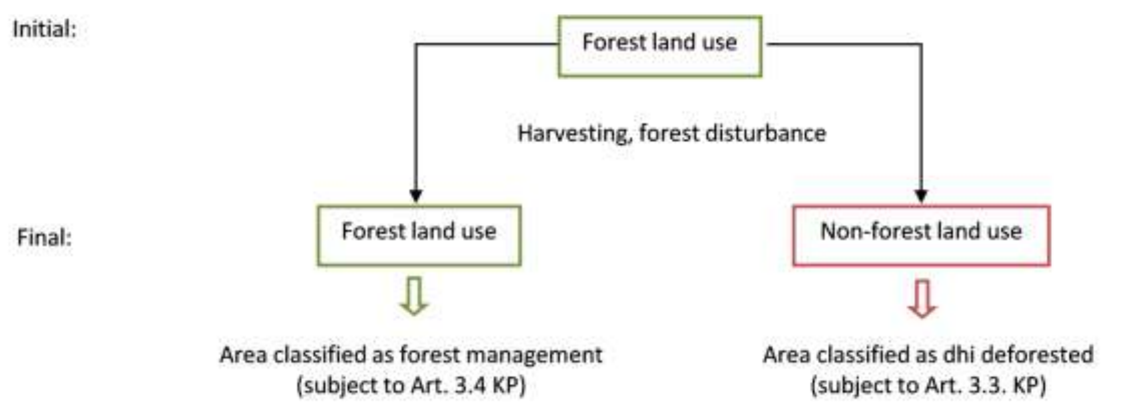


Figure 77: Scheme for differentiation between a) harvest or forest disturbance that is followed by reforestation, and b) deforestation

11.4.3 Information about the size and geographic location of forest areas that have lost forest cover but which are not yet classified as deforested

Forest management routinely generates small unstocked areas (bare areas) in forests. Pursuant to the data of the BWI 2 (2002), such areas total about 66,000 ha and account for 0.6 % of the total forest area. As explained above in Chapter 11.4.2, such areas continue to fall within the national forest definition and continue to figure in calculations relative to carbon stocks and their changes.

11.5 Article 3.4

11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Since an integrated procedure is used for surveying forest lands, land-use changes and the carbon-stock changes caused by relevant activities, the statements made in Chapter 11.4.1 apply mutatis mutandis for the activity "forest management".

Pursuant to Art. 1 No. 1 Federal Forest Act (BWaldG), "forests are to preserved, to be enlarged as necessary and to be properly and sustainably managed, in light of their economic value (utility function) and of their importance with regard to the environment, especially the long-term vitality of natural systems and cycles, and with regard to climate, water cycles, air quality, soil fertility, landscape beauty, agrarian structures and infrastructure and the population's needs for rest and recreation (protection and recreation functions)".

Forests are thus assigned three key basic functions, namely utility, conservation and recreation functions, in light of which they are to be preserved and properly and sustainably managed. In addition, Art. 11 (1) p. 1 BWaldG sets forth that "forests (…) (should) be properly and sustainably managed, in the framework of their defined purposes." While that formulation does not mean that forests "must" be managed, and thus it does not establish a general obligation, it is important to note that it does not use "may" phrasing, which would rule out any obligation. The wording chosen thus clearly reveals a basic orientation – namely, that forests should be managed. An obligation to manage forest lands thus applies to all of Germany[116].

In the interest of protecting forests' three basic functions, forests, pursuant to Art. 1 No. 1 in conjunction with Art. 11 (1) p.1 BWaldG, should be protected and properly and sustainably managed. The aim of proper forest management as set forth by the Marrakesh Accords thus agrees with the requirements set forth by the Federal Forest Act (BWaldG). In both cases, management is oriented to the aim of ensuring that the forest can continue to fulfill its functions in perpetuity.

The Marrakesh Accords define forest management as "a system of practices". That indicates that management involves actions / measures. A forest area that is left untouched, and for which no measures are taken, is thus not a managed forest area. For a forest area to qualify as "unmanaged", however, no human activities may take place in it, i.e. no active human interventions may be permitted in it (equivalent to MCPFE conservation category 1.1). Forest areas meeting those criteria are "practically non-existent" in Germany (BMELV, 2009). In 2007, forest conservation areas in which permitted human interventions are restricted to a minimum, i.e. fully protected areas (MCPFE conservation category 1.2), accounted for 1.1% of Germany's total forest area, and were tending to be enlarged (BMELV, 2009). The primary focus with regard to such forest areas is on biotope and species conservation (for example, protected forests, natural forest reserves, core zones of national parks and biosphere reserves). Certain types of interventions are expressly permitted, however (for example, measures to control wildfires, hoofed game, diseases or insect calamities[117]). For protected forests, as for all protected areas, concepts are to be prepared that set forth / define / describe the object/focus of protection, the protection purpose, the necessary requirements and prohibitions for achieving the protection purpose and the necessary relevant care, management, development and restoration measures[118] (for example, in ordinances or guidelines on protected areas; cf. for example, Art. 23 (2) State Forest Act (LWaldG) of Mecklenburg – West Pomerania). In addition, some 23% of Germany's forest area consists of protected areas whose conservation purpose is actively assured via management measures (MCPFE conservation category 1.3); 56 % consist of forests whose primary purpose is to conserve landscapes and specific natural elements (MCPFE conservation category 2); and 34 % have the primary purpose of providing protective functions (MCPFE

[116] Häusler and Scherer-Lorenzen (2002) speak of an obligation, for all forest owners, "to carry out sustainable, proper management"; the citation appears in: Nachhaltige Forstwirtschaft in Deutschland im Spiegel des ganzheitlichen Ansatzes der Biodiversitätskonvention. BfN – Skripten 62, p. 5 and 15.

[117] In addition, environmentally compatible measures to develop forests for recreational purposes and for nature-compatible research are permitted.

[118] Cf. for example, Art. 22 (1) Federal Nature Conservation Act (BnatSchG).

conservation category 3). In MCPFE conservation categories 1.3 through 3, management is to be aligned with the relevant conservation purpose. Such categories thus fulfill the criteria for forest management. Human activities for protecting conservation areas are also certainly allowed in MCPFE category 1.2. Pursuant to IPPC GPG LULUCF (2003), such areas thus fulfill forest-management criteria in accordance with Art. 3.4 KP: "For example forested national parks (…) where these parks are managed to fulfil relevant ecological (including biodiversity) and social functions, and are subject to forest management activities such as fire suppression, a country may choose to include these forested national parks as lands subject to forest management."[119] It should be noted that the aforementioned area shares in the different forest-conservation categories cannot simply be summed, since they overlap to some extent; in some cases, the same forest area will have been repeatedly included (BMELV, 2009).

Large parts of Germany's forest lands are subject to planning. According to estimates of the BMELV, forest-management plans (economic plans, operational plans or reports) are in place for about ¾ of the country's forested area (BMELV, 2009). In addition to such operational plans, in many cases forest landscape plans (forest framework plans) are also prepared for forests, in the framework of landscape planning[120]. The aim of forest framework planning is to "safeguard the forest functions necessary for the development of ecological and economic conditions pursuant to Art. 1 No. 1 (BWaldG)". That accords precisely with the aim prescribed by IPCC GPG with respect to forest management. To that end, measures may be, or must be, prescribed (cf. for example, Art. 6 (3) No. 4 p. 2 BWaldG old version; Art. 6 (1) No. 2 Bavarian Forest Act (BayWaldG); Art. 9 (4) State Forest Act (LWaldG) of Mecklenburg – West Pomerania; Art. 6 p. 2 Forest and Landscape Act of the State of Lower Saxony (NWaldLG); Art. 7 (1) State Forest Act for the State of North Rhine – Westphalia (LFoG NRW); Art. 6 (2) Forest Act of the State of Saxony-Anhalt (WaldG Sachsen-Anhalt)[121]). In some cases, requirements explicitly call for such planning to serve as a guideline for management, inter alia (cf. Art. 8 (3) LFoG NRW).

All in all, it must thus be considered confirmed that all forests in Germany are managed in accordance with forest-management criteria as set forth by the Marrakesh Accords and by IPCC GPG LULUCF (2003).

A compilation of excerpts from state forest acts, relative to requirements for forest management and for forest framework planning, is provided by STEUK (2010). A pertinent summary is presented in Table 335.

[119] IPCC Good Practice Guidance LULUCF (2003) Chapter 4.2.7.2, p. 4.62 f.

[120] Until 2005, the Federal Forest Act (BWaldG) required the preparation of forest framework plans. Because the Länder differ widely in their planning structures, those provisions were eliminated, however. Cf. BMELV (2009) Waldbericht der Bundesregierung (Forest Report of the Federal Government), p. 28.

[121] For definition of measures in operational plans, cf. Art. 5 (6) p. 3 State Forest Act (LWaldG) of Schleswig-Holstein.

Table 335: Overview of obligations relative to forest management, preparation of plans and use of forest framework plans, as set forth by the forest acts of the Länder

State (Land)	Forest-management obligations			Obligations to prepare plans (economic plans, operational plans, operational reports or other specialised forest-management plans)			Obligations to prepare forest framework plans
	State forest	Municipal forest	Private forest	State forest	Municipal forest	Private forest	
Baden-Württemberg	X	X	X	X	X	(X)	(X)
Bavaria	X	X	X	X	[X]		(X)
Berlin	X	X	X				X
Brandenburg							X
Bremen	X	X	X				
Hamburg	X	X	X				X
Hesse	X	X	X	X	X	[X]	
Mecklenburg – West Pomerania	X	X	X				X
Lower Saxony	X	X	X	[X]	[X]		X
North Rhine – Westphalia	X	X	X		X		X
Rhineland-Palatinate	X	X	X	[X]	[X]	[X]	X
Saarland	X	X	X	X	X	(X)	X
Saxony	X	X	X	X	X		(X)
Saxony-Anhalt	X	X	X	X	X		X
Schleswig-Holstein				[X]	[X]		
Thuringia	X	X	X	X	X	[X]	X

Legend:

X Binding requirement (includes "should" requirements)

[X] Requirement is binding only under certain conditions (for example, conditions pertaining to minimum size)

(X) Optional guideline / not binding (a "can" requirement)

11.5.2 Information related to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year

Germany has elected for crediting of forest management pursuant to Article 3.4 KP only (cf. Chapter 11.1.2).

No information about other activities is available.

11.5.3 Information relating to Forest Management

As explained above in Chapter 11.5.1, the law requires German forests to be managed properly and sustainably. National provisions on forest management are set forth in the Federal Forest Act (BWaldG). In addition, the Länder have their own Land (state) forest acts in place that further detail the provisions of the Federal Forest Act. A comparison of Germany's national provisions with the relevant international definition shows broad agreement.

International definition pursuant to the Marrakesh Accords[122]*:*

[122] Paragraph 1 lit. f of Annex A of Decision 16/CMP.1

"'Forest management' is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner."

National definitions pursuant to state forest acts (Landeswaldgesetze - LWaldG):

Pursuant to Art. 1 No. 1 Federal Forest Act (BWaldG), the purpose of the Act is, in particular, "to conserve forest for the sake of its economic value (utility function) and for the sake of its (…) (conservation and recreation function), to increase it, if necessary, and to assure its proper management for the long term". Pursuant to Art. 11 (1) p. 1 BWaldG, forests are to be "managed properly and sustainably, in the framework of their defined purposes." In keeping with the Federal Government's restricted legislative competence in this regard, the Federal Government simply provides a framework that the Länder implement and detail with regard to specific applications (cf. Art. 5 and Art. 11 (1) p. 2 BWaldG). As a result, the Länder define what is to be understood by "proper and sustainable forest management". A compilation of relevant sections of Länder forest acts is provided by STEUK (2010).

The forest-management requirements pursuant to Länder forest acts are comparable to those set forth by international forest legislation. The requirement that forests are to be managed sustainably, with a view to fulfilling ecological (including biological diversity), economic and social functions[123], is found in all Länder forest acts. In Germany, ecological, economic and social functions are often referred to as "conservation, utility and recreation" functions[124] (cf. Table 336). Where the ecological, economic and social functions that are to be served by management are not referred to explicitly as such in Länder laws, the laws add the phrase "within the framework of its [their] defined purposes"[125]. Forests are thus to be managed sustainably, within the framework of their defined purposes. This orientation is found in Art. 1 BWaldG (purpose of the act), which appears verbatim in every Land forest act. In addition, Art. 1 No. 1 BWaldG sets forth that forests are to be protected especially "in light of their economic value (utility function) and their (…) (conservation and recreation functions)". The aim of protecting economic, ecological and social functions is thus found in all such laws. Furthermore, both the Federal Forest Act and the forest acts of the Länder warrant the sustainability of forest management.

[123] Cf. Art. 4 No. 1 BayWaldG; Art. 1a LFoG NRW; a similar meaning also is seen in Art. 6 (1) LWaldG RLP; and a similar meaning is seen in Art. 18 (1) in conjunction with Art. 19 (1) p. 2 ThürWaldG.

[124] Cf. Art. 1 No. 1 BWaldG; Art.13 LWaldG BW; Art. 11 (2) No. 1 LWaldG B; Art. 4 (2) LWaldG Bbg; Art.5 (1) BremWaldG, Art. 6 (1) HeFoG; Art. 6 (1) No. 1 LWaldG MV; Art. 11 (1) NWaldLG; Art. 5 (1) LWaldG SH.

[125] Cf. Art. 6 (1) LWaldG Ha; Art. 11 (1) LWaldG SL; Art. 17 SächsWaldG; Art. 4 (1) WaldG LSA; Art. 18 (1) ThürWaldG.

Table 336: Comparison of forest functions pursuant to the Federal Forest Act and the IPCC

Forest functions pursuant to BWaldG	Forest functions pursuant to MA
Utility function	Economic functions
Conservation function	Ecological functions
Recreation function	Social functions

11.6 Other information

11.6.1 Key-category analysis for Article 3.3 activities and any elected activities under Article 3.4

In connection with analysis for the UNFCCC inventory, key-category analysis was also carried out for activities pursuant to Article 3.3 and for selected activities pursuant to 3.4. The results are presented in tabular form in Chapter 1.5.2 of this report. The procedures, bases and methods used are described in detail in Chapter 17.1.4.

11.7 Information relative to Article 6 (JI & CDM projects / management of ERU)

Pursuant to Paragraph 5 (1) Sentence 1 of the Project Mechanisms Act (Projekt-Mechanismen-Gesetz; ProMechG), no projects in the area of LULUCF may be approved in Germany that are to take place in Germany.

12 INFORMATIONEN ON ACCOUNTING OF KYOTO UNITS

12.1 Background information

Chapter 12 and 14 include information on the German emission trading registry. The accounting on Kyoto units and the public availability of information is described in chapter 12. Any significant changes in the national registry are reported in chapter 14.

In June 2012, the previously existing decentralised registry architecture of the European emissions trading was fundamentally changed. The Union Registry introduced an EU-wide standardisation and centralisation of the system, but user accounts are still administered by the Member States. Due to the fact that the Union registry is developed and operated by the European Commission most of the requested information on national registry in accordance with paragraph 32 of the annex to decision 15/CMP.1 needs to be provided by the EU commission. Therefore, the chapter 14 of this report was provided by the EU commission on 27 February 2013. The text was retained unchanged. The answers to 15/CMP.1 annex II.E paragraph 32 (a), (g) and (h) were specified directly by the German registry administration.

12.2 Summary of information reported in the SEF tables

According to decision 15/CMP.1, annex, part 1, section E each Party must include information on its aggregate holdings and transactions of Kyoto units in its annual report. The information has to be reported in the Standard Electronic Format (SEF), which is an agreed format, embodied in a special report, for reporting on Kyoto units.

The SEF for 2012 was generated on 8 April 2013 with the Union registry in version 5.2.5, provided by the EU commission at 23 March 2013 and the SEF application version 1.2, provided by the secretariat at 9th of January 2009.

Amendment on 10/052013: The Union registry in version 5.2.5 calculated an incorrect amount of ERUs for 2012. Therefore, the SEF has to be re-submitted. The following values are corrected.

The German SEF for 2012 contains the information required in paragraph 11 of the annex to decision 15/CMP.1 and adhere to the guidelines of the SEF. The SEF has been submitted to the UNFCCC Secretariat electronically and the contents of the report can also be found in annex 6 (chapter 22.2.2.1) of this document.

At the end of 2012, AAUs amounting to 4,914,117,183 were contained in the German registry. The largest proportion or 2,733,213,882 AAUs, were recorded in party holding accounts, 2,180,899,876 AAUs were in the retirement account and 3,425 in other cancellation accounts. Besides AAUs the registry contained in total 61,212,961 ERUs and 135,948,656 CERs; no RMUs, tCERs or lCERs.

In total for 2012, the German registry received 53,063,615 AAUs, 58,832,501 ERUs and 71,579,172 CERs. Conversely, 71,786,779 AAUs, 31,490,006 ERUs and 69,822,433 CERs were transferred to foreign national registries. Transactions with most European countries within the European Emissions Trading Scheme (ETS) took place. In addition, ERU and CER have been received from outside the ETS (Japan, Russia, Ukraine).

More details are available in the SEF, which is shown in annex 6 (chapter 22.2.2.1) of this document.

12.3 Discrepancies and Notifications

15/CMP.1 annex I.E paragraph 12 List of discrepant transactions	One discrepant transaction occurred on 12 December 2012. The transaction was terminated on 13 Decmeber 2012 (26 h delay) with response code 4003. More details can be found in annex 6 (22.2.2.2) of this document.
15/CMP.1 annex I.E paragraph 13 and 14 List of CDM notifications	No CDM notifications occurred in 2012.
15/CMP.1 annex I.E paragraph 15 List of non-replacements	No non-replacements occurred in 2012.
15/CMP.1 annex I.E paragraph 16 List of invalid units	No invalid units exist as at 31 December 2012.
15/CMP.1 annex I.E paragraph 17 Actions and changes to address discrepancies	According to the SIAR Reporting Requirements and Guidance for Registries the code 4003 should be reported by the Party, but it will not be assessed as a discrepancy. 4003 can occur and the improved DES transaction message model was deployed in ITL v2.0 in Q4 of 2010, and this has reduced the number of occurances. Any actions or changes to address discrepancies are in the responsibility of the EU commission and will be reported in chapter 14.

12.4 Publicly accessible information

13/CMP.1 annex II paragraph 45
Account information

The requested information is publicly available for all accounts. The data of operator holding accounts can be viewed online at:
http://ec.europa.eu/environment/ets/oha.do?form=oha&languageCode=en&account.registryCodes=DE&accountHolder=&identifierInReg=&installationIdentifier=&installationName=&permitIdentifier=&mainActivityType=-1&complianceStatus=-1&search=Search&searchType=oha&currentSortSettings=

The data of all accounts can be viewed online at:
http://ec.europa.eu/environment/ets/account.do?languageCode=en&account.registryCodes=DE&identifierInReg=&accountHolder=&search=Search&searchType=account&currentSortSettings=
Representative name and contact information is classified as confidential due to Article 83 paragraph 8 and 9 Registry Regulation No. 1193/2011.

13/CMP.1 annex II paragraph 46
Joint implemention project information

The complete documentation of the JI projects is presented in the German JI project database which is accessible at the following URL. The database also contains already registered but not yet approved JI projects.
https://jicdm.dehst.de/promechg/pages/project1.aspx
In 2012, ERU for ten JI projects were converted from AAU to ERU. No ERU converted from RMU were issued. In total for 2012, 7,039,160 ERU were generated:

JI Project ID	Converted Amount	Unit Type
1000016	17,432	ERU converted from AAU
1000017	1,614,728	ERU converted from AAU
1000018	3,888,885	ERU converted from AAU
1000024	428,821	ERU converted from AAU
1000142	4,957	ERU converted from AAU
1000168	150,729	ERU converted from AAU
1000182	387,118	ERU converted from AAU
1000183	493,465	ERU converted from AAU
1000197	49,375	ERU converted from AAU
1000211	3,650	ERU converted from AAU
Sum	7,039,160	

13/CMP.1 annex II paragraph 47
Unit holding and transaction information

The information requested in (a), (d), (f) and (l) is classifed as confidential due to Article 83 paragraph 1 Registry Regulation No. 1193/2011 as well as national data protection law and therefore not publicly available. Transactions of units within the most recent five year period are also classified as confidential, therefore the transactions provided are only those completed more than five years in the past.
The information requested in (b), (c), (e), (g), (h), (i), (j) and (k) is publicly available at
http://ec.europa.eu/environment/ets/transaction.do?languageCode=en&startDate=&endDate=&transactionStatus=4&fromCompletionDate=&toCompletionDate=&transactionID=&transactionType=-

	1&suppTransactionType=-1&originatingRegistry=DE&destinationRegistry=-1&originatingAccountType=-1&destinationAccountType=-1&originatingAccountNumber=&destinationAccountNumber=&originatingAccountIdentifier=&destinationAccountIdentifier=&originatingAccountHolder=&destinationAccountHolder=&search=Search&currentSortSettings=&resultList.currentPageNumber=1 (b) In 2012 there was no issuance of AAU. (c) In 2012, 7,039,160 ERU were issued. (e) No RMU was issued in the reported year. (g) No RMU was cancelled on the basis of activities under Article 3, paragraph 3 and 4 in the reported year. (h) No ERU, CER, AAU and RMU were cancelled on the basis of activities under Article 3, paragraph 1 in the reported year. (i) In 2012, 597 AAU, 1,842 ERU and 134,595 CER were voluntary cancelled. No RMU was cancelled. (j) In 2012, 33,231,950 ERU, 41,123,292 CER, 907,807,291 AAU, and no RMU, tCER, lCER were retired. (k) There were no carry over of ERU, CER, AAU or RMU from the previous commitment period.
13/CMP.1 annex II paragraph 48 Authorized legal entities information	The following legal entities are authorized by the Member State to hold Kyoto units: *(see table below)* OHA: Operator Holding Account (installation and aircraft) PHA: Person Holding Account TA: Trading Account EPA: External Platform Account NHA: National Holding Account

	Legal entities authorised by Germany to hold units
AAU	Federal Government only
ERU	Each account holder of OHA, PHA, TA, EPA and NHA
CER	Each account holder of OHA, PHA, TA, EPA and NHA
RMU	Federal Government only
tCER	Federal Government only
lCER	Federal Government only

12.5 Calculation of the Commitment Period Reserve

Germany's Commitment Period Reserve (CPR) is calculated as 90 percent of Germany's assigned amount (4,868,096,694 tonnes CO_2 equivalent) calculated pursuant to Article 3 paragraphs 7 and 8 of the Kyoto Protocol. The initial CPR of the current commitment period did not change and is still 4,381,287,024 tonnes CO_2 equivalent (or AAU).

In accordance to Article 4 paragraph 4 Registry Regulation No. 1193/2011 the Union registry has to prepare for keeping the CPR. If a transfer proposal would result in an infringement of the CPR, the registry should reject it internally.

The German registry did not violate the CPR during the reported year.

13 Information on Changes in the National System

The emphasis in this reporting period was on further implementation and consolidation of the improvements achieved, through 2010, in institutionalisation of the National System. This involved a special focus on further consolidation on the extensive institutional improvements made in the LULUCF sector (of the National System) as a result of the remarks in the 2010 In-Country Review 2010. Furthermore, new gaps that had appeared in the data streams were closed in 2011.

Cooperation agreement with the German Electrical and Electronic Manufacturers' Association (ZVEI):

On 31 December 2010, a commitment entered into voluntarily in 2001 by semiconductor manufacturers with production sites in Germany, calling for reduction of emissions of certain fluorinated gases, expired. With that expiry, the voluntary data-provision commitment of the German Electrical and Electronic Manufacturers' Association (ZVEI) also expired. The data delivery for the year 2010 was the last under the commitment. For this reason, in 2011 the Single National Entity conducted intensive discussions with the ZVEI relative to the conclusion of a cooperation agreement on provision of the required data. In those discussions, the ZVEI, although its voluntary commitment had expired, expressed a willingness to continue providing all required data, on a voluntary basis, until an agreement was concluded. That has made it possible to prevent a gap in the data streams for reporting. In September 2012, the cooperation agreement with the ZVEI was then concluded. That agreement assures the long-term institutional provision of data for these source categories.

14 INFORMATION ON CHANGES IN NATIONAL REGISTRIES

Directive 2009/29/EC adopted in 2009, provides for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time, and with a view to increasing efficiency in the operations of their respective national registries, the EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and decision 24/CP.8.

With a view to complying with the new requirements of Commission Regulation 920/2010 and Commission Regulation 1193/2011, in addition to implementing the platform shared by the consolidating Parties, the registry of EU has undergone a major re-development. The consolidated platform which implements the national registries in a consolidated manner (including the registry of EU) is called Consolidated System of EU registries (CSEUR) and was developed together with the new EU registry on the basis the following modalities:

1. Each Party retains its organization designated as its registry administrator to maintain the national registry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries;
2. Each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number;
3. Each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a unique account number comprising the identifier of the Party and a unique number within the Party where the account is maintained;
4. Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions;
5. The transaction log and registries continue to reconcile their data with each other in order to ensure data consistency and facilitate the automated checks of the ITL;

6. The requirements of paragraphs 44 to 48 of the Annex to Decision 13/CMP.1 concerning making non-confidential information accessible to the public would be fulfilled by each Party individually;
7. All registries reside on a consolidated IT platform sharing the same infrastructure technologies. The chosen architecture implements modalities to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other, notably:
   (a) With regards to the data exchange, each national registry connects to the ITL directly and establishes a distinct and secure communication link through a consolidated communication channel (VPN tunnel);
   (b) The ITL remains responsible for authenticating the national registries and takes the full and final record of all transactions involving Kyoto units and other administrative processes such that those actions cannot be disputed or repudiated;
   (c) With regards to the data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation;
   (d) The data storage architecture also ensures that the data pertaining to a national registry are distinguishable and uniquely identifiable from the data pertaining to other consolidated national registries;
   (e) In addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorisation and configuration rules.

Following the successful implementation of the CSEUR platform, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. During the go-live process, all relevant transaction and holdings data were migrated to the CSEUR platform and the individual connections to and from the ITL were re-established for each Party.

The following changes to the national registry of Germany have therefore occurred in 2012, as a consequence of the transition to the CSEUR platform.

In accordance to the SIAR Reporting Requirements and Guidance for Registries a high level description for each change should be provided as test plans, test reports and readiness documentation. The required documents are confidential and accessible for assessors only ("documentation annexed to this submission"). Therefore the documents which are mentioned in the below table are not available within this document.

15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	No change in the name or contact information of the registry administrator occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	The EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway have decided to operate their registries in a consolidated manner. The Consolidated System of EU registries was certified on 1 June 2012 and went to production on 20 June 2012. A complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. This description includes: • Readiness questionnaire • Application logging • Change management procedure • Disaster recovery • Manual Intervention • Operational Plan • Roles and responsibilities • Security Plan • Time Validation Plan • Version change Management The documents above are provided as an appendix to this submission. A new central service desk was also set up to support the registry administrators of the consolidated system. The new service desk acts as 2nd level of support to the local support provided by the Parties. It also plays a key communication role with the ITL Service Desk with regards notably to connectivity or reconciliation issues.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	In 2012, the EU registry has undergone a major redevelopment with a view to comply with the new requirements of Commission Regulation 920/2010 and Commission Regulation 1193/2011 in addition to implementing the Consolidated System of EU registries (CSEUR). The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission. During certification, the consolidated registry was notably subject to connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). All tests were executed successfully and lead to successful certification on 1 June2012.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	The overall change to a Consolidated System of EU Registries triggered changes the registry software and required new conformance testing. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission. During certification, the consolidated registry was notably subject to connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to

	demonstrate capacity and conformance to the DES. All tests were executed successfully and lead to successful certification on 1 June 2012,
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	The overall change to a Consolidated System of EU Registries also triggered changes to discrepancies procedures, as reflected in the updated manual intervention document and the operational plan. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission..
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The overall change to a Consolidated System of EU Registries also triggered changes to security, as reflected in the updated security plan. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	Since June 2012 the publicly available information can be accessed via the European Union Transaction Log home page as specified in paragraph 12.4 of this report.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	The new internet address of the German part of the Union registry is: **https://ets-registry.webgate.ec.europa.eu/euregistry/DE/index.xhtml**
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	The overall change to a Consolidated System of EU Registries also triggered changes to data integrity measures, as reflected in the updated disaster recovery plan. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	On 2 October 2012 a new software release (called V4) including functionalities enabling the auctioning of phase 3 and aviation allowances, a new EU ETS account type (trading account) and a trusted account list went into Production. The trusted account list adds to the set of security measures available in the CSEUR. This measure prevents any transfer from a holding account to an account that is not trusted.
The previous Annual Review recommendations	The previous year’s German SIAR Part 2 Assessment report did not state any recommendations.

15 Information regarding minimisation of negative impacts pursuant to Article 3 (14)

Most of the measures that would be carried out in Germany would not be expected to have direct effects on developing countries. In the case of other measures, the expected effects are largely considered to be positive. Such effects, for example, would include establishment of technical and administrative structures for climate protection.

Almost all of the possible indirect effects are also considered to be positive. Such effects would include beneficial impacts on energy supplies and prices in co-operating countries.

Promotion of biofuels:

Promotion of non-sustainably produced biofuels could have negative impacts. Such promotion could leading to destruction of, or adverse shifts in, resources in developing countries. In future, such effects are to be prevented via implementation of pertinent sustainability ordinances. The ordinances define sustainability standards and relevant certification systems (e.g. the 2009 Ordinance on requirements pertaining to sustainable production of fuels (Biokraftstoff-Nachhaltigkeitsverordnung (Biokraft-NachV)), in the version amended on 22 June 2010) and thus transpose the Directive of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources (2009/28/EC).

It needs to be emphasised that the certification systems should be designed to ensure that production of biofuels in developing countries does not lead to food-security conflicts, at either the local or international levels.

The criteria enshrined in the relevant European laws cover the following:

- Minimum requirements pertaining to reduction of greenhouse-gas emissions;
- Prohibition on use of biofuels produced on land of value with regard to biodiversity aspects, and
- Prohibition on use of biofuels produced on land with high CO_2 removals (wetlands, peat bogs and forests).

What is more, intensified use of second-generation biofuels helps to prevent food-security conflicts.

Germany is taking an active role in relevant international forums for cooperation, such as the "Global Bioenergy Partnership", a G8 initiative. The "Bioenergy and Food Security" project of the United Nations Food and Agriculture Organization (FAO), which is financed by Germany, is oriented to implementation of minimum ecological and social standards. The aim is the project is to develop criteria, in cooperation with decision-makers of potentially affected countries, for assessment of the opportunities and risks of bioenergy use in rural regions.

Reduction of hard-coal subsidies:

Reduction of subsidies for Germany's own fossil fuels helps prevent climate-protection measures from having negative impacts on third countries. On 7 February 2007 in Germany, the Federal Government, the Land (state) of North Rhine – Westphalia and the Land Saarland, and the RAG AG coal corporation and the IG BCE industrial union (for the mining, chemicals and energy sectors) reached an agreement calling for socially compatible termination of subsidised hard-coal production in Germany by the end of 2018. In 2012, the German Bundestag (Parliament) will review this decision on the basis of a joint report of the Federal Government and the governments of the Länder in which the relevant mining districts are located.

Policies and measures at the EU level, especially EU emissions trading:

In addition to designing its own policies and measures for climate protection in Germany, the Federal Government plays an active role in shaping climate-protection measures at the European level. European emissions trading is of special importance in this context. The energy-sector and industrial companies in Germany that are participating in the European emission trading scheme (ETS) account for nearly half of all German greenhouse-gas emissions. In and of itself, the ETS has no direct impacts on third countries. On the other hand, since 2008 part of the proceeds generated in Germany from auctioning of emissions certificates within the ETS system have been used to support climate-protection projects in developing countries. The International Climate Initiative (ICI), which is responsible for the pertinent funding allocations, finances projects in the areas of emissions reduction, adaptation to climate change and protection of tropical rain forests. Such efforts are in line with the Emissions Trading Directive, which provides for part of the auction proceeds to be used for climate-protection and adaptation measures in developing countries.

As of the beginning of 2012, international air transports are being included within the European emissions trading scheme. This could have negative impacts on third countries, since now both European airlines and airlines from third countries require certificates for flights to and from the EU. The relevant legislation underwent an intensive process including careful analysis, hearings for experts and hearings for potentially affected parties. A working group established especially for this issue, within the framework of the "European Climate Change Programme", found that the measure would be a cost-effective way to reduce air-transport emissions. The pertinent quantitative analyses carried out explicitly considered the possible impacts on developing countries (European Commission 2006).

Analyses on the basis of Eurocontrol data showed that airlines from third countries contribute only moderately to the air transports falling within the emissions trading regime and thus would be only moderately affected by relevant cost increases. What is more, most of the flights between the EU and third countries are flights between the EU and other industrialised countries, with the result that the total burdens on companies from developing countries would be considerably lower than the burdens applying in industrialised countries. Furthermore, the Emissions Trading Directive makes it possible, in cases in which third countries carry out comparable climate-protection measures in their own air-transport sectors, for flights from their territories into the EU to be exempted from the EU-ETS.

In addition, due to possibilities for using CDM certificates, integration of air transports within the ETS can be expected to boost demand for CDM projects, which will have indirect positive effects for developing countries in the form of additional investments in climate-protection technologies.

Support for developing countries in energy-sector diversification:

Germany is making a broad range of efforts aimed at supporting developing countries in diversifying their energy sectors and thus lessening their vulnerability to trends in world market prices for energy. Especially noteworthy efforts in this context include cooperation in the area of renewable energies in the Mediterranean region and with the Gulf countries, inter alia via the EU-GCC Energy Experts Group; cooperation in resarch and development; the Mediterranean Solar Plan; the Regional Center for Renewable Energy and Energy Efficiency (RCREEE); and the EU's contributions to the Maghreb Electricity Market Integration Project (IMME).

In addition, Germany is involved in financing for the Global Energy Efficiency and Renewable Energy Fund (GEEREF), a regional programme for investments in developing countries in the areas of renewable energies and energy efficiency. GEEREF is aimed at accelerating transfer of environmentally friendly technologies into poorer regions of the world.

Overview:

The following tables list various policies and measures (sorted by sectors), along with their direct and indirect effects on developing countries.

Table 337: Cross-cutting measures

Measure	Direct effects	Indirect effects
Emissions trading	none	Positive: Auction proceeds are being partly used for climate protection and adaptation measures in developing countries
Air transports in emissions trading	Negative: Higher costs for airlines from third countries, for flights to and from the EU	Positive: Auction proceeds are being partly used for climate protection and adaptation measures in developing countries
CDM	Positive: Additional investments in climate-protection measures in DC	none
JI	none	none
Energy/CO_2 taxes	none	none

Table 338: Energy-policy measures

Measure	Direct effects	Indirect effects
Promotion of renewable energies	none	Positive: Potential reduction of dependence on fossil fuels; Potential improvement of electricity supplies in rural areas; Improvement of air quality
Promotion of biofuels	none	Negative: If biofuel imports lead to destruction of forests and other CO_2 sinks, or if biofuel-biomass cultivation leads to food shortages / food-price increases in developing countries. Positive: Economic development
Promotion of energy efficiency	none	Positive: Can lead to reduced energy costs and improved air quality
Promotion of CHP systems	none	Positive: Helps reduce energy costs

Table 339: Agriculture

Measure	Direct effects	Indirect effects
Orienting of subsidies to food security and animal-welfare standards instead of to production quantities	Positive: Encourages competition in agriculture	none
Improved management of animal waste	none	none
Biogas use / anaerobic fermentation	none	Positive: Comparatively cheap energy source.

Table 340: Forestry

Measure	Direct effects	Indirect effects
Reforestation	none	Positive: Less deforestation
Sustainable forest management	none	none

Table 341: Waste recycling / treatment

Measure	Direct effects	Indirect effects
CH_4 separation from waste and sewage sludge	none	Positive: Cost-effective energy source
Composting	none	none

16 OTHER INFORMATION

This chapter is currently not required.

17 ANNEX 1: KEY CATEGORIES OF THE GERMAN GREENHOUSE-GAS INVENTORY

In accordance with the *"IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories"*[126] (*Good Practice Guidance*), the Parties to the Framework Convention on Climate Change, and, in future, the Parties to the Kyoto Protocol as well, are obliged to calculate and publish annual emissions data.

These emissions inventories must be readily comprehensible (transparency); must be calculated in a consistent manner in the time series since 1990 (consistency); must be evaluated uniformly at international level via application of the prescribed calculation methods (comparability); must contain all the relevant emission sources and sinks in the reporting country (completeness); must be evaluated with error specification; and must undergo ongoing internal and external quality management (accuracy).

To facilitate concentrating the many and detailed activities and resources required for this purpose on the inventory's principal source categories, the IPCC has introduced the term "key category". Key categories are source categories which are highlighted in the national inventory system because their emissions have a significant influence on total emissions of direct greenhouse gases, either in terms of absolute emissions, or as a contribution to the emissions trend over time, or in both ways.

In its chapter 7, the Good Practice Guidance specifies the methods to be applied for identifying key categories. These methods include inventory analysis for one year (Tier 1 Level Assessment), time-series analysis of inventory data (Tier 1 Trend Assessment), detailed analysis of inventory data with error evaluation (Tier 2 Trend Assessment with consideration of inaccuracies) and assessment of qualitative criteria (pursuant to Chapter 7.2.2 GPGAUM)

Tier 1 analyses must always be carried out using two procedures. In a first procedure, only emissions from sources are evaluated, and storage in sinks is not considered. In a second procedure, emissions storage in sinks is then included (without any consideration of whether it is positive or negative). As would be expected, the two results differ. Pursuant to the Good Practice Guidance, both results must be taken into account in determination of key categories.

For identified key categories, the Parties are then required to use highly detailed calculation methods (Tier 2 or higher; the relevant methods are also specified in the Good Practice Guidance). Should direct use of such methods prove impossible, for whatever reason (e.g. data are not available for the required input variables, etc.), Parties are required to prove that the methods applied nationally achieve at least a comparable degree of accuracy in the

126 This Report was produced as a response to a suggestion by the UN Framework Convention on Climate Change to the Intergovernmental Panel on Climate Change (IPCC). The relevant effort called for completing determination of uncertainties in inventories and for preparing a report on "good practice" in inventory management.
It was prepared in order to support countries in preparing their own emissions inventories. The aim of such support was to prevent over-valuation or under-valuation of results and to reduce the inaccuracies of the inventories as far as possible.
This report is published on the Internet at : http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm

calculation result. Such proof, as well as the key-category analysis performed overall, must be outlined in the national inventory report to be prepared annually.

17.1 Description of the method for identifying key categories

The results of key-category analysis via the two Tier 1 methods (Level and Trend), the Tier 2 method and the method calling for assessment of qualitative criteria are outlined below. In this context, we call attention to the description of the underlying methods in the *Good Practice Guidance*. In a departure from that source's proposal for structuring included source categories, a greater degree of detail was chosen for the present analysis. Annual emissions inventories were divided, with regard to their CO_2-equivalent emissions, into a total of 120 individual activities.

17.1.1 Tier 1 procedure

Level analysis has the purpose of identifying those source categories responsible for 95 % of total national emissions (as CO_2-equivalent emissions), in the Kyoto Protocol's base year and in the current year; those sources are then defined as key categories (●). Calculations were performed using formula 7.1 from the Good Practice Guidance.

In the source category summary used in this analysis, a total of 31 key categories were identified in 2013 using this approach (cf. Table 7, Chapter 1.5).

Trend analysis identifies as key categories (●) those source categories which have made a particular contribution to changes in total greenhouse gas emissions in 2011, in terms of the development of their contribution since the base year. In this respect, it is irrelevant whether such changes have led to a reduction or an increase in total emissions. Calculations were performed using formula 7.2 from the Good Practice Guidance.

Tier 1 Trend analysis, using source-category structuring as described, identified a total of 29 key categories (cf. Table 7, Chapter 1.5).

17.1.2 Tier 2 procedure

Key-category analysis pursuant to the Tier 2 approach is based on the results of current uncertainties determination in accordance with Tier 1. The results have provided extensive confirmation of the results of the pertinent Tier 1 key-category analyses. Seven additional categories also have to be considered, however (cf. Table 8, Chapter 1.5.1).

17.1.3 Assessment with qualitative criteria

Germany assesses key categories with help of qualitative criteria. Chapter 7.2.2 of the GPGAUM provides recommendations relative to the criteria to be applied. The criteria allow assessment on the basis of use of emissions-reduction equipment, of expected disproportionate emissions increases, of a high level of uncertainty or of unexpectedly lower or higher emissions in a given category. The criteria may be used as a basis for defining additional categories as key categories.

In the category adipic acid production (2.B.3), a redundant waste-gas-treatment system was installed. In light of that installation, the category has been classified as a key category, on the basis of qualitative criteria. 2.B.3 is already a key category, however, in terms of Tier 1 Level and Trend assessment. SF_6 emissions from soundproof windows are reported in 2.F.9.

Even though such a trend cannot yet be recognized, it is clear that SF_6 emissions must be expected to increase sharply in coming years as disposal of old windows increases. For that reason – i.e. on the basis of qualitative criteria – the category has already been identified as a key category. That classification leads to no change, however, since 2F is already a key category, by Tier 1 Level and Trend, for SF_6. Qualitative assessment on the basis of large uncertainties is not required, since Germany carries out Tier 2 key-category analysis for the entire inventory every three years. No unexpectedly low or high emissions have been seen in the inventory.

Use of qualitative criteria has not identified any additional key categories in Germany.

Germany uses all recommended procedures for identifying and evaluating source categories. The IPCC Guidelines require 95% of emissions from sources / removals in sinks to be classified in key categories. In keeping with the fact that Germany identifies key categories by combining the results of all analysis procedures and evaluations, emission-causing activities accounting for about 98 % of the inventory have been identified as key categories.

17.1.4 Key-source analysis for Kyoto reporting

The following CRF Table NIR.3 summarises information relative to key-source analysis in Kyoto reporting. Additional information is presented in Chapter 1.5.2.

Table 342: KP CRF Table NIR.3: Summary Overview for Key Categories for Land Use, Land-Use Change and Forestry Activities under the Kyoto Protocol

Key Categories of Emissions and Removals	Gas	Criteria used for Key Category Identification			Comments [(3)]
		Associated category in UNFCCC inventory[(1)] is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory [(1), (4)] (including LULUCF)	Other[(2)]	
Specify key categories according to the national level of disaggregation used[(1)]					
Afforestation and Reforestation	CO2	Conversion to forest land	Yes	High expected growth.	The value is very close to the value in the smallest category considered key in the UNFCCC inventory. The value has increased about tenfold since 1990.
Deforestation	CO2	Conversion to cropland, Conversion to grassland, Conversion to settlements, Conversion to other land	No	Regarding only Land converted to Grassland: high expected growth.	Regarding only Land converted to Grassland: The value is very close to the value in the smallest category considered key in the UNFCCC inventory. The value has increased about tenfold since 1990.
Forest Management	CO2	Forest land remaining forest land	Yes	None	No Comment

(1) Seesection 5.4 of the IPCC good practice guidance for LULUCF.

(2) This should include qualitative consideration as per section 5.4.3 of the IPCC good practice guidance for LULUCF or any other criteria.

(3) Describe the criteria identifying the category as key.

(4) If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO.

18 ANNEX 2: DETAILED DISCUSSION OF THE METHODOLOGY AND DATA FOR CALCULATING CO_2 EMISSIONS FROM COMBUSTION OF FUELS

18.1 The German Energy Balance

In the Federal Republic of Germany, energy statistics are published by numerous agencies, and these statistics can differ in terms of their presentation, scope and aggregation. The Energy Balances of the Federal Republic of Germany are the central data foundation for determining/preparing energy-related emissions, scenarios and forecasts of the impacts of energy-policy and environmental-policy measures. On an annual basis, the associations in the German energy sector, working in co-operation with economic research institutes, and in the framework of the Working Group on Energy Balances (AGEB), combine the relevant data to form a complete picture. They then make the data available to the public in the form of Energy Balances.

The complete Energy Balances for the years since 1990 are available in the Internet at:

http://www.ag-energiebilanzen.de/viewpage.php?idpage=63

The AGEB's Web site presents a foreword for the Energy Balances, in German and English, that describes the structure of the Energy Balance.

The members of the Working Group on Energy Balances (AGEB) include (as of: October 2012):

- Bundesverband der deutschen Energie- and Wasserwirtschaft e.V. (BDEW) (Association of the German Energy and Water Industry), Berlin
- Deutscher Braunkohlen-Industrie-Verein e.V. (DEBRIV) (German Lignite Industry Association), Cologne,
- Deutsches Institut für Wirtschaftsforschung (DIW) (German Institute for Economic Research), Berlin,
- Energiewirtschaftliches Institut an der Universität Köln (EWI) (Institute of Energy Economics at the University of Cologne), Cologne,
- EEFA GmbH, Münster
- Gesamtverband des deutschen Steinkohlenbergbaus (GVSt) (Association of the German hard-coal mining industry), Herne,
- Mineralölwirtschaftsverband (MWV) (Association of the German Petroleum Industry), Berlin,
- Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI) (Rhine-Westphalian Institute for Economic Research), Essen.
- Verein der Kohlenimporteure e.V. (German Coal Importer Association), Hamburg

In addition, the efforts of the Working Group on Energy Balances (AGEB) are supported by the Association of Industrial Energy and Power Producers (VIK). Since the 1994 balance year, overall responsibility for preparation of Energy Balances has lain with the German Institute of Economic Research (DIW; Berlin); since 2002, the DIW has carried out relevant work in co-operation with EEFA (Energy Environment Forecast Analysis GmbH) and with Mr. Rossbach from the Association of the German Petroleum Industry (MWV; for the section on petroleum). Overall, with due regard for the available data, the Energy Balances provide a comprehensive picture of energy production and use quantities/structures in the German economy.

The most important sources are listed in Table 343. In a number of categories, furthermore, experts personally provide relevant data – in categories, for example, such as non-energy-related consumption by the chemical industry.

Table 343: Data sources for the Energy Balances:

All energy resources	Federal Office for Statistics 43 Manufacturing industry: Energy, gas and water supply 433 Specialised statistics in the area of energy and water supply 43311 Monthly report on the electricity sector (066) 43321 Monthly report on the gas sector (068) 43331 Survey of electricity sales, revenue (083) 43341 Survey of gas deliveries, imports and exports and gas-based revenue (082) 43351 Survey of electricity generation systems in the mining and manufacturing sectors (067) 43371 Annual survey of network operators with regard to electricity feed-in (070) 43381 Annual survey on sewage gas (073) 43391 Annual survey on liquefied petroleum gas (075) 434 Specialised statistics in the area of energy and water supply: heat supply 43411 Annual survey of production, use, purchases and sale of heat (064) 43421 Survey of geothermal systems (062) 435 Other specialised statistics in the area of energy and water supply 43511 Monthly survey of coal imports and exports (061) 43521 Survey of bio-fuels (063) 43531 Annual survey of energy use in the mining and manufacturing sectors (060) Wolfgang Bayer (2003): Amtliche Statistik (official statistics), newly organized, in: Wirtschaft und Statistik, Vol. 1, p. 33-40. Bundesverband der deutschen Energie- and Wasserwirtschaft e.V. (BDEW) (Association of the German Energy and Water Industry) BDEW annual statistics (Jahresstatistik) BDEW surveys on use of renewable energy resources Market research results, company data, calculations by the Working Group on Energy Balances (AGEB)
Hard coal and lignite	Statistics from the Kohlenwirtschaft e.V. (Coal Industry Association) Coal mining in the energy industry of the Federal Republic of Germany – annual reports Coal industry statistics Sales statistics and other unpublished energy statistics
Petroleum	Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle) Official Petroleum Statistics for the Federal Republic of Germany Mineralölwirtschaftsverband e.V. (MWV) (Association of the German Petroleum Industry) Petroleum Statistics – Annual Reports Wirtschaftsverband Erdöl- and Erdgasgewinnung e.V. (Association of the Petroleum and Natural Gas Extraction Industry) Annual reports Federal Ministry of Food, Agriculture and Consumer Protection

(AGEB, 2010)

18.2 Structure of the Energy Balances

The Energy Balances, which are structured in matrix form, provide an overview of the interconnections within the energy sector. As a result, they not only provide information about consumption of energy resources in the various source categories, they also show the relevant flows of such resources, from production to use in the various production, transformation and consumption areas (cf. Figure 78). The ***production balance*** shows:

- Domestic production
- Imports
- Removals from stocks
- Exports
- Maritime bunkering
- Additions to stocks

of energy resources, and it summarises them under ***primary energy consumption***. The primary Energy Balance provides the basis for calculations under the IPCC reference procedure (PROGNOS, 2000). The ***usage balance*** provides a key basis for preparation of emissions inventories. The usage balance can also be used for determination of primary energy consumption. It comprises:

- The transformation balance
- Flaring and line losses
- Non-energy-related consumption, and
- Final energy consumption.

Differences between the production and usage balances are compensated for in the position "Statistical differences".

The ***transformation balance***, part of the usage balance, shows what energy resources are transformed, as well as what other resources they are transformed into. The transformation production shows the results of such transformation. Energy transformation can involve either substance modification – such as transformation of crude oil (transformation input) into petroleum products (transformation production) – or physical transformation – such as combustion of hard coal (transformation input) – in power stations, for production of electrical energy (transformation production). The energy consumption in the transformation sector shows how much energy was needed for operation of transformation systems (the transformation sector's own consumption). The transformation balance is broken down by facility type; a total of 12 different types of facilities are considered.

The Energy Balance until 1994			Line
Primary Energy Balance		Domestic production	1
		Imports	2
		Removals from stocks	3
		Domestic energy production	4
		Exports	5
		Bunker fuels	6
		Additions to stocks	7
		Domestic primary energy consumption	8
Transformation balance	Transformation input	Coking plants	9
		City gas works	10
		Hard-coal-briquetting plants	11
		Lignite-briquetting plants	12
		Public thermal power stations	13
		Mine and colliery power stations	14
		Other industrial thermal power stations	15
		Nuclear power stations	16
		Hydroelectric power stations	17
		Combined heat and power (CHP) stations, district heating stations	18
		Blast furnaces	19
		Refineries	20
		Other energy producers	21
		Total transformation inputs	22

The Energy Balance as of 1995			Line
Primary Energy Balance		Domestic production	1
		Imports	2
		Removals from stocks	3
		Domestic energy production	4
		Exports	5
		Bunker fuels	6
		Additions to stocks	7
		DOMESTIC PRIMARY ENERGY CONSUMPTION	8
Transformation balance	Transformation input	Coking plants	9
		Hard-coal-briquetting and lignite-briquetting plants	10
		Public thermal power stations (not including CHP)	11
		Industrial thermal power stations	12
		Nuclear power stations	13
		Hydroelectric power stations, wind-power and photovoltaic systems	14
		Public combined heat and power (CHP) stations	15
		District heating stations	16
		Blast furnaces	17
		Refineries	18
		Other energy producers	19
		Total transformation inputs	20
	stor mati on emis	Coking plants	21
		Hard-coal-briquetting and lignite-briquetting plants	22

	Transformation emissions	Coking plants	23
		City gas works	24
		Hard-coal-briquetting plants	25
		Lignite-briquetting plants	26
		Public thermal power stations	27
		Mine and colliery power stations	28
		Other industrial thermal power stations	29
		Nuclear power stations	30
		Hydroelectric power stations	31
		Combined heat and power (CHP) stations, district heating stations	32
		Blast furnaces	33
		Refineries	34
		Other energy producers	35
		Total transformation emissions	36
	Consumption in energy production and in transformation sectors	Hard-coal mines, hard-coal-briquetting plants	37
		Coking plants	38
		City gas works	39
		Lignite mines, lignite-briquetting plants	40
		Power stations (plants)	41
		Oil and gas production	42
		Refineries	43
		Other energy producers	44
		Total energy consumption in the transformation sector	45
		Flaring and line losses, evaluation differences	46
		Domestic energy supply, pursuant to transformation balance	47
		Non-energy-related consumption	48
		Statistiscal differences	49
Final energy consumption (Endenergieverbrauch)	by sections	Final energy consumption (Endenergieverbrauch)	50
		Other mining	51
		Non-metallic minerals	52
		Iron and steel industry	53
		Iron and steel foundries	54
		Drawing shops and cold-rolling mills	55
		Non-ferrous metal products and casting	56
		Chemical industry	57
		Pulp and paper	58
		Rubber processing	59
		Other production of basic materials and producer's goods	60
		Basic materials and producer's goods	52-60
		Machinery	61
		Automotive, aircraft and spacecraft	62
		Electrical engineering, precision mechanics, optics	63
		Ironware, tinware and metalware	64
		Other manufacture of capital goods	65
		Manufacture of capital goods	61-65
		Glass and fine ceramics	66
		Production of plastic goods	67
		Textiles	68
		Other manufacture of consumables	69
		Manufacture of consumables	66-69
		Sugar industry	70
		Other food production	71
		Food, drink and tobacco	72
		Food, drink and tobacco	70-72
		Other mining and manufacturing sector overall	73
		Railway transport	74
		Road transports	75
		Air transports	76
		Coastal and inland navigation	77
		Total transport	78
		Residential, institutional and commercial overall	79
		Military agencies	80

		Public thermal power stations (not including CHP)	23
		Industrial thermal power stations	24
		Nuclear power stations	25
		Hydroelectric power stations, wind-power and photovoltaic systems	26
		Public combined heat and power (CHP) stations	27
		District heating stations	28
		Blast furnaces	29
		Refineries	30
		Other energy producers	31
		Total transformation emissions	32
	Consumption in energy production and in transformation sectors	Coking plants	33
		Hard-coal mines, hard-coal-briquetting plants	34
		Lignite mines, lignite-briquetting plants	35
		Power stations (plants)	36
		Oil and gas production	37
		Manufacture of refined petroleum products	38
		Other energy producers	39
		Total energy consumption in the transformation sector	40
		Flaring and line losses	41
		DOMESTIC ENERGY SUPPLY, PURSUANT TO TRANSORMATION BALANCE	42
		NON-ENERGY-RELATED CONSUMPTION	43
		Statistiscal differences	44
Final energy consumption (Endenergieverbrauch)	by sections	FINAL ENERGY CONSUMPTION	45
		Production of non-metallic minerals; other mining	46
		Food and tobacco	47
		Paper	48
		Primary chemicals	49
		Other chemical industry	50
		Rubber and plastic products	51
		Glass and ceramics	52
		Processing of non-metallic minerals	53
		Metals production	54
		Non-ferrous metals, NFM foundries	55
		Metals processing	56
		Machinery	57
		Transport equipment	58
		Other economic sectors	59
		Mining, non-metallic minerals, manufacturing sector overall	60
		Railway transport	61
		Road transports	62
		Air transports	63
		Coastal and inland navigation	64
		Total transport	65
		Residential	66
		Commercial and institutional, and other consumers	67
		Residential, commercial and institutional	68

Source: AGEB, 2003:

Figure 78: Line structure of Energy Balances until 1994 and as of 1995

Non-energy-related consumption, as a component of the consumption balance, is shown as a total, without allocation to facility types or branches of industry. It describes which energy resources are used as raw materials (e.g. in the chemicals industry, transformation of energy resources into plastics).

Finally, the consumption balance indicates the final consumption sectors in which energy is transformed into the useful energy ultimately needed (such as power, light, room and process heating) (***final energy consumption***). This includes industry, sub-divided into 14 sectors, transport, households and commercial use, trade, services and other consumers (including agriculture).

Figure 78 shows the structure of the production and consumption balances in the energy balances until 1994 and as of 1995.

Energy resource structure in energy balances ...

Through 1994

Hard coal	HC coal HC coke HC briquettes HC raw tar HC pitch HC other Crude benzene
Lignite	L coal L briquettes L coke L coal dust Hard lignite
Other solid fuels	Firewood Peat Sewage sludge
Petroleum	Oil Gasoline Raw gasoline Avgas Jet kerosene Diesel Heating oil, light. Heating oil, heavy Petrol coke Other petroleum products
Gases	LP gas Refinery gas Coke-oven gas Blast-furnace gas Natural gas Petroleum gas Pit gas Landfill gas
Electricity and other energy resources	Electricity Hydropower Nuclear power District heat Other energy resources
Total energy resources	Primary energy resources Secondary energy resources Total

As of 1995

Hard coal	HC coal HC briquettes HC coke Other HC products
Lignite	L coal L briquettes Other L products Hard lignite
Petroleum	Oil Gasoline Raw gasoline Jet kerosine Diesel fuel Heating oil, light Heating oil, heavy Petrol coke LP gas Refinery gas Other petroleum products
Gases	Coke-oven and city gas Blast-furn. & converter gas Natural gas, petroleum gas Pit gas
Renewable energies	Hydropower Wind and photovol. systems Waste and other biomass Other renewable energies
Electricity and other energy resources	Electricity Nuclear power District heat
Total energy resources	Primary energy resources Secondary energy resources Total

Source: ZIESING et al, 2003

Figure 79: Energy resources in the Energy Balance of the Federal Republic of Germany

The energy flow in the Energy Balances is depicted for 30 energy resources. These energy resources can be allocated to the following main groups:

- Hard coal,
- Lignite,
- Petroleum (including LPG and refinery gas),
- Gases (coke oven and blast furnace gas, natural gas, firedamp, excluding landfill gas and the aforementioned gases),
- Renewable energy resources (including waste fuels),
- Electrical power and other energy resources.

Energy Balances have been drawn up for the years 1990 to 1994, both separately for the old and new Länder and for Germany as a whole. With the conversion of the official statistics to the classification of industrial sectors (*FEDERAL STATISTICAL OFFICE*, 2002c), since 1995 only Energy Balances for Germany as a whole (in the territorial delimitation of 3 October 1990) have been submitted. The main group structure (until 1994 and as of 1995) is shown in Figure 79. Via the "Renewable energies" satellite balance, renewable energies are further broken down as of 1996 (AGEB 2003).

As of the year 2000, the energy-resource structure in the area of renewable energies / waste was changed: hydroelectric and windpower systems, and photovoltaic systems, were combined, and waste/biomass was divided into renewable and non-renewable fractions. Since 2004, non-recyclable waste and waste heat are also listed under final-energy consumption within the Energy Balance.

In the Energy Balance, fuels / energy resources are listed in *natural units*, including tonnes (t) for solid and liquid fuels, cubic metres (m^3) for gases, kilowatt hours (kWh) for electrical power, and joules (J) for waste, renewable energy sources, nuclear power and district heating. In order to render the data comparable and suitable for addition, all values are converted into joules (J) using calorific value tables and conversion factors. Unlike gas statistics or international Energy Balances, the Energy Balance lists even gases in terms of calorific value.

To date, Energy Balances through 2010 have been published. Until the 2010 report, the Federal Environment Agency met requirements for currentness, in emissions reporting, by preparing provisional Energy Balances on the basis of the evaluation tables. As of the 2011 report, the Working Group on Energy Balances (AGEB) provides the Federal Environment Agency with a complete provisional Energy Balance, for purposes of inventory preparation.

18.3 Methodological issues: Energy-related activity rates

Essentially, the inventories for air pollutants and greenhouse gases prepared by the Federal Environment Agency are based on the Energy Balances for Germany prepared by the Working Group on Energy Balances (AGEB). The data required for emissions calculation can be read directly from Energy Balance lines 11, 12, 15, 16, 40, 60, 65 and 68. For biomass fuels, EB lines 14 and 19, depending or the fuel in question, also have to be used in calculation.

In a few cases, the special requirements pertaining to emissions calculation, and the need to assure the completeness of data, necessitate a departure from the above-described system, and additional data have to be added:

- The emissions-relevant fuel inputs for lignite drying have to be calculated out of EB line 10. A precise description of source category 1.A.1.c is provided in Chapter 3.2.8.2.

- Natural gas inputs in compressors, for the years 1995-2002, can be read directly from the Energy Balance (EB line 33). For the years 1990-1994, and for the period as of 2003, the values have to be calculated outside of the Energy Balance. The method is described in Chapter 3.2.10.5.2 (source category 1.A.3.e).
- For systematic reasons, and for reasons having to do with a focus on energy production, the Energy Balance does not list incinerated waste quantities completely for all relevant years. In this area as well, therefore, the lacking data have to be added from waste statistics. Relevant explanations are provided in Chapter 3.2.6.2 (source category 1.A.1.a) and in Chapter 3.2.9.11.2 (source category 1.A.2.f Other).
- Firewood use in the source categories commercial and institutional is not listed in the Energy Balance and has to be added. A description of source category 1.A.4 is provided in Chapter 3.2.11.2.

In the Energy Balance, inputs of reducing agents, in pig-iron production, are listed in part as energy-related consumption, in EB line 54, and in part as transformation inputs, in EB line 17 (top-gas equivalent). Use of the related blast-furnace gas for energy production is listed in the relevant Energy Balance lines, 11, 12, 15, 33 and 54. To prevent double counting, the fuel inputs from blast furnaces, as listed in EB line 54, and the relevant top-gas equivalent, are not reported.

18.4 Uncertainties, time-series consistency and quality assurance in the Energy Balance

In an endeavour to ensure that Energy Balances are always meaningful, it is necessary to make allowance for changes in the underlying statistics, for changes in the energy sector and for changes in requirements of data users. Such changes were made as early as the 1970s. Partly as a result of increasing energy-market liberalisation, and in conjunction with the formation of a European single market, the condition of the statistical energy database has worsened in recent years of change (ZIESING et al, 2003). With the introduction of the Act on Energy Statistics, which has been in force since 2003, the data basis has improved again, although the relevant other data collection has necessitated changes in the overall data structures. In 2009, the Energy Balances for the period 2003 to 2006 were revised. Changes were carried out in the areas of transformation inputs of natural gas, petroleum gas and renewable energies – in Energy Balance lines 11 (thermal power stations for the public power supply), 12 (industrial thermal power stations), 14 (hydroelectric power, wind-power, photovoltaic and other systems), 15 (heat/power stations for the public heat/power supply), 16 (district heating stations), 19 (other energy producers), 66 (residential) and 67 (commercial and institutional and other consumers). These changes also have impacts on the sum of transformation inputs and primary energy consumption (cf. DIW, EEFA, 2009: "Dokumentation zur Revision der Energiebilanzen für die Bundesrepublik Deutschland für die Jahre 2003 bis 2006" ("Documentation on revision of Energy Balances for the Federal Republic of Germany, for years 2003 to 2006")).

The changes affect both the data sources used – extensive transitions were made on the basis of public statistics – and allocation of fuel inputs to heat and power production in CHP systems. Separate listing of CHP systems in public statistics led to recalculations of Energy Balances, with the help of the relevant Finnish method. In only a few cases – such as mine-gas inputs in public power stations and inputs of hard coal and natural gas in district heating stations – do these two effects lead to noticeable discontinuities in the time series between 2002 and 2003. The available data for the period prior to 2002 cannot be improved retroactively, however.

The revision was also used for the purpose of taking account of data updates of the *Federal Statistical Office* and the Federal Office of Economics and Export Control (BAFA) that occurred after the publication of the Energy Balances. Also as part of the revision, the efficiencies for electricity production with use of biogenic fuels were adjusted, for the year 2003, to the efficiencies applied since 2004.

18.4.1 The balance year 1990 and the Energy Balances for 1991 to 1994

The base year 1990 plays a key role in national emissions inventories, and it is especially important as a reference year for agreed emissions-reduction targets under climate protection policy. For Germany, admittedly, this is linked to the problem that the country did not have the same national territorial status throughout the entire year of 1990. Radical changes in the territory of the GDR and the new Länder, including profound economic woes and fundamental organisational/structural problems, greatly complicated the process of collecting energy statistics in eastern Germany for 1990. This also had certain repercussions for the old Länder, for which the AGEB was still able to prepare and publish balances in the conventional manner (ZIESING et al, 2003).

For the GDR / new German Länder, the Institut für Energetik (IfE) in Leipzig assumed the tasks of preparing an Energy Balance for 1990 that would be compatible with western German balances (IFE, 1991). In this effort, the Institute had access to a study, carried out under the direction of DIW Berlin (German Institute for Economic Research), whose aims included preparing suitable Energy Balances for the GDR for the years 1970 to 1989 (DIW, 1991). The AGEB Energy Balances, for the old German Länder, and the IfE Energy Balances, for the new German Länder, are being aggregated for the new Energy Balances prepared in the framework of the EUROSTAT project (ZIESING et al, 2003) for the year 1990 and for Germany as a whole. In keeping with the system in force as of 1995, some changes have been made in the original balances for 1990 and for the years 1991 to 1994 (cf. ZIESING et al, 2003). Furthermore, in keeping with the procedure used by international organisations (IEA, EUROSTAT, ECE), the so-called "efficiency approach" is used, instead of the formerly used "substitution approach", for Energy Balances for Germany since 1995. In addition, recalculations with the efficiency approach have been carried out back to the year 1990.

Due to a lack of suitable data, it was not possible to adjust differentiation of final energy consumption, by source categories, in the manufacturing sector. The applicable system for this area changed considerably in 1995, when a transition was made from the SYPRO manufacturing-sector system (Systematik des produzierenden Gewerbes) to the Classification of Economic Activities, edition 1993 (*FEDERAL STATISTICAL OFFICE*, 2002c).

These Energy Balances are seen as the primary energy statistics to be used in determining energy-related CO_2 emissions in Germany.

In revision of activity rates for stationary combustion in 1990 in the new German Länder, some shifting of fuel inputs between Energy Balance lines resulted. The overall framework remained unchanged, however.

18.4.2 Quality reportof the Working Group on Energy Balances (AGEB) regarding preparation of Energy Balances for the Federal Republic of Germany

In 2012, the Working Group on Energy Balances (AGEB) began submitting annual joint quality reports, to the Federal Environment Agency (UBA), that document its quality-assurance measures in preparation of Energy Balances. Such reports contain the content of the individual reports submitted over the course of the previous relevant year.

The following section presents the content of the current reports, in their original wording (different typeface).

18.4.2.1 Background

In the framework of greenhouse-gas reporting, the National Co-ordinating Committee for the National System of Emissions Inventories has established minimum requirements pertaining to quality control and quality assurance (QC/QA). Those requirements are to be fulfilled on all levels of inventory preparation. One of the most important data sets for determination of greenhouse-gas emissions consists of the Energy Balances for the Federal Republic of Germany, which the Working Group on Energy Balances (AGEB) has been commissioned to prepare. The German Institute for Economic Research (DIW, Berling) and the EEFA research institute also work on such Energy Balances, as sub-contractors to the AGEB. All persons working on Energy Balances are required to comply with minimum requirements pertaining to QC/QA, in areas such as transparency, consistency, comparability, completeness and accuracy.

To document its data sources and quality-assurance measures in preparation of Energy Balances, the Working Group on Energy Balances (AGEB) herewith submits its current quality report to the Federal Environment Agency (UBA). It focuses especially on the 2010 Energy Balance and on the 2011 Estimated Balance (Schätzbilanz). The Annex describes methodological changes made as of 2010, as well as revisions made in the period 2003 through 2009, and it compares a) the 2011 Estimated Balance with the 2010 Energy Balance and b) the 2010 Energy Balance with the 2010 Estimated Balance.

18.4.2.2 Work-sharing in preparation of Energy Balances

The DIW Berlin is responsible for preparing Energy Balances and evaluation tables for the following energy areas:

- Erdgas, Natural gas, petroleum gas
- Hydroelectric power, windpower und photovoltaics,
- Biomass and renewable waste,
- Other renewable energy sources,
- Non-renewable waste, waste heat, etc.,
- Electricity,
- Nuclear energy and
- District heat

Also in the framework of its Energy Balance work, the DIW Berlin coordinates the quarterly estimates of primary energy consumption for the Federal Republic of Germany, and it prepares estimates for the energy area "Other".

In addition, DIW Berlin awards a service contract to Mr. Ulrich Rossbach, who prepares the petroleum section of the Energy Balances. Mr Rossbach is responsible for preparing Energy Balances and evaluation tables for the following energy areas:

- Crude oil,
- Petrol,
- Naphtha,
- Jet fuels,
- Diesel fuel,
- Light heating oil,

- Heavy fuel oil,
- Petrol coke,
- Liquefied petroleum gas
- Refinery gas, and
- Other petroleum products

The tasks of the EEFA research institute include preparing complete Energy Balances (including evaluation tables) for the following fuels:

- Hard coal, hard-coal coke, hard-coal briquettes and other hard-coal products,
- Lignite (raw), lignite briquettes, other lignite products and hard lignite, and the gases
- Coking-plant gas and city gas, top gas and converter gas, and pit gas.

In the framework of its work on the Energy Balances, the EEFA institute also coordinates deliveries and reporting of energy-statistics data in the context of international obligations (IEA/EUROSTAT Joint Questionnaires).

Since Energy Balance year 2009, estimate balances have been prepared in the framework of work for the evaluation tables. They incorporate data from Statistik-Nr. 066 (Erhebung über die Elektrizitäts- und Wärmeerzeugung der Stromerzeugungsanlagen der allgemeinen Versorgung; Survey of electricity and heat generation of public-sector electricity generation systems) of the Federal Statistical Office (StBA), association data of the German Association of Energy and Water Industries (BDEW) and data of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat) relative to "Other renewable energy sources". The estimates are coordinated especially with the BDEW and the AGEE-Stat.

At that early stage in Energy-Balance preparation, important official data sources, such as surveys relative to energy consumption of industrial sectors, are normally not yet available. The pertinent data gaps are closed with the help of estimates. It is clear that an estimated Energy Balance cannot fulfill the strict requirements pertaining to data quality that the corresponding final Energy Balance meets, a work published with a time lag of about one year.

18.4.2.3 Quality of the data sources used

For preparation of the Energy Balances for the Federal Republic of Germany, the DIW Berlin makes use of the following data of the Federal Statistical Office:

- Survey of energy use of mining, quarrying and manufacturing companies,
- Survey of electricity generation systems in the mining and manufacturing sectors,
- Survey of electricity and heat generation of public-supply electricity generation systems,
- Survey of heat generation, demand, use and supply,
- Survey of network operators relative to electricity feed-in,
- Survey of production, use and supply of sewage gas,
- Survey of supply, import and export of natural gas and petroleum gas, and of revenue of producers,
- Survey of production, supply, import and export of gas, and of revenue of gas utilities and gas sellers,
- The official mineral-oil statistics (Amtliche Mineralölstatistik (AMS)); and Table 9, for biofuels, of the Federal Office of Economics and Export Control (BAFA), for the renewable energy sources covered in the Satellite Balance.

The data of the Federal Statistical Office (StBA) and of the Federal Office of Economics and Export Control (BAFA) are subject to official quality requirements. The quality reports of the Federal Statistical Office are available in the Internet, at its Web site:

http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Navigation/Publikationen/Qualitaetsberichte/Qualitaetsberichte.psml (checked on 8 August 2011).

In addition to available official data, the DIW Berlin also uses the following association data:

- Data on gross electricity generation in the Federal Republic of Germany (BDEW)
- Data on electricity generation in nuclear power stations (Deutsches Atomforum e.V.)

and data of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat) relative to "Other renewable energy sources".

At regular intervals, the Federal Ministry of Economics and Technology (BMWi) commissions methodologically reliable studies that serve as a supplementary source of information on energy consumption of the residential and commercial / institutional sectors.

All scientific work at the DIW Berlin is required to conform to ethical principles for research and consultation. Such principles are based on the "Proposals for ensuring good scientific practice" ("Vorschläge zur Sicherung guter wissenschaftlicher Praxis") of the DFG's "Commission on "Self-regulation in the science sector" ("Selbstkontrolle in der Wissenschaft"), on the recommendations and rules for good scientific practice applied by the Leibniz Association and on the code of ethics of the Verein für Socialpolitik economists association.

In preparation of the petroleum sections of the Energy Balance for the Federal Republic of Germany, Mr Ulrich Rossbach uses the following official data:

- Official Mineral Oil Statistics for the Federal Republic of Germany (AMS), published by the Federal Office of Economics and Export Control (BAFA), Eschborn
- Survey of energy use by manufacturing, mining and quarrying companies (Fachserie 60, Statistisches Bundesamt (Federal Statistical Office) and the statistical offices of the Länder), Wiesbaden, and surveys for the 16 German Länder (states)
- Survey of electricity generation systems in the mining and manufacturing sectors (Fachserie 067, StBA (Federal Statistical Office)); similar surveys for the 16 German Länder (states), (StLA (statistical offices of the Länder)
- Survey of electricity and heat generation of public-supply electricity generation systems (Fachserie 066, StBA)
- Survey of heat generation, demand, use and supply (Fachserie 064, StBA)
- Survey of production, purchase, use and supply of liquefied petroleum gas (Fachserie 075, StBA); similar surveys for the 16 German Länder (states)
- Finances and taxes, energy taxes, Fachserie 14, Reihe 9.3, StBA).

The data of the Federal Statistical Office (StBA) and of the Federal Office of Economics and Export Control (BAFA) are subject to official quality requirements. The quality reports of the Federal Statistical Office are available in the Internet, at its Web site:

http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Navigation/Publikationen/Qualitaetsberichte/Qualitaetsberichte.psml (checked on 8 August 2011)

In addition to the available official data, the following data are also used:

- Statistics on petroleum production and consumption (MWV-Jahresbericht (annual reports) / MWV-Mineralöl-Zahlen (petroleum statistics), various years; Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry, Berlin)
- Company statistics, and diverse additional data items, on petroleum production and consumption (MWV, Berlin and MWV member companies; direct surveys of consumers and of associations)

- Data on petroleum and natural gas production (annual report of the Wirtschaftsverband Erdöl- und Erdgasgewinnung (W.E.G.) German oil and gas industry association)
- Annual report, various years, German Liquid Petroleum Gas Association (Deutscher Verband Flüssiggas e.V. – DVFG), Berlin
- Statistics, various years, Association of German Transport Companies (Verband Deutscher Verkehrsunternehmen – VDV), Cologne
- Various studies on energy consumption in the sectors "Residential" and "Commercial and Institutional", under commission to the Federal Ministry of Economics and Technology (BMWi), Berlin
- Various studies on fuel consumption of machines in the "non-road" sector, Institute for Energy and Environmental Research (ifeu-Institut GmbH), Heidelberg

In preparing Energy Balances, the EEFA institute draws on a range of sources, in their order of importance, including official statistics, surveys and statistics of energy-sector associations and data from survey studies of research institutes. To close unavoidable data gaps, it relies on its own experts' assessments. The main official data sources used include the following:

- Survey of energy use of mining, quarrying and manufacturing companies,
- Monthly reports on coal imports,
- Survey of electricity generation systems of mining, quarrying and manufacturing companies,
- Survey of electricity and heat generation of electricity generation systems serving the public grid,
- Survey of heat generation, demand, use and supply.

In addition, in carrying out calculations for the Energy Balance, the EEFA institute uses numerous statistics provided by the Statistik der Kohlenwirtschaft coal-sector-statistics association. The Statistik der Kohlenwirtschaft association's key members include the Association of the German hard-coal mining industry (GVSt) and the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations. Examples of statistics that enter into calculations relative to the hard coal sector include

- Statistics on domestic sales, broken down by types of hard coal and consumer groups, and
- Statistics on production, use in transformation sectors and changes in stocks (form 4a).

With regard to lignite, the following data are used:

- Data on extraction, production of lignite products, producers' own consumption and sales (form 5), and information from production reports,
- Data on domestic sales / use, broken down by Länder and consumer groups, and
- Data from other unpublished statistics.

The coal-statistics data available in Germany have a semi-official status, and they are very precise and reliable. For more than 50 years, the Statistik der Kohlenwirtschaft coal-sector-statistics association has served as a liaison between coal-sector companies and official producers of statistics (cf. in the Internet: http://www.kohlenstatistik.de/download/Langfassung.pdf).

Official statistics in this area are based on surveys carried out by the Statistik der Kohlenwirtschaft association. Additional data on the coal sector, available to the general public, are provided in the annual publications "Der Kohlenbergbau in der Energiewirtschaft der Bundesrepublik Deutschland" ("Coal mining as a part of the energy sector of the Federal Republic of Germany") and "Zahlen zur Kohlenwirtschaft" ("Coal-industry statistics"), and on the Web site http://www.kohlenstatistik.de. The superior transparency of these data sources (in some cases, highly specific data items are provided) attests to their reliability and accuracy. The Act on Energy Statistics (Energiestatistikgesetz) has no separate paragraph relative to surveys on the domestic coal sector; its refers instead explicitly to the functioning system of coal statistics.

For preparation of Energy Balances, the important aspects of these data sources, in addition to their quality, include their multi-year availability and their standardised, consistent presentations of time series. Such aspects play a critically important role in ensuring that the procedures and methods used for preparation of Energy Balances generate data that can be consistently integrated, without structural discontinuities, in the basic scheme for the Balances. Both the official sources and – especially – the coal-sector statistics have long histories. In some areas, they provide consistent time series that reach far into the past. Where breaks in time series cannot be avoided, as a result of reviews or changes in statistical foundations (for example in the Act on Energy Statistics), such breaks are well-documented in the sources used for preparation of Energy Balances. This ensures that methods are always properly adjusted.

Yet another supplementary information source consists of studies that, for selected reference years, collect primary statistical data on energy consumption of the residential and commercial / institutional sectors. Such studies document the quality of their up-scaling results. It should also be noted that the Federal Ministry of Economics and Technology (BMWi) commissions research institutes to carry out such surveys. As a result, once the final report for such a survey has been accepted, the survey acquires a semi-official status that guarantees that it meets certain quality standards.

18.4.2.4 Transparency of methods and procedures

The Act on Energy Statistics (Energiestatistikgesetz – (EnStatG) entered into force on 1 January 2003. That act consolidates official energy statistics, from different legal frameworks, and adapts them to users' current information requirements. Since the act's entry into force, the Federal Statistical Office has also collected and provided data for the areas heat market, combined heat / power generation (CHP) and renewable energy sources. As a result of the restructuring, the Federal Statistical Office, in addition to providing data on electricity and heat generation from combined heat / power generation (CHP), also provides data on all fuel inputs for CHP, for both the general public supply and industry (broken down by energy sources).

Such changes in the available statistics have made it necessary to adjust the methods used for the Energy Balances – especially for their descriptions of industrial final energy consumption. As a consequence of the described expansion in the data supply, as of 2003 separate data on fuel inputs for generation of electricity only are no longer available for either public or industrial electricity generation.

The Federal Statistical Office does not collect data on breakdowns of fuel inputs by "electricity" and "heat" in industrial and public-supply combined heat / power generation (CHP) systems; such statistics are collected by the Working Group on Energy Balances (AGEB) and estimated by institutes it commissions. The "Finnish" method used for such purposes is based on Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004. That method is exactly defined, mathematically, and it is explained in the forewords to the Energy Balances.

With regard to quality assurance, the Finnish method makes calculations relative to power/heat production for the public supply and for industry logical and transparent. The necessary pertinent framework assumptions, such as the reference efficiencies of non-CHP generation as provided in the documentation for the Energy Balances, are clearly stated in the process. In sum, although Energy Balance preparation is a process that makes use of frequently complex transformational methods, its results can still be highly transparent and unambiguous. As a result, all Energy Balance entry fields can always be traced back to their primary statistical foundations.

Primary data provided by official or association sources – regardless of its quality – can seldom simply be "plugged into" the Energy Balance without undergoing the statistical processing normally used to prepare the Energy Balances. Description of relevant complex energy flows, using matrices that conform to the formal parameters and methodological specifications for the Energy Balances, and on the basis of statistical raw data, requires numerous transformation steps, recalculations and reallocations. What is more, in some (few) areas of the Energy Balance primary statistics are no longer available, and thus data gaps have to be closed through use of formal estimation methods, applied in accordance with the requirements of each relevant individual case.

Energy Balances are always prepared on the basis of the most current available official statistics and association surveys. In some areas of secondary importance with regard to energy consumption, Energy Balance preparers have to make their own estimates in order to fill out the given Energy Balance framework. The EEFA institute uses a broad range of methods and modelling instruments in carrying out such estimates within the framework of Energy Balance preparation. The most important elements of the EEFA system of models, in the framework of preparation of Energy Balances, include a power-station model and an energy-demand model. The energy-demand model alone comprises more than 1,500 equations. By adequately modelling all important substitution processes and technological changes, especially with regard to sectoral production processes, it is able to describe the energy consumption of the industrial and residential sectors. In formal terms, this energy model accords with the organisational principle used for the Energy Balances, since its sectoral organisation, apart from minor modifications in the area of energy-intensive economic sectors, conforms to the standard classification of economic sectors (WZ), while its breakdown by energy sources / fuels is largely in line with the corresponding system found in the Energy Balances.

The EEFA energy model has been refined and tested in the framework of numerous scientific research projects. In addition, the estimation approaches and methods used in the model have been published in national and international trade journals and may thus be considered transparent, publicly accessible and generally accepted. On request, the EEFA research institute is happy to provide a list of the relevant model-related publications, along with short descriptions of the models.

18.4.2.5 Checking and verification of results

Measures for quality assurance and control cover the following areas:

- Assurance of data quality / transparency of methods and procedures,
- Mechanisms for checking and critically reviewing the Energy Balances, measures that assure the Balances' correctness, completeness and consistency, and
- Measures for documentation and archiving, designed to ensure the Balances' clarity and reproducibility,
- Expert responsibility for preparation of Energy Balances.

Critical discussion, verification and checking of results take place on various levels:

- The Energy Balances Group (Gruppe Energiebilanzen) of DIW Berlin carries out "four-eyes" checks of results and reviews them for plausibility on the basis of control figures (for example, changes in light of annual comparisons, implied net calorific values, utilisation levels).
- In addition, the AGEB member associations carry out supporting checks.
- With regard to renewable energies, the Working Group on Renewable Energy Statistics (AGEE-Stat) carries out its own consultations and "four-eyes" checks.
- The EEFA research institute also cooperates in exchanging, and mutually checking, Energy Balance results.
- Furthermore, at early stages data and results are exchanged and discussed with the DIW's Energy Balance staff and with responsible experts of the Federal Environment Agency (UBA).

- The "Official Mineral Oil Statistics" for Germany (AMS), which are published monthly and annually, imply that the entire system for petroleum production and consumption in Germany is a closed system that is free of internal contradictions. The statistical basis for the AMS is the "Integrated Mineral Oil Report" (IM), which all major oil companies are provided to submit. To fulfill their reporting obligations, oil companies apply extensive input/output models that take account of all "oil streams".
- The Federal Office of Economics and Export Control (BAFA) regularly reviews the data provided by the oil companies. In addition, BAFA also surveys and monitors major traders / importers, a group defined via the "survey group" process. Furthermore, companies that make one-time direct imports are also subject to pertinent reporting obligations.
- On the other hand, the Official Mineral Oil Statistics contain no information – apart from a very few exceptions – on sectoral oil consumption in Germany, and such information is required for the Energy Balance. Such information is obtained from the aforementioned official and other sources, reviewed and – if necessary – modified. The results must not fall outside of (i.e. be too low or too high) the framework defined by the AMS (production/consumption). So-called "secondary fuels", which are not covered by the AMS, are an exception in this regard.
- The plausibility of oil-consumption data is reviewed via reference to relevant indicators, in a process that involves carrying out regression and correlation calculations.
- The Federal Statistical Office does not collect data on breakdowns of fuel inputs by "electricity" and "heat" in industrial and public-supply combined heat / power generation (CHP) systems; such statistics are collected by the Working Group on Energy Balances (AGEB) and estimated by institutes it commissions. The "Finnish" method used for such purposes is based on Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004. That method is exactly defined, mathematically, and it is explained in the forewords to the Energy Balances.
- The net calorific values for petroleum products and crude-oil inputs are reviewed on an annual basis, and reset as necessary. This process is carried out in light of technical progress and market trends. The aim of the process is to make conversion of tonne data into terajoule units as precise as possible.
- Data and results are exchanged and discussed with the DIW's Energy Balance staff and with responsible experts of the Federal Environment Agency (UBA). Oil data and relevant balance sheets (statistical summaries) are also considered, and modified as necessary, by the "Methods working group" ("Arbeitskreis Methoden – AKM) of the Federal Ministry of Economics and Technology (BMWi).

Only when the completed Energy Balance has successfully passed through all controlling bodies is it published on the AGEB's Web site and are provisional Energy Balance data provided to the Federal Environment Agency for further processing within the system for the national greenhouse-gas inventory.

With a view to effective prevention of errors in data calculation and estimation for the Energy Balances, the annual balances are prepared via standardised procedures. To that end, a broad range of instruments has been developed that automate proven estimation procedures, and formal calculation methods, within the context of Energy Balance preparation. This approach, which often permits simple entry of statistical raw data into the suitable calculation tools, largely eliminates calculation and transformation errors. What is more, its use of consistent, standardised methods plays an important role in assuring time-series consistency.

In spite of all its efforts to prepare Energy Balances that are error-free, properly executed and available promptly, the possibility of error cannot be completely ruled out. For this reason, the EEFA research institute carries out the following checks as part of the balance-preparation process:

- Two EEFA staff members independently prepare the annual Energy Balance and then check each other's results,
- The EEFA research institute regularly verifies the Balances' time-series consistency. Where a time series shows implausible jumps that cannot be attributed to transfer or calculation errors, and that must be tied to developments in the underlying primary statistics, the problem is discussed constructively with the relevant data-supplying institution.
- The Energy Balances are cross-checked against the data provided to IEA/Eurostat.
- The AGEB's energy-sector member associations – relative to the Balance sections for which the EEFA research institute is responsible, i.e. the German Coal Importer Association, the Association of the German hard-coal mining industry (GVSt), the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations and the Statistik der Kohlenwirtschaft coal-sector-statistics association – provide constructive critical support, and review and discuss the Balance results.
- Beginning at early stages of Balance preparation, the EEFA Energy Balance staff regularly exchange information and engage in discussion with the responsible experts of the Federal Environment Agency (UBA).
- The Energy Balance results are shared with, and reviewed by, the research institutes that cooperate in the framework of this research effort (DIW Berlin)

18.4.2.6 Documentation and archiving

DIW Berlin and the EEFA research institute keep careful, detailed documentation relative to the annual Energy Balances. The documentation covers every Energy Balance entry, lists the statistical sources and surveys used and precisely describes the calculation methods and procedures used.

The purpose of the documentation is to ensure that all steps can be retraced, both by Energy Balance staff and by the persons who use the Energy Balances. Regular updating of the documentation contributes to data quality and helps to assure consistency in time series and methods.

All statistical data, calculation methods and estimation procedures used in preparation of Energy Balances for the Federal Republic of Germany are archived in both electronic and printed form. The pertinent electronic data are backed up automatically by the DIW's central IT department, on dedicated server space, and they are backed up manually at regular intervals. For electronic archiving, EEFA uses portable media (CD-ROMs, DVD), external drives and network-based server systems. Data back-ups are carried out both automatically and manually (at regular intervals).

18.4.2.7 Qualified staff

For execution of the service project "Preparation of Energy Balances for the Federal Republic of Germany" ("Erstellen von Energiebilanzen für die Bundesrepublik Deutschland"), DIW Berlin and the EEFA research institute rely on experienced staff with solid backgrounds in the areas of statistics, economics and the energy sector.

18.4.2.8 Explanations regarding the currentness and ongoing availability of official statistics, association data and other data relative to preparation of Energy Balances

Official statistics

The final annual figures for the 066 monthly survey became available in May 2011; the 064 annual surveys became available in October 2011; the 067 survey became available in September 2011; the 070 survey became available in December 2011; the 073 survey became available in July 2011; and the 082/082P survey data became available in January 2012. The 060 survey became available (the corrected version) in June 2012 (source: IDEV, StBA (Federal Statistical Office), last checked on 12 October 2012).

The results of surveys 066 (electricity generation systems for the public supply) and 067 (electricity generation systems for industry) have to be converted via the "Finnish" method. Calculations, checking, consultations, etc. involving BDEW, AGEE-Stat, EEFA and MWV take at least three weeks; the pertinent data then enter the Energy Balance in June or October of the following year.

The Energy Balance can be completed only when the results of survey 060 (energy use by industry), which are an important Energy-Balance component, become available. That is the bottleneck for the process. Calculations carried out on a sectoral basis, plausibility checks, checking-related enquiries to the Federal Statistical Office (which then has to forward the requests to the Länder) and consultations with participating associations all take at least three weeks; the final Energy Balance is then prepared no earlier than the middle or end of November of the following year.

As a result of these time constraints, an estimated Balance is prepared in July (in a process first carried out for the 2009 report) that incorporates the available official data from survey 066. The remaining data are estimated and agreed on in cooperation with the AGEB member associations.

A second bottleneck is tied to the time of availability of biofuels data based on BAFA data from official petroleum statistics. Sectoral classification of transports is carried out in cooperation with the Association of the German Petroleum Industry (MWV) and the Länder. For the 2010 Balance year, the pertinent data did not become available until June 2012. Surveys 082P and 082, which provide the statistical basis for sectoral classification of (final-energy) consumption of natural gas and petroleum gas, became available in January 2012 for the Balance year 2010, and they were revised by the Federal Statistical Office in September 2012. Those data were the last official data entered into the 2010 Energy Balance.

Association statistics

The final Energy Balance incorporates data of the associations BDEW and Deutsches Atomforum, data which become available at an early time (from BDEW, in July; from Deutsches Atomforum, in January).

Because quarterly estimates of primary energy consumption in Germany are carried out, provisional data in the relevant areas become available quickly. The BDEW provides important provisional data, dated as of August, that are also of relevance to final energy consumption as recorded in the estimate Balance. Every summer, that organisation publishes data under the heading "The German energy market – facts and figures on the gas, electricity and district-heating sectors" ("Energiemarkt Deutschland – Zahlen und Fakten zur Gas-, Strom- und Fernwärmeversorgung"). In addition, the estimated Balance incorporates BDEW data on gross electricity generation, data of Gesamtverband Steinkohle (GVSt; Association of the German hard-coal mining industry), of the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations, of the Association of the German Petroleum Industry (MWV) and of the Deutsche Atomforum nuclear-energy association.

Other data

For the final Energy Balance, data of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), relative to "renewable energy sources", are also used; those data become available in July/August.

Provisional data on renewable energy sources are discussed with AGEE-Stat and the BDEW. They enter into the estimated Balance and, thus, into the evaluation tables.

Table 344: Federal Statistical Office surveys used in preparation of Energy Balances for the Federal Republic of Germany

Survey	No.	Survey period	Currentness, pursuant to quality report	Type of data	Group surveyed	Units surveyed
Survey of energy use by the mining, quarrying and manufacturng sectors	060	Annually	End of the following year *(available as of the end of October / beginning of November)*	Electricity generation, deliveries and consumption **Fuels / energy sources, orders and consumption, by energy source / fuels** **Fuels / energy sources, deliveries and stocks, by energy source / fuels** Average net calorific value	Sections B "Mining and quarrying" and C "Manufacturing"	**Producing companies** (currently, at least 40,000) with **at least 20 employees** **Exception:** Plants of Manufacturing sector companies with **10 or more persons active in the relevant economic sectors**
Survey of heat generation, demand, use and supply,	064	Annually	End of the following year *(available usually at the end of September)*	District heating: Net heat generation, demand, deliveries and network losses. No information on energy sources / fuels is provided Heating plants: **Fuel inputs and heat production, by energy sources / fuels**	Operators of **heating plants** with outputs of at least 1 MWth, and operators of **district heating networks** (only large networks that have grown "historically"). No **"island networks" for district heating are surveyed**	**Max. of 1,000 operators** of heating plants, including absorption systems for refrigeration, and with outputs of **at least 2 MW_{th}.**
Survey of electricity and heat generation of electricity generation systems serving the public grid	066K	Monthly; annually	6 weeks after the end of the reporting period; end of June of the following year *(available in May)*	Number, net-electricity and net-heat production, by plant type, **Electricity and heat production, by energy sources / fuels** **Fuel inputs for electricity and/or heat production, by energy sources / fuels** (separate survey of CHP systems)	Companies and plants in the **electricity sector (public grid)**	**Max. of 1,000 operators of plants with outputs of at least 1 MW_{el}.**
Survey of electricity generation systems of manufacturing, mining and quarrying companies	067	Annually	9 weeks after the end of the reporting period *(available usually at the end of September)*	**Number and bottleneck capacity, by plant type** **Net-electricity and net-heat production (separate survey of CHP systems)** **Fuel inputs for electricity and/or heat production, by energy sources / fuels (separate survey of CHP systems)** Own consumption of electricity and heat	Sections B "Mining and quarrying" and C "Manufacturing"	Operators (currently, about 500) of systems serving their **own requirements**. Surveys cover systems for generating electricity, including systems for co-generation of electricity and heat (CHP) with **outputs of at least 1 MW_{el}**
Survey of network operators relative to electricity feed-in	070	Annually	12 weeks after the end of the reporting period *(available usually at the end of September)*	**Electricity feed-in, by Länder and energy sources / fuels** **Power statistics, separately for Länder and energy sources / fuels**	Operators of electricity grids for the public supply	**Exhaustive survey**
Survey of production, use and supply of sewage gas	073	Annually	8 weeks after the end of the reporting period *(available at the end of June / beginning of July)*	**Anaerobic sewage-gas collection** **Fuel inputs in power stations** **Fuel inputs for heating only or motors (drive units) only** **Electricity feed-in** **Own consumption**	Operators of wastewater-treatment plants	for no more than 6,000 operators of wastewater-treatment plants (currently, **about 1,300 operators**)
Survey of supply, import and export of natural gas and petroleum gas, and of revenue of producers	082P	Annually	National results become available three months after the end of the period covered by the report	**Survey of supply, import and export of natural gas and petroleum gas, and of revenue of producers** **Sales of natural gas and petroleum gas, and revenue of producers, by Länder**	Producers of natural gas and petroleum gas	Exhaustive survey

Survey	No.	Survey period	Currentness, pursuant to quality report	Type of data	Group surveyed	Units surveyed
Survey of production, supply, import and export of gas, and of revenue of gas utilities and gas sellers	082	Annually	National results become available 12 months after the end of the period covered by the report The result for 2009 became available in May 2011	**Extraction and production of gas, demand for gas, and value of relevant imports** **Deliveries and exports of gas, and relevant revenue** **Gas production, by gas types** **Gas deliveries, and revenue, by Länder**	Gas-sector companies	Exhaustive survey

Link to the nomenclature for classification of industrial sectors (Nomenklatur der Wirtschaftszweige; WZ 2008):
http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Klassifikationen/GueterWirtschaftklassifikationen/Klassifikationenwz2008__umsteiger__xls,property=file.xls
Link to the quality reports on energy statistics, and a questionnaire:
http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Navigation/Publikationen/Qualitaetsberichte/EnergieWasser.psml

18.4.2.9 Methodological changes as of 2010, and revisions, 2003 through 2009

Background

The purposes served by the Energy Balances of the Federal Republic of Germany include determining the country's greenhouse-gas emissions (Kyoto Protocol). The Energy Balances are regularly reviewed in the framework of reviews carried out by the United Nations (UNFCCC). As a result of such reviews, the methods and database used for some Energy Balance positions have been modified for the period as of 2010 and, retroactively, for the period as of 2003 / 2005. The revision was also used for the purpose of taking account of data updates of the Federal Statistical Office (StBA) and the Federal Office of Economics and Export Control (BAFA) that occurred after the publication of the Energy Balances. The Energy Balance entry spaces that have been affected by such revision are listed in the following table.

Table 345: Revised entries of the Energy Balance

Energy sources / fuels	**Energy Balance line (EBZ)**	**Name of the Energy Balance line (EBZ)**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Hard coal	EBZ 12	Industrial thermal power stations (electricity)							x	
	EBZ 34	Hard-coal mines, hard-coal-briquetting plants	x	x	x	x	x	x		
Lignite briquettes	EBZ 66	Residential							x	
	EBZ 67	Commercial and institutional							x	
Coking-plant and city gas	EBZ 12	Industrial thermal power stations (electricity)							x	
Natural gas	EBZ 1	Domestic production			x	x	x	x	x	x
	EBZ 2	Imports			x	x	x	x	x	
	EBZ 3	Removals from stocks			x		x	x		
	EBZ 5	Exports				x	x	x	x	
	EBZ 7	Additions to stocks			x	x			x	
	EBZ 12	Industrial thermal power stations (electricity)			x	x	x			
	EBZ 33 through 39	Energy consumption in the transformation sector			x	x	x	x	x	x
	EBZ 41	Flaring and line losses	x	x	x	x	x	x	x	x
	EBZ 43	Non-energy-related consumption			x	x	x	x	x	x
	EBZ 46 through 59	Industrial sectors			x	x	x	x	x	x
	EBZ 62	Road transports			x	x	x	x	x	x
	EBZ 66	Residential			x	x	x	x	x	
	EBZ 67	Commercial and institutional			x	x	x	x	x	x
Biomass	EBZ 2	Imports							x	x
	EBZ 5	Exports							x	x
	EBZ 67	Commercial and institutional								x
District heat (Fernwärme)	EBZ 36	Power stations - own consumption	x	x	x	x	x	x	x	
	EBZ 59	Other economic sectors				x				
	EBZ 67	Commercial and institutional	x	x	x	x	x	x	x	

Remark.: The table does not include changes in Energy Balance lines (EBZ) that have occurred solely as a result of calculations (e.g. statistical differences).

18.4.2.9.1 Methodological changes as of 2010

Natural gas, petroleum gas

EBZ 1 Domestic production

With regard to production, the pertinent official data of the Federal Statistical Office (Statistik 069) are now used, instead of the relevant data of the Wirtschaftsverband Erdöl- und Erdgasgewinnung (W.E.G.) German oil and gas industry association. (Data revision as of 2005)

EBZ 33 through 39 Energy consumption in the transformation sector

The change in booking of non-energy-related consumption (see below) also has an effect on energy consumption in the transformation sector (EBZ 33 through 39). (Data revision as of 2005)

EBZ 39 lists the own consumption of gas supply companies. Pursuant to questionnaire 082, such own consumption comprises gas consumption to maintain all technical aspects of operations (consumption in connection with gas production, gas storage and gas transport). (Data revision as of 2005)

EBZ 41 Flaring and line losses

Previously, flaring losses were determined via a difference calculation carried out on the basis of W.E.G. data. As of the 2010 Energy Balance year, the W.E.G.'s figures on flaring losses, in m³, are used, and converted with the help of the implied gross calorific value for utilised production, in TJ (Hi). (Data revision as of 2003)

Pursuant to the German Association of Energy and Water Industries (BDEW), domestic line losses of natural gas are negligible.

EBZ 43 Non-energy use (NEU)

Previously, data of the German chemical industry association (VCI) were used in the area of non-energy-related consumption (NEV). Now, official data of the Federal Statistical Office are used for this area. (Data revision as of 2005)

EBZ 46 through 59 Industry (NEU)

The change in booking of non-energy use also has an effect on final energy consumption by industry (EBZ 46 through 59). (Data revision as of 2005)

EBZ 62 Road transport (natural gas fueling stations):

As a result of a new sub-category in official statistics, data of the German Association of Energy and Water Industries (BDEW) are now being used in this area, instead of data of the Federal Statistical Office. (Data revision as of 2005)

EBZ 67 Commercial and Institutional and other consumers

As of 2010, operational consumption of gas-supply companies, as taken from statistics of the Federal Statistical Office (questionnaire 082), is also booked as part of the Commercial and Institutional sector. "Operational consumption" refers to companies' general consumption (and not to the own consumption that is listed in EBZ 39). (Data revision as of 2005)

Balance in natural units

As of 2010 the unit "m³" is being supplanted by "kWh (Hi)". (Data revision as of 2005)

Biofuels

EBZ 2 and 5 Imports, exports

BAFA has revised the pertinent foreign-trade statistics in keeping with methodological changes. (Data revision as of 2009)

Biomass and renewable waste

EBZ 67 Commercial and Institutional sector

As of 2010, inputs of biogas and liquid biomass for CHP heat generation will be listed as part of final energy consumption in the Commercial and Institutional sector, on the basis of pertinent data provided by the Federal Network Agency (BNetzA).

Other revisions, 2003 through 2009

The aforementioned changes for 2010 have been appropriately applied to earlier years (cf. the table). In addition, the following revisions have also been carried out.

Hard coal

EBZ 12 Industrial thermal power stations (electricity only)

The Federal Statistical Office has revised its figures (067) for the year 2009.

EBZ 34 Hard-coal mines, briquetting plants

As of 2009, the official data of the Federal Statistical Office are being used for this area. (Data revision as of 2003)

Lignite briquettes

EBZ 66 and 67 Residential and Commercial and Institutional

Rebooking (transfer) for the year 2009.

Coking-plant and city gas

EBZ 12 Industrial thermal power stations (electricity only)

The Federal Statistical Office has revised its figures (067) for the year 2009.

Natural gas, petroleum gas

EBZ 2 and EBZ 5 Imports, exports

The data in this area have been revised, retroactively, for the years 2005 through 2010. The resulting changes are manifested in the official statistics 082 and 082P, which are used for this area of the Energy Balance.

EBZ 3 and EBZ 7 Removals from stocks, additions to stocks

For the years 2005, 2007 and 2008, the pertinent companies have corrected their figures in this area, and the resulting changes are manifested in the official statistics 082 and 082P.

EBZ 12 Industrial thermal power stations (only for electricity)

The Federal Statistical Office has revised its figures (067) for the years 2005 through 2007.

EBZ 66 Residential

The Federal Statistical Office has revised its figures (082, 082P) for the years 2005 through 2009.

District heat

Data corrections in EBZ 36 Power stations, heating plants, EBZ 59 Other economic sectors and EBZ 67 Commercial and Institutional sector, for the years as given in the table.

Diekmann, Wernicke (DIW Berlin), Buttermann, Baten (EEFA), Rossbach, 8 October 2012

18.4.2.10 Comparison of the 2011 Estimated Energy Balance (provisional) with the 2010 Energy Balance (final)

The AGEB normally publishes the final Energy Balances in the spring of the next calendar year but one. With a view to providing data at earlier times, as of 2009 estimated Energy Balances are being prepared along with the evaluation tables. In some cases, those balances are based on different data sources (cf. the quality report of DIW and EEFA, August 2011).

In the framework of the UNFCCC's review of Energy Balances, with respect to quality control and assurance, careful attention is given to discrepancies between final Energy Balances and estimated Energy Balances (for 2010, cf. DIW, EEFA 3 September 2012). In addition, the estimated Energy Balance for 2011 has been compared with the 2010 Energy Balance (see below).

In such comparisons, both absolute and relative discrepancies are calculated, to make it possible to identify any significant discrepancies between final and provisional Energy Balances. Such significant discrepancies have to be individually explained. The occurring numbers of discrepancies, for Energy Balance lines and Energy Balance columns, have been analysed in light of a combination of the criteria "discrepancies in TJ" and "discrepancies in %". In such analysis, the combined occurrence of a discrepancy of 10,000 TJ and 20 % seems to be a suitable threshold above which discrepancies have to be explained.

The differences between the 2011 estimated Energy Balance and the 2010 Energy Balance 2010 are in keeping with the differences, with respect to the previous year, that were foreseeable at the time the estimated Energy Balance was prepared. The general reasons for such differences include economic trends, structural changes, changes in prices, weather-related effects and special developments such as the decision to discontinue use of nuclear power. Such general trends in energy consumption and its determining factors in 2011, in comparison to the corresponding aspects in 2010, are discussed in the annual report of the Working Group on Energy Balances (AG Energiebilanzen; 2012).[127]

[127] AG Energiebilanzen (Working Group on Energy Balances): Energieverbrauch in Deutschland im Jahr 2011 (energy consumption in Germany in 2011). mild temperatures prompted reduced primary energy consumption in 2011. February 2012. www.ag-energiebilanzen.de

In addition, it must be noted that data discrepancies can occur in that other data sources have to be used to prepare the estimated Energy Balances, in some cases, than are used to prepare the final Energy Balances. Furthermore, differences can occur as a result of changes in methods.

The comparison of the Energy Balances serves the primary purpose of checking and documenting the plausibility of noticeable changes. In some Balance positions, changes determined via the aforementioned criteria are simply not unusual, however. For example, this applies to changes in stocks, which by nature differ significantly from year to year.

The Federal Environment Agency has received an overview, with explanations, of conspicuous positions that resulted in the comparison of the 2010 Energy Balance and the 2011 estimated Energy Balance. The overview details the key results of the comparison.

18.4.2.11 Comparion of the 2010 Energy Balance (final) with the 2010 Estimated Energy Balance (provisional)

The AGEB normally publishes the final Energy Balances in the spring of the next calendar year but one. With a view to providing data at earlier times, as of 2009 estimated Energy Balances are being prepared along with the evaluation tables. In some cases, those balances are based on different data sources (cf. the quality report of DIW and EEFA, August 2011).

In the framework of the UNFCCC's review of Energy Balances, with respect to quality control and assurance, careful attention is given to discrepancies between final Energy Balances and estimated Energy Balances.

In such comparisons, both absolute and relative discrepancies are calculated, to make it possible to identify any significant discrepancies between final and provisional Energy Balances. Such significant discrepancies have to be individually explained. The occurring numbers of discrepancies, for Energy Balance lines and Energy Balance columns, have been analysed in light of a combination of the criteria "discrepancies in TJ" and "discrepancies in %". In such analysis, the combined occurrence of a discrepancy of 10,000 TJ and 20 % seems to be a suitable threshold above which discrepancies have to be explained.

The Federal Environment Agency has received an overview, with explanations, of conspicuous positions that resulted in the comparison of the 2010 Energy Balance and the 2010 estimated Energy Balance. The overview details the key results of the comparison.

18.5 Energy-Data Action Plan for inventory improvement

Also in 2012, the Working Group on Energy Balances (AGEB) prepared an "Energy-Data Action Plan for inventory improvement" that outlined actions to be taken to address the criticism that emerged from the inventory review. This action plan fulfills the action-plan requirement set forth in Paragraph 39 of the 2011 review report (FCCC/ARR/2011/DEU).

Table 346: Energy-Data Action Plan for inventory improvement

No.	Issue	Responsibility	Responsibility for execution	Ref-erence (para-graph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementa-tion / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
1	Energy-Data Action Plan for inventory improvement	Federal Ministry of Economics and Technology (BMWi) / UBA / AGEB / Federal Statistical Office (Destatis)	UBA	39	*address review relevant issues in an action plan in the 2011 submission. […] The ERT reiterates the recommendation of the previous review report that Germany prepare a plan for the remaining abovementioned issues, and to report on it and on any progress achieved in its next annual submission*	Action plan; NIR	The pertinent action plan is being prepared, for the first time, for the 2013 inventory report	A coordinated Energy-Data Action Plan for inventory improvement is available for the 2012 inventory review process Review date: 3 through 8 September	Sept. 12	
2.1	Deadline compliance of the final Energy Balance	BMWi / AGEB / persons responsible for questionnaire / Federal Statistical Office / statistical offices of the Länder	BMWi	39	*timeliness of reporting […]*	Process analysis, energy data; NIR	For the 2013 inventory report, a process analysis is presented. Inter alia, it covers reporting channels (these are described more precisely than in the past), the efforts made to shorten such channels and the relevant success achieved.	Process analysis, describing applicable reporting channels more precisely than in the past, and describing efforts made to shorten such channels and the relevant success achieved, enables review experts to determine that Germany has made use of all available possibilities for optimisation; the status of relevant work is described in the NIR 2013.		

No.	Issue	Responsibility	Responsibility for execution	Ref-erence (para-graph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementa-tion / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
2.2	Deadline compliance of the final Energy Balance	BMWi / AGEB / person responsible for questionnaire / Federal Statistical Office / statistical offices of the Länder	BMWi / AGEB (not for official data) / Destatis (for official data); persons responsible for questionnaire	137	*In the course of the review, the ERT formulated a number of recommendations relating to the transparency of background and methodological information (e.g. in the energy[...] sectors), justification and documentation of recalculations (e.g. in the energy[...] sectors)[...] The key sectoral recommendations are that Germany: [...] (b) Improve the timeliness of reporting of the NEB (energy);*	Process analysis, energy data; NIR	Shorten reporting channels by taking account of such channels in the framework of amendment of the Energy Statistics Act (EnStatG)	In future, official statistics are to be gathered at an earlier time than has been the case to date.		
2.3	Deadline compliance of the final Energy Balance	BMWi / AGEB / persons responsible for questionnaire / Federal Statistical Office / statistical offices of the Länder	Federal Statistical Office (Destatis) / Statistical offices of the Länder (StaLas)	137	*In the course of the review, the ERT formulated a number of recommendations relating to the transparency of background and methodological information (e.g. in the energy[...] sectors), justification and documentation of recalculations (e.g. in the energy[...] sectors)[...] The key sectoral recommendations are that Germany: [...] (b) Improve the timeliness of reporting of the NEB (energy);*	Process analysis, energy data; NIR	At an experts' meeting (Referenten-besprechung) involving the Länder, the Federal Statistical Office will discuss the possibility of gathering certain statistics, such as 060, earlier (for example, by mid-September instead of the end of September).	The statistical offices of the Länder now provide the 060 statistics by mid-September, instead of by the end of September		

No.	Issue	Responsibility	Responsibility for execution	Ref-erence (para-graph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementa-tion / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
3.1	Discrepancies between provisional and final EB	BMWi / AGEB / persons responsible for questionnaire / Federal Statistical Office / statistical offices of the Länder	AGEB; UBA	39	*significant differences between the preliminary and final NEB*	QC report; NIR	Energy data consistency analysis (EDKA)	Identification and clarification of discrepancies, along with differentiation and addressing of a) Informational deficits b) Documentation requirements c) Data problems d) Methodological changes	ongoing	
3.2	Discrepancies between provisional and final EB	AGEB	AGEB	39	*significant differences between the preliminary and final NEB*	QC	The AGEB is working to reduce estimation errors.	The status of such work is documented in the NIR 2013	September 2012, 2013 (NIR)	
3.3	Discrepancies between provisional and final EB	AGEB, UBA	UBA	39	*significant differences between the preliminary and final NEB*	NIR	In the 2013 National Inventory Report (NIR), the possibilities for reducing such discrepancies are described, and the pertinent results will be presented in the framework of a "differences discussion". In September, in the runup to the 2012 inventory review, significant differences will be explained, and initial information will be provide to review experts.	The status of such work is documented in the NIR 2013: Documentation, revision of data for earlier years, reduction of estimation errors	September 2012, 2013 (NIR)	

No.	Issue	Responsibility	Responsibility for execution	Ref-erence (para-graph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementa-tion / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
4	Complex National System	Federal Ministry of Economics and Technology (BMWi) / UBA / AGEB	UBA	39	*The previous review report noted several issues related to Germany's NEB (such as [...] the complexity of the NEB compiling process that may contribute to the problems with regard to timeliness and quality.*	NaSE	Exchange regarding the results of the inventory review and derivation of requirements for action;	Energy-data workshop on 16 Nov. 2010 Energy-data workshop on 5 August 2011 Energy-data workshop on 27 April 2012 Energy-data workshop on 7 August 2012		Applies especially in connection with the upcoming review to take place from 3 to 8 September
5	Quality assurance	EEFA / German Institute for Economic Research (DIW) / DESTATIS/ AGEB / UBA	AGEB / UBA	39	*lack of QA/QC procedures in place for some data sources used to compile the NEB*	NIR	Joint AGEB quality report in the new Annex 2 of the NIR 2012 and in subsequent inventory reports	the NEB is subject to QA/QC procedures in accordance with the national system	Apr 12	
6.1	Discrepancies between EB and IEA data	BMWi, AGEB, persons responsible for the questionnaire	BMWi	39	*low comparability with the IEA data*		To be jointly defined in the framework of the action plan			

No.	Issue	Responsibility	Responsibility for execution	Ref-erence (para-graph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementa-tion / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
6.2	Discrepancies between EB and IEA data	BMWi, AGEB, persons responsible for the questionnaire	BMWi	45	*The ERT also noted differences between the inventory data and the corresponding IEA data (e.g. for solid fuels exports, the data show differences of over 60 per cent in some recent years […] Germany has provided some explanations for the divergences and informed the ERT that it is continuing to investigate these differences. The ERT considers that the differences cause no underestimation of emissions, but reiterates the recommendation of the previous review report that Germany explain the reasons for these differences between its inventory data and the corresponding IEA data in its next annual submission.*		To be jointly defined in the framework of the action plan			
7.1	Improvement of the balance sheet for gases	BMWi / Destastis / DIW / UBA / an others	Destatis	39	*significant amount of flaring/losses of natural gas in the NEB that were not transparently accounted for*	NIR, EB	Meeting involving all participating energy experts; review and adjustment of the data source	The significant amount of flaring/losses of natural gas are taken into account	Apr 12	Completed

No.	Issue	Responsibility	Responsibility for execution	Ref-erence (para-graph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementa-tion / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
7.2	Improvement of the balance sheet for gases	BMWi / Destastis / DIW / UBA / an others	Destatis	39	*significant amount of flaring/losses of natural gas in the NEB that were not transparently accounted for*	NIR, EB	Updating of the gas balance sheets in the positions relative to flaring losses, and in positions relative to production, foreign trade, changes in stocks, non-energy-related consumption and energy-related consumption, in the Energy Balances for 2005 and for subsequent years	The significant amount of flaring/losses of natural gas are taken into account with regard to the time series	Fall of 2012	

18.6 Uncertainties in the activity rates for stationary combustion systems

See NIR 2007, Chapter 13.6.

18.7 CO_2 emissions

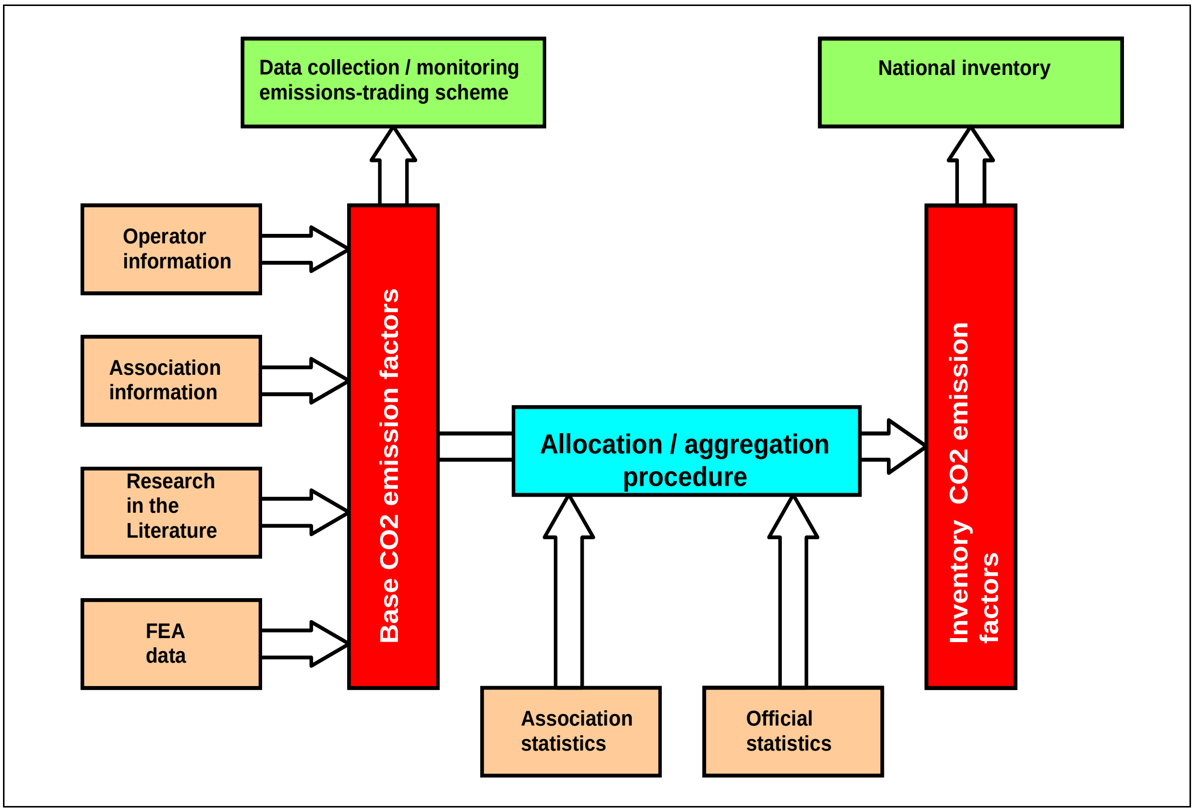
The emission factors on which the inventory is based were derived from the list of "*CO_2-Emissionsfaktoren für die Erstellung der nationalen CO_2-Inventare*" ("CO_2 emission factors for preparation of national CO_2 inventories"; Öko-Institut, 2004c).

18.7.1 Preliminary remarks on methods

In the framework of EU emissions trading, it is necessary to provide highly differentiated CO_2 emission factors for facility operators, to ensure that determination of facility-specific emissions is as precise as possible.

Since CO_2 emission factors for preparation of national inventories are considerably less finely differentiated, and emissions allowances must be allocated to facility operators on a cyclical basis, maximum consistency must be sought. Requirements pertaining to the ETS allocation periods thus fit with the need for consistency in inventory-calculation methods.

Figure 80: Basic and inventory emission factors for CO_2



Source: Öko-Institut

With this in mind, a consistent concept for CO_2 emission factors was developed (Figure 80).

The system is based on a set of differentiated CO_2 emission factors that – for the most part – are geared to the requirements of the emissions-trading scheme (so-called "basic" emission factors for CO_2). These emission factors were developed on the basis of a range of very different data sources. The data include operator data, data provided by associations and data gained from literature research. In addition, in some areas data of the Federal Environment Agency were used, and such data are now being enhanced via the ETS database.

With the help of structural data from association statistics and (quasi-) official statistics, the basic emission factors for CO_2 are allocated and aggregated in such a manner that they can fit with the activity data that can be used to prepare the national inventories. Emission factors on such an aggregation and allocation level are then referred to as "inventory emission factors" for CO_2.

18.7.2 Basic emission factors for CO_2

Current information on basic emission factors is available at the Federal Environment Agency's Web site, at the following URL:

http://www.umweltbundesamt.de/emissionen/publikationen.htm

18.7.3 Basic and inventory emission factors for CO_2

With the basic emission factors for CO_2 (not including the area of secondary fuels), along with data on energy-consumption structures, the CO_2 emission factors are determined at the differentiation level required for national CO_2 inventories (cf. Table 347).

With regard to *hard coal*, it is initially assumed that anthracite is used in small combustion systems, in residential heat-generation systems licensed in accordance with provisions of the Technical Instructions on Air Quality Control (TA Luft), in the small consumption sector (as of 1995: commerce, trade, services / commercial and institutional) and by military agencies. No further differentiation is carried out for anthracite. Neither is any further differentiation carried out for use of ballast coal.

For determination of CO_2 emission factors for hard coal, an energy-related mix of German hard-coal production, differentiated by districts (Ruhr, Saar, Aachen, Lower Saxony) is assumed; data for such a mix are available via the Statistik der Kohlenwirtschaft (coal-industry statistics). The relevant district-specific emission factors are then used, on this basis, to calculate a weighted average. Then, a mix consisting of domestic production and imports (broken down by countries of origin) is obtained. The relevant database consists of the aforementioned domestic-production figures and, initially, detailed data from the Association of Coal Importers (Verein der Kohlenimporteure). For calculation of the import mix, all hard-coal imports, broken down by supplier countries, are adjusted to take account of relevant amounts of coke and coking coal, and of the relevant (small) amounts of imports of other hard-coal products, and then converted to energy content.

The mix for domestic hard-coal production, and that for imports, are linked via the import fraction of hard coal used. This fraction is based on data, provided by the Association of Coal Importers (Verein der Kohlenimporteure), on fractions of imported coal found in the various areas of application. It does not include uses in the iron and steel industry and in coking plants.

The basis for country-specific CO_2 emission factors that enter into the CO_2 emission factor for the import mix consists of (unweighted) averages for the relevant countries of origin. For German hard coal, corresponding production data are used for weighting.

No further differentiation was carried out for hard-coal briquettes and hard-coal coke.

For use of raw lignite in public-sector power stations, the district-specific figures for CO_2 emission factors are used directly. A mixed value covering the different relevant districts (Rheinland, Lausitz, Mitteldeutschland, Helmstedt, Hessen) is calculated solely for the area of raw-lignite inputs in district-heating stations.

Through subtraction of crude-lignite quantities used in public power stations, and of quantities used in product production, from total production and import quantities (imports are significant only in connection with use of hard lignite), a difference is obtained that represents crude lignite use by industry and commerce, trade and services. This figure can then be broken down, via calculations, by areas of origin.

STATISTIK DER KOHLENWIRTSCHAFT (coal-sector statistics) production data are also used as a basis for calculating weighted averages, for the old and new German Länder and for Germany as a whole, from separate data sets for the various lignite products (lignite briquettes, fluidised-bed coal, pulverised lignite, dry lignite and lignite coke).

No further aggregation is carried out for the CO_2 emission factors for all other fuels; the values shown in Table 347 are used. The following should be noted with respect to allocations:

- For the period 1990 to 1994, for which separate balances are drawn up for the old and the new German Länder, weighted CO_2 emission factors, differentiated according to old and new German Länder, are used where appropriate.
- For the period until 1994, the CO_2 emission factor for Russian natural gas is assumed for the new German Länder.
- Gas separated under high pressure from natural gas is only relevant for West Berlin (until 1995).

In future, more emission factors from the ETS are to be used in the inventory. To prevent inconsistencies, it must be ensured that the fuel qualities involved are identical. Therefore, the net calorific values reported in national statistics are compared with the corresponding values reported for emissions trading, in order to determine which values can be used for the inventory. That work has not yet been completed.

Table 347: Emission factors for CO_2 as of 1990, as derived for emissions reporting: energy

Fuel-based emission factors [t CO_2/TJ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Coal															
Hard coal (Steinkohle)															
Raw hard coal (power stations, industry)	93.3	93.4	93.4	93.4	93.4	93.4	93.5	93.6	93.7	93.7	93.7	93.9	94.0	94.0	94.0
Hard-coal briquettes	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0
Hard-coal coke	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
Anthracite (heat market for households, commerce, trade, services)	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0
Ballast hard coal, *old German Länder*	90.0	90.0	90.0	90.0	90.0										
Lignite (Braunkohle)															
Raw lignite															
Public district heating stations, Germany.						112.5	112.3	112.3	112.2	112.2	112.1	111.9	112.1	112.1	112.3
Industry, commerce, trade, services, Germany						109.5	111.9	112.9	112.8	111.8	112.4	111.9	112.1	112.0	111.9
Old German Länder	113.9	113.8	113.8	113.9	113.9										
New German Länder	108.8	108.1	107.8	108.0	108.3										
Public power stations; District:															
Rheinland	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0
Helmstedt	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0
Hesse	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	NO
Lausitz	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0
Mitteldeutschland	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0
Lignite briquettes, Germany						100.0	100.0	99.9	99.7	99.7	99.7	99.7	99.7	99.7	99.7
Old German Länder	99.0	99.0	99.0	99.0	99.0										
New German Länder	99.7	100.0	100.0	100.0	100.3										
Lignite tar, *New German Länder*	97.0	97.0	97.0	97.0	97.0										
Lignite dust and fluidised bed coal, *Germany*						97.8	97.7	97.7	97.8	97.9	98.0	98.0	97.9	97.9	97.9
Old German Länder	98.0	98.0	98.0	98.0	98.0										
New German Länder	96.7	96.6	96.8	97.5	97.1										
Lignite coke	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0
Hard lignite	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0

Fuel-based emission factors [t CO_2/TJ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Petroleum															
Crude oil	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Petrol	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0
Raw gasoline *Germany*						80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Old German Länder	80.0	80.0	80.0	80.0	80.0										
New German Länder	74.0	74.0	74.0	74.0	74.0										
Kerosene	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Avgas	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3
Diesel fuel, *Germany*						74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Old German Länder	74.0	74.0	74.0	74.0	74.0										
New German Länder	73.0	74.0	74.0	74.0	74.0										
Light heating oil, *Germany*						74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Old German Länder	74.0	74.0	74.0	74.0	74.0										
New German Länder	73.0	74.0	74.0	74.0	74.0										
Heavy heating oil	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0
Petroleum	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Petrol coke	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0
LP gas, *Germany*						65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
Old German Länder	65.0	65.0	65.0	65.0	65.0										
New German Länder	64.0	65.0	65.0	65.0	65.0										
Refinery gas	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Other petroleum products, *Germany*						80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Old German Länder	80.0	80.0	80.0	80.0	80.0										
New German Länder	78.0	78.0	78.0	78.0	78.0										
Lubricants	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Gases															
Coking-plant and city gas, *Germany*						40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Old German Länder	40.0	40.0	40.0	40.0	40.0										
New German Länder	50.0	50.0	50.0	50.0	50.0										
Top gas, Old and new German Länder	264.0	264.0	264.0	264.0	264.0										
Top gas and converter gas, *Germany*						255.8	257.9	257.8	257.5	257.4	257.5	257.7	257.5	257.6	257.5
Fuel gas, *New German Länder*	49.0	49.0	49.0	49.0	49.0										
Other gases, *Germany*														60.0	60.0
Natural gases															
Natural gas, *Germany*						56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0
Old German Länder	56.0	56.0	56.0	56.0	56.0										
New German Länder	55.0	55.0	55.0	55.0	55.0										
Petroleum gas	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0
Pit gas	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0

Fuel-based emission factors [t CO_2/TJ]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Waste															
Household waste / municipal waste	109.6	107.0	104.6	100.1	98.0	96.9	95.8	94.7	93.6	92.5	91.5	91.5	91.5	91.5	91.5
Industrial waste, *Germany*						71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Old German Länder [2)]	73.9	73.9	74.0	74.1	74.3										
New German Länder [2)]	74.9	74.8	74.7	74.6	74.6										
Special waste, *Germany*						83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0
Special fuels [1)]															
Used oil	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7
Recycled plastics						74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6
Recycled tyres	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4
Bleaching clay	NO	NO	NO	NO	NO	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3
Commercial waste - plastic	NO	NO	NO	NO	NO	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1
Commercial waste - paper	NO	NO	NO	NO	NO	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9
Commercial waste - other	NO	NO	NO	NO	NO	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1
Commercial waste - packaging	NO	NO	NO	NO	NO	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9
Sewage sludge	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	95.1	95.1
Solvents (waste)	NO	NO	NO	NO	NO	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Oil sludge	NO	NO	NO	NO	NO	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0
Paper-industry residues	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2
Processed municipal waste	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8
Carpet waste	NO	NO	NO	NO	NO	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4
Textile waste	NO	NO	NO	NO	NO	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3

Fuel-based emission factors [t CO_2/TJ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Biomass fuels [3]															
Spent liquors from pulp production	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Fibre/de-inking residues	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9
Waste wood, wood scraps (industry)	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1
Waste wood, wood scraps (commercial/institutional)	NO	NO	NO	NO	NO	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
Bark	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4
Animal meals and fats	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6
Animal fat	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	74.9	74.9	74.9	74.9
Firewood [4]	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4
Landfill gas, sewage gas, biogas [4]	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6
Bioethanol	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0
Biodiesel [4]	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8
Other factors [kg/t]															
Flue-gas desulphurisation	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0

Fuel-based emission factors [t CO_2/TJ]	2005	2006	2007	2008	2009	2010	2011
Coal							
Hard coal (Steinkohle)							
Raw hard coal (power stations, industry)	94.0	94.2	94.1	94.3	94.3	94.2	94.2
Hard-coal briquettes	93.0	93.0	93.0	93.0	93.0	93.0	93.0
Hard-coal coke	105.0	105.0	105.0	105.0	105.0	105.0	105.0
Anthracite (heat market for households, commerce, trade, services)	98.0	98.0	98.0	98.0	98.0	98.0	98.0
Ballast hard coal, *old German Länder*							
Lignite (Braunkohle)							
Raw lignite							
Public district heating stations, Germany.	112.3	112.2	112.3	112.3	112.2	112.2	112.3
Industry, commerce, trade, services, Germany	111.4	110.6	111.6	110.7	110.6	110.0	109.5
Old German Länder							
New German Länder							
Public power stations; District:							
Rheinland	114.0	114.0	114.0	114.0	114.0	114.0	114.0
Helmstedt	99.0	99.0	99.0	99.0	99.0	99.0	99.0
Hesse	NO	NO	NO	NO	NO	NO	NO
Lausitz	113.0	113.0	113.0	113.0	113.0	113.0	113.0
Mitteldeutschland	104.0	104.0	104.0	104.0	104.0	104.0	104.0
Lignite briquettes, Germany	99.7	99.7	99.6	99.6	99.8	99.8	99.9
Old German Länder							
New German Länder							
Lignite tar, *New German Länder*							
Lignite dust and fluidised bed coal, *Germany*	98.0	98.0	97.9	98.0	98.0	98.0	98.0
Old German Länder							
New German Länder							
Lignite coke	108.0	108.0	108.0	108.0	108.0	108.0	108.0
Hard lignite	97.0	97.0	97.0	97.0	97.0	97.0	97.0

Fuel-based emission factors [t CO_2/TJ]	2005	2006	2007	2008	2009	2010	2011
Petroleum							
Crude oil	NO	NO	NO	NO	NO	NO	NO
Petrol	72.0	72.0	72.0	72.0	72.0	72.0	72.0
Raw gasoline *Germany*	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Old German Länder							
New German Länder							
Kerosene	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Aircraft fuel	69.3	69.3	69.3	69.3	69.3	69.3	69.3
Diesel fuel, *Germany*	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Old German Länder							
New German Länder							
Light heating oil, *Germany*	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Old German Länder							
New German Länder							
Heavy heating oil	78.0	78.0	78.0	78.0	78.0	78.0	78.0
Petroleum	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Petrol coke	101.0	101.0	101.0	101.0	101.0	101.0	101.0
LP gas, *Germany*	65.0	65.0	65.0	65.0	65.0	65.0	65.0
Old German Länder							
New German Länder							
Refinery gas	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Other petroleum products, *Germany*	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Old German Länder							
New German Länder							
Lubricants	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Gases							
Coking-plant and city gas, *Germany*	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Old German Länder							
New German Länder							
Top gas, Old and new German Länder							
Top gas and converter gas, *Germany*	257.7	257.5	257.7	257.8	257.5	257.7	257.9
Fuel gas, *New German Länder*							
Other gases, *Germany*	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Natural gases							
Natural gas, *Germany*	56.0	56.0	56.0	56.0	56.0	56.0	56.0
Old German Länder							
New German Länder							
Petroleum gas	58.0	58.0	58.0	58.0	58.0	58.0	58.0
Pit gas	55.0	55.0	55.0	55.0	55.0	55.0	55.0

Fuel-based emission factors [t CO_2/TJ]	2005	2006	2007	2008	2009	2010	2011
Waste							
Household waste / municipal waste	91.5	91.5	91.5	91.5	91.5	91.5	91.5
Industrial waste, *Germany*	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Old German Länder [2)]							
New German Länder [2)]							
Special waste, *Germany*	83.0	83.0	83.0	83.0	83.0	83.0	83.0
Special fuels [1)]							
Used oil	78.7	78.7	78.7	78.7	78.7	78.7	78.7
Recycled plastics	74.6	74.6	74.6	74.6	74.6	74.6	74.6
Recycled tyres	88.4	88.4	88.4	88.4	88.4	88.4	88.4
Bleaching clay	82.3	82.3	82.3	82.3	82.3	82.3	82.3
Commercial waste - plastic	83.1	83.1	83.1	83.1	83.1	83.1	83.1
Commercial waste - paper	64.9	64.9	64.9	64.9	64.9	64.9	64.9
Commercial waste - other	68.1	68.1	68.1	68.1	68.1	68.1	68.1
Commercial waste - packaging	56.9	56.9	56.9	56.9	56.9	56.9	56.9
Sewage sludge	95.1	95.1	95.1	95.1	95.1	95.1	95.1
Solvents (waste)	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Oil sludge	84.0	84.0	84.0	84.0	84.0	84.0	84.0
Paper-industry residues	86.2	86.2	86.2	86.2	86.2	86.2	86.2
Processed municipal waste	59.8	59.8	59.8	59.8	59.8	59.8	59.8
Carpet waste	80.4	80.4	80.4	80.4	80.4	80.4	80.4
Textile waste	63.3	63.3	63.3	63.3	63.3	63.3	63.3

Fuel-based emission factors [t CO_2/TJ]	2005	2006	2007	2008	2009	2010	2011
Biomass fuels [3]							
Spent liquors from pulp production	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Fibre/de-inking residues	54.9	54.9	54.9	54.9	54.9	54.9	54.9
Waste wood, wood scraps (industry)	102.1	102.1	102.1	102.1	102.1	102.1	102.1
Waste wood, wood scraps (commercial/institutional)	95.1	95.1	95.1	95.1	95.1	95.1	95.1
Bark	101.4	101.4	101.4	101.4	101.4	101.4	101.4
Animal meals and fats	80.6	80.6	80.6	80.6	80.6	80.6	80.6
Animal fat	74.9	74.9	74.9	74.9	74.9	74.9	74.9
Firewood [4]	71.4	71.4	71.4	71.4	71.4	71.4	71.4
Landfill gas, sewage gas, biogas [4]	54.6	54.6	54.6	54.6	54.6	54.6	54.6
Bioethanol	72.0	72.0	72.0	72.0	72.0	72.0	72.0
Biodiesel [4]	70.8	70.8	70.8	70.8	70.8	70.8	70.8
Other factors [kg/t]							
Flue-gas desulphurisation	440.0	440.0	440.0	440.0	440.0	440.0	440.0

1) Designations of fuels as defined for the inventory data can diverge from other standards, and they are listed as such, and given EF as such, only in the inventory.

2) Designations of fuels as defined for the inventory data can diverge from other standards, and they are listed as such, and given EF as such, only in the inventory

3) Listed for selected fuels; calculated CO_2 emissions are reported only as memo items, and do not enter into the total inventory quantities; biomass fractions from special fuels (see above) are not listed separately, because their CO_2 EF are not differentiated.

4) Default values

Remark: The information and FAQ provided by the German Emissions Trading Authority (DEHSt) must be taken into account in any use of substance data from the NIR in the context of the ETS.

Table 348: Emission factors for CO_2 as of 1990, as derived for emissions reporting: industrial processes

Industrial processes [kg CO_2/ t (raw material or product)]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
2.A.1 Production of cement clinkers	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
2.A.2 Production of burnt lime	745.75	745.75	745.75	745.75	745.75	745.75	745.75	745.75	745.75	745.75	745.75	745.75	745.75	745.75	745.75
2.A.2 Production of dolomite lime	867.35	867.35	867.35	867.35	867.35	867.35	867.35	867.35	867.35	867.35	867.35	867.35	867.35	867.35	867.35
2.A.3 Use of limestone	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00
2.A.4.b Use of soda ash	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00
2.A.7.a Production of container glass	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00
2.A.7.a Production of flat glass	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00
2.A.7.a Production of household and table glassware	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
2.A.7.a Production of special glass (mix)	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00
2.A.7.a Production of glass fibres (mix)	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00
2.A.7.a Production of rock wool (mix)	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00
2.A.7.a Production of glass (mix not differentiated for new German Länder)	174.00	174.00	174.00	174.00	174.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.A.7.a Production of glass (mix for Germany, including cullet inputs)	106.01	101.80	99.34	96.79	83.97	101.63	99.75	97.09	94.99	94.56	97.41	100.58	97.47	96.37	98.27
2.A.7.b Production of masonry bricks	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10
2.A.7.b Production of roof tiles	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60
2.B.1 Production of ammonia	2,124.10	2,139.00	2,154.20	2,469.70	2,441.40	2,410.30	2,349.30	2,411.70	2,366.60	2,419.00	2,340.80	2,347.80	2,394.10	2,381.20	2,422.20
2.B.4 Production of calcium carbide	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
2.B.5 Coke burn-off in catalyst regeneration	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42
2.B.5 Production of carbon black	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196
2.B.5 Production of methanol	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
2.C.1 Production of electric steel	8.50	8.00	7.50	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374
2.C.1 Production of oxygen steel; limestone input	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00
2.C.2 Ferroalloys production	1500.00	1222.00	944.00	527.00	249.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00
2.C.2 Ferroalloys production (new German Länder)	1500.00	1500.00	1500.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.3 Production of foundry aluminium	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00

Industrial processes [kg CO_2/ t (raw material or product)]	2005	2006	2007	2008	2009	2010	2011
2.A.1 Production of cement clinkers	530.00	530.00	530.00	530.00	530.00	530.00	530,00
2.A.2 Production of burnt lime	745.75	745.75	745.75	745.75	745.75	745.75	745,75
2.A.2 Production of dolomite lime	867.35	867.35	867.35	867.35	867.35	867.35	867,35
2.A.3 Use of limestone	440.00	440.00	440.00	440.00	440.00	440.00	440,00
2.A.4.b Use of soda ash	415.00	415.00	415.00	415.00	415.00	415.00	415,00
2.A.7.a Production of container glass	193.00	193.00	193.00	193.00	193.00	193.00	193,00
2.A.7.a Production of flat glass	208.00	208.00	208.00	208.00	208.00	208.00	208,00
2.A.7.a Production of household and table glassware	120.00	120.00	120.00	120.00	120.00	120.00	120,00
2.A.7.a Production of special glass (mix)	113.00	113.00	113.00	113.00	113.00	113.00	113,00
2.A.7.a Production of glass fibres (mix)	198.00	198.00	198.00	198.00	198.00	198.00	198,00
2.A.7.a Production of rock wool (mix)	299.00	299.00	299.00	299.00	299.00	299.00	299,00
2.A.7.a Production of glass (mix not differentiated for new German Länder)	NO	NO	NO	NO	NO	NO	NO
2.A.7.a Production of glass (mix for Germany, including cullet inputs)	101.59	100.88	95.36	95.07	94.22	98.92	99,29
2.A.7.b Production of masonry bricks	29.10	29.10	29.10	29.10	29.10	29.10	29,10
2.A.7.b Production of roof tiles	28.60	28.60	28.60	28.60	28.60	28.60	28,60
2.B.1 Production of ammonia	2,372.80	2,310.70	2,364.20	2,382.90	2,492.10	2,377.50	2,353.9
2.B.4 Production of calcium carbide	C	C	C	C	C	C	C
2.B.5 Coke burn-off in catalyst regeneration	62.42	62.42	62.42	62.42	62.42	62.42	62.42
2.B.5 Production of carbon black	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196
2.B.5 Production of methanol	C	C	C	C	C	C	C
2.C.1 Production of electric steel	7.374	7.374	7.374	7.374	7.374	7.374	7.374
2.C.1 Production of oxygen steel; limestone input	440.00	440.00	440.00	440.00	440.00	440.00	440.00
2.C.2 Ferroalloys production	110.00	110.00	110.00	110.00	110.00	111.00	111.00
2.C.2 Ferroalloys production (new German Länder)	NO	NO	NO	NO	NO	NO	NO
2.C.3 Production of foundry aluminium	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00

C Confidential data

Remark: The information and FAQ provided by the German Emissions Trading Authority (DEHSt) must be taken into account in any use of substance data from the NIR in the context of the ETS.

18.8 Analysis of CO_2 emissions from non-energy-related use of fuels

The great majority of the coal, oil and gas that Germany uses is used for energy-related purposes. The remainder of the coal, oil and gas is used as feedstock for production processes. This consumption enters into the balance as "non-energy use" (NEU).

In the German Energy Balance, this consumption is listed separately, in line 43. The chemical industry is the leading user of fossil fuels for non-energy-related purposes. The German chemical sector uses such fuels in production of basic chemicals such as ammonia, ethylene und propylene, which are used, in additional production steps, to make such important products as fertilisers and plastics. Additional applications include production of graphite electrodes, asphalt for road construction and a range of waxes and lubricants.

Table 349 (see below) presents a comparison of a) the consumption listed in line 43 and b) reported emissions of CO_2 and NMVOC from use of fossil fuels in non-energy-related applications. Emissions from non-energy-related applications were correlated with the various relevant fuels in keeping with Table 1.3 from Volume 3 of IPCC-GL 2006 and in accordance with information provided by producers and experts. In some cases, we had to make our own estimates of the applicable correlation with individual fuels.

The comparison highlights a discrepancy between the carbon quantities reported in line 43 and the relevant emissions, especially in the case of mineral oils. In 2010, NMVOC and CO_2 emissions correlated with about 9 % of non-energy-related consumption; some 91 % of non-energy-related consumption is tied to indirect emissions.

To compare a) the carbon used in connection with the fuels and b) the resulting emissions, one must also take relevant products' entire life cycles into account. Such life cycles include production, use and disposal of products – and exports. In source category CRF 1.A, Germany reports (inter alia) emissions from waste incineration for energy-related purposes. Many products are not disposed of in the same year in which they are produced. In some products, carbon can be bound up for considerable periods of time. In asphalt, for example, bitumen carbon can remain stored for especially long periods. Other products, such as plastics, are exported as tradeable goods. Waste is also exported to other countries. Such products, along with the carbon they contain, cannot be taken into account in the carbon balance for Germany considered in the present context. They are responsible for a significant discrepancy between the carbon quantities used, and those emitted, in non-energy-related consumption in Germany. The carbon quantities used in non-energy-related consumption are considerably greater than the carbon quantities that would correspond to the reported CO_2 and NMVOC emissions from non-energy-related use of fossil fuels.

To determine whether the quantities listed in the Energy Balance as "non-energy use" actually show up in the relevant feedstock quantities, the fossil-fuel carbon stored in relevant products was balanced. In the chemical industry, fossil fuels are used in crackers, reforming processes and production of synthetic gases. In crackers and reforming, the most important products resulting from such processes are ethylene, propylene, 1,3-butadiene, benzene, toluene and xylene; in production of synthetic gases, the most important such products are ammonia and methanol. The products produced in refineries include bitumen, lubricants and paraffins, waxes and vaseline. Bitumen is used in a range of applications, including road surfaces and bitumen sheeting for roofs. Lubricants are used in road vehicles and machines (inter alia). For purposes of comparison with line 43, the produced quantities of the listed products were obtained from data of the Federal Statistical Office. Those data were then stoichiometrically converted into proportional CO_2 equivalents.

For methanol, ethylene, propylene, 1,3-butadiene, benzene, toluene and xylene, the carbon content was stoichiometrically converted, via the molar masses of the products and of CO_2, into CO_2 equivalents. Then, the pertinent CO_2 equivalent emissions were distributed among the three feedstocks used in Germany (naphta, LP gas and other mineral-oil products). The possible relevant distributions include distribution of emissions and products' carbon content among the various fuels involved. Below, conversion into CO_2 equivalents is illustrated with the example of ethylene (C_2H_4):

M (CO_2) = 44 g/mol
M (C_2H_4) = 28
CO_2 equivalents = Activity data * 2 * 44/28.

In the case of carbon black, the product is assumed to consist of pure carbon. That carbon was also converted into CO_2 equivalents, via the applicable stoichiometric relationship.

The production quantities of lubricants, waxes, paraffins, vaseline and other products were converted via the following values, taken from the monitoring guidelines used in emissions trading (Table 4, p. 33).

	EF **t CO_2/TJ**	**Lower net calorific value** **TJ/Gg**
Bitumen	80.6	40.2
Paraffin wax	73.3	40.2
Lubricating oil	73.3	40.2

For 2010 in the 2013 Submission, the sum of the carbon from the pertinent emissions and of the carbon stored in products amounts to 94 % of the non-energy-related consumption given in line 43 of the Energy Balance. The total share for the chemical industry is about 78 %, and the total share for refinery products is about 21 %.

Table 349: Verification of completeness of reported CO_2 from non-energy use of fossil fuels

Year	2010	Units	Coal						Petroleum									Gas	
			Hard coal	Hard-coal coke	Other hard-coal products	Lignite (Braunkohle)	Other lignite products	Total, solid fuels	Raw benzene (naphtha)	Diesel fuel	Heating oil, light	Heating oil, heavy	Petrol coke	Liquid gas	Refinery gas	Other petroleum products	Total, liquid fuels	Natural gas	Total, gas
A: Listed NEU quantity (Energy Balance line 43)		TJ	1 703	2 521	4 411	300	15 826		469 333	8	39 337	157 909	7 341	60 537	19 302	145 059		110 434	
B: Carbon content		kg C/GJ	26.8	29.2	26.8	27.6	27.6		20.0	20.2	20.2	21.1	26.6	17.2	15.7	20.0		15.3	
C: Total input as feedstock / non-energy use		Gg C	45.6	73.6	118.2	8.3	436.8	682.5	9,386.7	0.2	794.6	3,331.9	195.3	1,041.2	303.0	2,901.2	17,954.0	1,689.6	1,689.6
D: Total input as feedstock / non-energy use		**Gg CO_2**	**167.3**	**269.9**	**433.5**	**30.4**	**1,601.6**	**2,502.7**	**34,417.8**	**0.6**	**2,913.6**	**12,216.9**	**716.0**	**3,817.9**	**1,111.2**	**10,637.7**	**65,831.5**	**6,195.3**	**6,195.3**
E: Implied oxidised carbon fraction		**%**	**0%**	**206%**	**0%**	**0%**	**0%**	**22%**	**96%**	**0%**	**0%**	**56%**	**2%**	**88%**	**0%**	**185%**	**95%**	**84%**	**84%**

	Activity data [Gg]	Emis-sions (Gg CO_2)	Activity data + emis-sions (C in Gg CO_2)										
					Activity data + emis-sions (C in Gg CO_2)								
F: Total reported fossil IPPU CO_2		**6,709**	**557**	**557**	**32,915**	**0**	**6,796**	**17**	**3,365**	**19,653**	**62,747**	**5,209**	**5,209**
2 Industrial processes		**6,709**		**557**			**6,796**	**17**	**3,365**	**4,812**	**47,906**	**5,209**	**5,209**
2B: Chemical industry		**6,152**		**0**	**32,915**	**0**	**6,796**	**17**	**3,365**	**4,812**	**47,906**	**5,209**	**5,209**
2B1: Ammonia production	3,128	4,076		0			2,717				2,717	1,359	1,359
2B1: Ammonia production: CO_2 for further use	3,361						3,361				3,361		
2B5: Carbide production	C	17		0				17			17		0
2B5: Other													
Methanol CH3OH	*C*	*718*					*718*				*718*		
Ethylene C2H4	*5,063*				*12,747*				*1,303*	*1,863*	*15,914*		
Propylene C3H6	*3,905*				*9,830*				*1,005*	*1,437*	*12,272*		
1,3-butadiene C4H6	*1,151*				*3,004*				*307*	*439*	*3,751*		
Benzene C6H6	*1,874*				*5,081*				*520*	*743*	*6,344*		
Toluene C7H8	*662*				*1,776*				*182*	*260*	*2,218*		
Xylene C8H10	*179*				*476*				*49*	*70*	*595*		
Carbon black	*684*	*1,341*									*0*	*3,850*	*3,850*

Year	2010	Units	Coal: Hard coal	Hard-coal coke	Other hard-coal products	Lignite (Braunkohle)	Other lignite products	Total, solid fuels	Petroleum: Raw benzene (naphtha)	Diesel fuel	Heating oil, light	Heating oil, heavy	Petrol coke	Liquid gas	Refinery gas	Other petroleum products	Total, liquid fuels	Gas: Natural gas	Total, gas
	Activity data [Gg]	Emis-sions (Gg CO_2)	Activity data + emis-sions (C in Gg CO_2)						Activity data + emis-sions (C in Gg CO_2)										
2C: Metal industry		**557**		**557**				**557**											
2C1: Iron and steel production (1)	IE	IE						0									0		0
2C2: Production of ferroalloys	55	6		6				6									0		0
2C3: Primary aluminium production	403	551		551				551									0		0
2C5: Other								0									0		0
Lead production	*NE*	*NE*						*0*									*0*		*0*
Zinc production	*NE*	*NE*						*0*									*0*		*0*
3: Solvents and other product use (2)	**IE**	**IE**						**0**	**IE**								**0**		**0**
Exceptions reported elsewhere																			
1A Combustion of fuels		**0**														**14,841**	**14,841**		
1A1b: Petroleum refineries																			0
Lubricants	1173							0								3,456	3,456		0
Waxes, paraffins, vaseline, etc.	123															362	362		
Bitumen	3,402															11,023	11,023		
1A3 Lubricants in road transports (3)	IE	IE						0								IE	0		0

(1) Since coke inputs in the iron and steel industry are not included in the Energy Balance, the relevant CO_2 emissions are not included here.

(2) Since over 90 % of solvents from basic chemicals are produced in steam crackers, it is assumed that carbon emitted from NMVOCs comes from products of such crackers.

(3) Use of lubricants is already covered by the total quantity of produced lubricants.

19 ANNEX 3: OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR INDIVIDUAL SOURCE OR SINK CATEGORIES, INCLUDING KP-LULUCF ACTIVITIES

19.1 Other detailed methodological descriptions for the source category "Energy" (1)

19.1.1 Revision of the activity rates for stationary combustion systems of the new German Länder for the year 1990 and for subsequent years (1.A.1 and 1.A.2)

Problems with the GDR's official statistics in 1990, the year of German reunification, along with the creation of a standardised system of official statistics for all of Germany, had a noticeable effect on the quality of figures, as reported in past inventories, for activity rates of stationary combustion systems of the new German Länder for the year 1990 (and for subsequent years). For this reason, these figures have been revised. This work was carried out by the Institute for Energy and Environment (Institut für Energetik und Umwelt gGmbH; IE gGmbH). In work package 1 of the research project "Base year and update" ("Basisjahr und Aktualisierung"; UBA, 2005c: FKZ 20541115), "the activity rates for stationary combustion systems of the new German Länder, in their role as a basis for emissions inventories and the report relative to determination of allocated quantities, were explicitly reviewed for any gaps, completed and corrected as necessary and substantiated". For a detailed description of the procedure used for revising the activity rates for stationary combustion systems, please see the 2010 NIR.

19.1.2 Energy industry (1.A.1)

19.1.2.1 Methodological aspects of determination of emission factors (Chapter 3.2.6.2)

This section of the Annex describes the main steps carried out in the research projects RENTZ et al (2002) and RENTZ et al (2002) und FICHTNER et al (2011) for determination of emission factors. (This description does not apply to the CO_2 emission factors whose determination is described in Annex 2 (Chapter 18.7).)

Determination of emission factors requires detailed analysis of all operational facilities with regard to technologies used and design-specific emission behaviour. Three overarching source categories are formed: large combustion systems, combustion systems within the scope of application of the Technical Instructions on Air Quality Control (TA Luft) and gas turbines. Existing plants are classified in terms of emissions-relevant characteristics, and the pertinent emission factors are determined. These so-called "technology-specific" factors can then be aggregated in an adequate manner. This database also provides the basis for estimating future emissions (changes in the overall make-up of the entire group of facilities, in terms of percentage shares for various facility types). This procedure thus consists of the following steps:

1. Characterisation of the technology-specific emissions behaviour of combustion systems.
   In a first step, the combustion and emissions-reduction technologies used in Germany

are briefly described, and the relevant emissions-determining factors are explained. On the basis of this characterisation, emission factors are derived for the various different relevant technologies, differentiated by size class and fuel type. The chosen classification is also oriented to applicable provisions under immissions-control law, an orientation that permits derived emission factors to be compared with limits applicable now or in the future.

2. Analysis of the relevant source-category structure
   Emissions calculations must be carried out using emission factors that have the same references as the pertinent energy-input data. The latter (data) are broken down by source categories that are derived from the national energy balance – cf. Chapter 3.2 – and are not based on the combustion technologies used. The project has defined and analysed the following source categories: Public electricity and heat production (CRF 1.A.1a), Industrial power stations (CRF 1.A.1c for mining-sector power stations; otherwise CRF 1.A.2), District-heating stations (CRF 1.A.1a), Refinery power stations (CRF 1.A.1b), Industrial combustion systems (CRF 1.A.1c and 1.A.2) and Residential and Institutional and commercial (small consumers) (CRF 1.A.4 and 1.A.5).
   In the analysis, the various technologies' contributions to total energy use must be determined. The most important data sources for this include the power-station database of the DFIU (now the KIT), relevant statistics, communications of industry associations (VGB, VDEW, VIK), operator information and technical publications. Furthermore, excerpts of emissions declarations from the years 1996 and 2004, as provided by some Länder authorities, were also evaluated in the present context.
3. Aggregation of emission factors
   On the basis of the percentage contributions for the various technologies – which were determined separately for the old and new Länder – the technology-specific emission factors are aggregated to form source-category-specific factors. Finally, factors for Germany as a whole are formed. The source-category-specific factors are sub-divided in accordance with the categories "large combustion systems", "TA Luft combustion systems" and "gas turbines", as well as by fuel type. The aggregated emission factors are formed first for the reference year 1995 (RENTZ et al, 2002) and for the reference year 2004 (FICHTNER et al, 2011).
4. Projections for the years 2000 and 2010 (RENTZ et al, 2002) and for the years 2010 and 2020 (FICHTNER et al, 2011)
   Technology-specific emission factors are defined for the purpose of describing ongoing technical progress. These are derived from characterisation of modern technologies. An increasing contribution of low-emissions technologies to total relevant activity, thus, can be represented by suitably changing the percentage shares for the technologies under consideration. The framework for such carrying forward consists of the relevant applicable provisions under immissions-control law. For the reference year 2010, it is assumed that requirements from the amended Technical Instructions on Air Quality Control (TA Luft) from 2002 and the EU Large Combustion Plants Directive of 2001 have been implemented; for the reference year 2020, we assume that the requirements of Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions have been implemented.

The above-described methods, beginning with characterisation of the emissions behaviour of relevant combustion technologies and gradually leading to aggregated factors at various regional and source-category-specific levels, make it possible to represent the required factors transparently.

The chosen methods for deriving emission factors for a given reference year are shown in Figure 81 below.

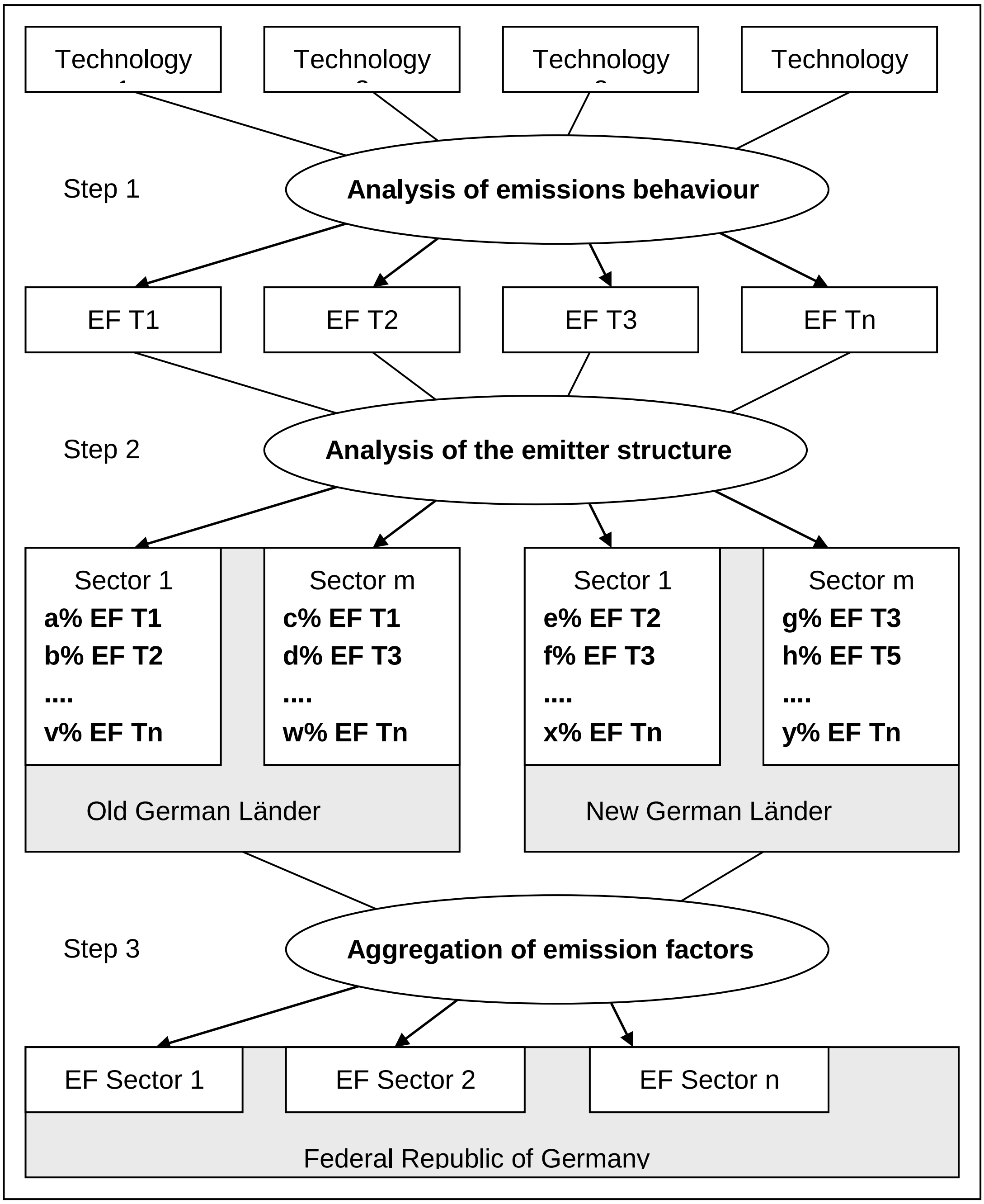


Figure 81: Methods for calculating emission factors

The origins and the quality of the data involved are discussed in detail in the relevant project reports (RENTZ et al, 2002; and FICHTNER et al, 2011). A large part of the data has been taken from the emissions declarations of the German Länder (states) Baden-Württemberg, Brandenburg, North Rhine – Westphalia and Thuringia for 1996, and from the emissions declarations of all Länder (except for Berlin) for the year 2004. The annual pollutant-load data included in those data are based, depending on the pollutant in question, on measurements from continuous monitoring, on individual measurements or on calculations based on physical laws, mass balances or emission factors. In the following, the emissions declarations of the state of Baden-Württemberg are used to show, by way of illustration, what data-determination methods tend to be used for the various types of combustion systems and substances in question. Such analysis makes it possible to classify the quality of the underlying data with regard to the derived technology-specific emission factors. At the same time, the description illustrates the data-evaluation procedure. Where a sufficient amount of data for a source category is available, the relevant value range is characterised via the median and the percentile is characterised at 25 % and 75 %[128]. This produces a robust estimate that, unlike characterisation via the mean value, is not distorted by extreme values. In general, percentiles at 5 % and 95 % are also listed, to describe the distribution of values. Similar percentile evaluations were also carried out for the emissions declarations of the other Federal Länder.

In the following, a distinction is made between measured data (either continuous measurements or individual measurements) and data based on calculations or emission factors. In evaluation, therefore, individual data items are first classified as either "measurements" (M) or "assumptions" (A). This general overview, in turn, is divided into the categories of large combustion systems, TA Luft combustion systems and gas turbines. These are then further subdivided, with regard to declaration obligations, into facilities subject to abbreviated (K) or complete (V) declarations. For each of the three groups of systems, evaluation and derivation of emission factors is carried out, using the sample data from Baden-Württemberg and with classification by "measurements" and "assumptions".

Table 350 provides an overview of the facility types considered, grouped on the basis of their numbers under the 4th Ordinance Implementing the Federal Immission Control Act (BImSchV) and of the type of declaration concerned.

128 For the entire value range of a variable X, the sum-frequency distribution can be used to estimate what percentage of all units considered will have a maximal value of x. That value is referred to as a *quantile* or, when percentage values are being considered, as a *percentile*. The best-known percentile, the one that separates the lower half of all values from the upper half, is the 50th percentile, the so-called *median*. The 25th and 75th percentiles cut off the upper and lower quarters of the distribution. They are thus also referred to as upper and lower *quartiles* or as the first and third *quartile* (with the median being a sort of second quartile).

Table 350: Facility types pursuant to Annex of 4th BImSchV (4th Ordinance on Execution of the Federal Immission Control Act)

Index	**Large combustion systems (Großfeuerungsanlagen)**		**Type of declaration required**
1 01 1	Power stations	≥ 50 MW for solid, liquid and gaseous fuels	V
1 02A 1	Combustion systems	≥ 50 MW for solid and liquid fuels	V
1 02B 1	Combustion systems	≥ 50 MW for gaseous fuels	V
Index	**TA Luft installations**		**Type of declaration required**
1 02A 2	Combustion systems for heating oil EL)	1 - < 50 MW, solid and liquid fuels (except	V
1 02B 2	Combustion systems	5 - < 50 MW heating oil EL	K
1 02C 2	Combustion systems Combustion systems installations	10 - < 50 MW for natural gas 10 - < 50 MW, except for natural gas	K V
1 03 1	Combustion systems	> 1 MW, other fuels	V
Index	**Gas turbine systems**		**Type of declaration required**
1 05 1	Gas turbines Gas turbines installations	≥ 50 MW for natural gas ≥ 50 MW, except for natural gas	K V
1 05 2	Gas turbines Gas turbines installations	< 50 MW for natural gas < 50 MW, except for natural gas	K V

In the analyses, emissions data are differentiated by combustion technologies. Table 351 provides an overview of this technology classification based on types. Categories 110 to 118 apply mainly to solid fuels, while 120 to 125 apply to liquid fuels and 130 to 132 apply to gaseous fuels.

Table 351: Classification of sources by type of combustion system

Technology	
Type	**Meaning**
110	Combustion systems for solid fuels / waste
111	Filled-shaft combustion systems
112	Combustion with throw feed
113	Combustion systems with pneumatic feed
114	Under-thrust combustion
115	Combustion with mechanically moved grids
116	Dust incineration with dry-ash ventilation
117	Dust incineration with wet-ash ventilation
118	Fluidised-bed combustion
120	Combustion systems for liquid fuels / waste
121	With evaporative burner
122	With pressure-atomising burner
123	With steam-atomising burner
124	With rotation-atomising burner
125	With air-atomising burner
130	Combustion systems for gaseous fuels / waste
131	With atmospheric gas burner
132	With gas-blower burner
141	Multiple-substance combustion systems
142	Mixed combustion
815	Gas turbines

19.1.2.2 *Methane emission factors in the research project RENTZ et al (2002)*

The following Table 352 summarises the emission factors shown in Tables 3, 4 and 5 of Annex E of the research project RENTZ et al (2002):

Table 352: Methane emission factors for combustion systems < 50 MW furnace thermal output and for gas turbines, pursuant to RENTZ et al, 2002

Facility type	Fuel	Länder	CH_4 EF [kg/TJ]
Combustion systems < 50 MW furnace thermal output	Hard coal	ABL	3.4
		NBL	3.3
	Hard-coal coke	ABL/NBL	19
	Lignite	NBL, Lausatian district (Lausitz)	269
		NBL, Central German district (Mitteldeutschland)	184
	Heating oil EL	ABL	0.02
	Natural gas	ABL/NBL	0.02
Gas turbines	Heating oil EL	D	0.5
	Natural gas	D	2

ABL old German Länder
NBL new German Länder
D Federal Republic of Germany as a whole

19.1.2.3 CO_2 emissions from flue-gas desulphurisation (CRF 1.A.1, Limestone balance)

In the framework of the research project "limestone balance" ("Kalksteinbilanz"; UBA 2006, FKZ 20541217/02), data for CO_2 emissions from flue-gas desulphurisation were determined for the source category Electricity and heat production in public power stations (cf. 4.2.3). Flue-gas desulphurisation systems have the task of converting sulphur dioxide in combustion gases, via chemical and physical processes, into substances that are less harmful. Limestone is commonly used as a reagent in flue-gas desulphurisation. Desulphurisation systems are tailored to the applicable requirements under immissions-control law and to the economic value of the resulting residual substances (plaster). The predominant process used in electricity generating plants is limestone scrubbing. Some 87 % of all power stations in Germany, in terms of installed output, use this process (RENTZ et al. 2002b).

Desulphurisation with $CaCO_3$ consists of several sub-reactions. For stoichiometric calculation of limestone inputs in the limestone-scrubbing process, the relevant chemical gross-reaction equation for the process is used (STRAUSS 1998):

$$CaCO_3 + SO_2 + 1/2O_2 + 2H_2O ==> CaSO_4.2H_2O + CO_2$$

This equation can be used to derive the limestone/plaster molar mass ratio. Such derivation shows that 581.39 kilograms of limestone are used per produced tonne of plaster. Plaster-production figures thus can be used to obtain the theoretically maximal limestone inputs for flue-gas desulphurisation in hard-coal-fired and lignite-fired power stations. The plaster-production figures do not indicate whether limestone or lime has been used, however. This problem was resolved with the help of statistics of the German Lime Association (BV Kalk) relative to sales of burnt and unburnt lime for the air-quality-control sector. Using the above reaction equation, the pertinent process-related CO_2 emissions can be determined from the mass relationship between $CaCO_3$ and CO_2. The results of the calculation are shown in the following table. They take account of figures for plaster production in all years between 1990 and 2008. To calculate plaster production for the years 2009 through 2011, we have used the 2008 plaster-production figure as a provisional input figure for the calculation.

Table 353: CO_2 emissions from flue-gas desulphurisation in public power stations

Year **CRF 1.A.1**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995** **Figures in Gg**	**1996**	**1997**	**1998**	**1999**	**2000**
CO_2 from flue-gas desulphurisation in public power stations	618	652	629	662	616	683	867	878	1,005	966	1,135
Year **CRF 1.A.1**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006** **Figures in Gg**	**2007**	**2008**	**2009**	**2010**	**2011**
CO_2 from flue-gas desulphurisation in public power stations	1,069	1,094	1,156	1,162	1,142	1,076	1,017	985	995	1,003	1043

Source: Calculation on the basis of of the "limestone balance" project (UBA 2006, FKZ 20541217/02); updated in 2008 (cf. NIR 2009)

In the inventory, these CO_2 emissions were assigned to emissions from use of solid fuels, because such use is the reason for operation of the flue-gas desulphurisation systems and for the systems' CO_2 emissions. Pursuant to expert estimates of the group carrying out the pertinent research, the uncertainty for limestone use and, thus, the uncertainty for related CO_2 emissions, is +/- 10 %.

19.1.3 Transport (1.A.3)

19.1.3.1 Transport – Civil aviation (1.A.3.a)

19.1.3.1.1 Derivation of additional emission factors (1.A.3.a)

Kerosene

Emissions of *sulphur dioxide* depend directly on the sulphur content of the jet kerosene being used. That, in turn, is subject to regional and chronological fluctuations. The emission factor used by Eurocontrol for sulphur dioxide, 0.84 kg SO^2/t jet kerosene, lies between the values used to date in the German inventory for the years 1990 to 1994 (1.08 to 1.03 kg SO_2/t jet kerosene) and the value used by the German inventory for subsequent years (0.4 kg SO_2/t jet kerosene). The figures given in IPCC 2006b, which, at 1 kg SO_2/t kerosene, are of an order similar to the old inventory values, are based on a sulphur content of 0.05 % by weight. According to current information of the Fachausschuss für Mineralöl- und Brennstoff-Normung[129] (FAM; technical committee for petroleum and fuels standardisation), jet kerosene in Germany typically has a total sulphur content of about 0.01 % by weight, i.e. one-fifth of the content given by the IPCC. The 2009 inventory report uses a sulphur-content figure of 0.021 % by weight for jet kerosene, on the basis of measurements from the year 1998 (DÖPELHEUER 2002). It seems plausible that the emission factor would decrease over time as a result of improved procedures and reduced maximum permitted levels. Consequently, a linear reduction is included here between the framework years 1990 (1.08 g SO_2 / kg kerosene), 1998 (0.4 g) and 2009 (0.2 g). In addition, it is assumed that all of the sulphur in the fuel is converted into sulphur dioxide. Because the emission factor depends directly and solely on the sulphur content of the jet kerosene, this emission factor is used for both flight phases.

For *water vapour*, the emission factor used by EUROCONTROL(2004) is 1,230 g H_2O / kg jet kerosene. CORINAIR (2006) uses a somewhat higher figure, 1,237 g H_2O / kg jet kerosene. In the interest of limiting the number of emission-factor sources, the CORINAIR figure (2006) is used. Since that emission factor is solely fuel-specific, it is applied to both flight phases, for both national and international air transports.

NO_X and *CO emissions* are calculated with the help of emission factors based on AV calculations. Those results, in turn, are based on aircraft-type-specific and operational-state-specific emission factors taken largely from the EMEP/EEA database. As in the previous year, adjusted emission factors had to be used with regard to some aspects of specific aircraft types that it was not possible to classify directly for these purposes, even by analogy to aircraft types with similar technical data. Those emission factors were determined via emissions functions, in the context of regression calculations, that calculate the emission factor for each engine type as a function of take-off weight. The basis for those functions consisted of the emission factors for existing aircraft types (cf. in this regard IFEU and ÖKO-INSTITUT 2010).

129 Personal e-mail communication with Dr. Feuerhelm, FAM Hamburg, 9 June 2009

Ammonia emissions are calculated, for both flight phases, with an emission factor of *0.173 g / kg jet kerosene* (UBA, 2010).

In each case, the *NMVOC* emission factors are obtained from the difference between the emission factor for hydrocarbons and that for methane.

The IPCC emission-factor database does not list any values for particulate emissions from jet kerosene (Total Suspended Particulate matter (TSP; $PM_{2.5}$; PM_{10}). For this reason, the emission factors for particulates (TSP) are taken from *Corinair 2006*. Table 8.2 in that source lists differentiated values for the flight phases of an average fleet: For national flights, 0.7 kg TSP / LTO and 0.2 kg TSP / t jet kerosene; for international flights, 0.15 kg TSP / LTO and 0.2 kg TSP / t kerosene. According to that table, jet-kerosene consumption per LTO cycle of 825 kg for national flights, and 1,617 kg for international flights, is assumed. These values are used to determine the emission factors for the LTO phase.

Avgas

In the *IPCC Guidelines* (2006a, page 3-64), the emission factors for *nitrous oxide* are explicitly defined as equal to the relevant values given for jet-kerosene use. That assumption has been adopted here – along with the forecasts for jet-kerosene use in cruise phases of national air transports (cruise phase in 2010).

As to fuel properties, there are no fundamental differences between avgas and automobile petrol[130]. Consequently, values for specific SO_2 emissions from automobile petrol may be used for avgas. Pursuant to the Fachausschuss für Mineralöl- und Brennstoff-Normung (FAM; technical committee for petroleum and fuels standardisation), the maximum permitted level for total sulphur content in petrol-station fuel is 10 mg/kg, or 0.001 % by weight, which is one-tenth of the figure given for jet kerosene. As a result, the 2008 emission factor for SO_2 from jet kerosene, which is reduced by 90 %, is used in the present context.

Since no information is available on how market shares of different types of avgas break down by *lead* content, lead emissions are calculated using the value determined for the most commonly used type (AvGas 100 LL (Low Lead)), 0.56 g/l. That value is somewhat lower than the standard value proposed by the EEA/EMEP Guidebook, 0.6 g/l liegt. Via a mean fuel density of 0.75 kg/l, that emissions value is converted to an emission factor of about *0.75 g lead / kg avgas*.

The emission factor for *particulates* (Total Suspended Particulate Matter – TSP) is obtained from the lead content of AvGas 100 LL, via multiplication by a factor of 1.6, which was adopted from the TREMOD model that is used for road transports (for the EF, cf. Table 354 below).

As to emission factors for *NMVOC*, pertinent values are given in the *Revised IPCC Guidelines 1996* (pages I 42 and 40); those values are used here.

The other emission factors are not available as special values for average small aircraft. For this reason, they are assumed to be the same as the relevant jet-kerosene emission factors (national, cruise).

[130] E-mail communication with Mr Winkler of the Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry, 8 June 2009

Table 354: Emission factors for avgas, 2011

Gas	EF in [g/kg]	Remarks regarding the source or calculation
CO_2	3,018.00	from IPCC Guidelines 2006, Table 3.6.4
CH_4	0.36	same as EF kerosene, LTO/national
N_2O	0.10	same as EF kerosene, cruise/national
SO_2	0.02	equivalent to 1/10 of EF kerosene, cruise/national/2008
NO_X	12.33	same as EF kerosene, cruise/national (calculated in TREMOD-AV)
NMVOC	13.06	from Revised IPCC Guidelines 1996, p. I.42
CO	647.00	calculated in TREMOD-AV
TSP	1.18	calculated from lead content of AvGas 100 LL
Pb	0.75	calculated from max. lead content of AvGas 100 L

Source: Öko-Institut (2012)

Table 355: Overview of emission factors used in the source category Transport – civil aviation (1.A.3.a)

[g/kg]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1.A.3.a – Overarching																						
CO_2	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150
SO_2	1.08	1.00	0.91	0.83	0.74	0.66	0.57	0.49	0.40	0.38	0.36	0.35	0.33	0.31	0.29	0.27	0.25	0.24	0.22	0.20	0.20	0.20
National, LTO																						
CH_4	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
N_2O	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
NO_X	13.36	13.35	13.32	13.38	13.43	13.47	13.54	13.60	13.66	13.72	13.77	13.82	13.87	13.91	13.95	14.01	14.07	14.12	14.16	14.22	14.24	14.23
NMVOC	2.68	1.98	1.60	1.20	1.24	1.35	1.46	1.46	1.54	1.56	1.59	1.63	1.55	1.40	1.52	1.52	1.61	1.68	1.77	1.80	1.83	1.90
CO	13.82	13.77	13.67	13.46	13.26	12.98	12.83	12.64	12.46	12.26	12.04	11.80	11.57	11.34	11.08	10.87	10.67	10.45	10.21	10.00	9.70	9.33
National, cruise																						
CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_2O	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NO_X	12.25	12.24	12.21	12.26	12.32	12.35	12.41	12.47	12.52	12.58	12.63	12.67	12.71	12.76	12.79	12.84	12.89	12.94	12.98	13.03	13.05	13.04
NMVOC	0.61	0.49	0.45	0.41	0.37	0.42	0.44	0.45	0.39	0.42	0.43	0.44	0.42	0.40	0.41	0.40	0.42	0.41	0.42	0.43	0.44	0.45
CO	10.15	10.11	10.04	9.89	9.74	9.53	9.42	9.28	9.15	9.01	8.85	8.67	8.50	8.33	8.14	7.99	7.84	7.68	7.50	7.34	7.12	6.85
International, LTO																						
CH_4	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
N_2O	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
NO_X	15.81	15.80	15.77	15.83	15.90	15.94	16.02	16.09	16.17	16.24	16.30	16.35	16.41	16.47	16.51	16.58	16.65	16.71	16.76	16.82	16.85	16.83
NMVOC	4.51	4.08	3.61	3.19	3.15	3.24	2.59	2.33	2.66	2.48	2.46	2.44	2.37	2.34	2.31	2.30	2.32	2.38	2.36	2.43	2.56	2.54
CO	21.41	21.33	21.17	20.86	20.54	20.11	19.88	19.58	19.31	19.00	18.66	18.28	17.93	17.57	17.17	16.84	16.53	16.19	15.82	15.49	15.03	14.45
International, cruise																						
CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_2O	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NO_X	15.59	15.58	15.54	15.61	15.67	15.71	15.80	15.87	15.94	16.01	16.07	16.12	16.18	16.23	16.28	16.34	16.41	16.47	16.52	16.59	16.61	16.60
NMVOC	0.41	0.40	0.39	0.40	0.39	0.40	0.40	0.41	0.42	0.41	0.42	0.43	0.43	0.44	0.44	0.45	0.46	0.48	0.48	0.50	0.51	0.52
CO	18.35	18.28	18.15	17.88	17.61	17.24	17.04	16.78	16.55	16.29	15.99	15.67	15.37	15.06	14.72	14.44	14.17	13.88	13.56	13.28	12.88	12.39

19.1.3.1.2 Detailed overview of the uncertainties underlying the pertinent activity data and emission factors (1.A.3.a)

Table 356: Overview of the applicable partial uncertainties for activity rates and emission factors

Individual components		Partial uncertainties		AR (kerosene & avgas)		SF (LTO/ cruise)		AR (kerosene) LTO and cruise		EM (H_2O) LTO and cruise		EM (CH_4) LTO and cruise		EM (N_2O) LTO and cruise		EM (SO_2) LTO and cruise		EM (H_2O) LTO and cruise		Remaining EM LTO + cruise		Source / reason for assumptions
		[%]		Total	n / i	n	i	n	i	n	i	n	i	n	i	n	i	n	i	n	i	
AR of AGEB and BAFA		-5	5	x	x																	Öko-Institut / DIW 2007 Here, the higher uncertainties of the Energy Balance are used. The uncertainties for the BAFA data are +3, -1% (conservatively estimated, using the approach for the uncertainties of mineral-oil statistics, which are based on BAFA data.)
Split factor SF n <> i		-10	10		x																	1990-2002: Calculations pursuant to TREMOD-AV; as of 2003, figures from Eurocontrol. The value here is a mixed value for the entire time series.
AR (kerosene)	n & i	-11	11					x	x													Calculated
Data of the Federal Statistical Office relative to aircraft movements	n	-0.1	0.1			x																Aviation statistics are based on the Transport statistics act (Verkehrsstatistikgesetz - VerkStatG). The data specified by Arts. 12, 13 VerkStatG are recorded. Pursuant to that act, all civil aviation craft, including aircraft, helicopters, airships, motorised gliders, sailplanes and manned balloons, are to be included in relevant surveys, as long as airports/airfields in Germany are involved.
	i	-0.1	0.1				x															
Real-distance addition	n & i	-3	3			x	x															The data of the Federal Statistical Office are oriented to great-circle distances. A detour factor for cruise flight has been used, as a means of estimating the distances actually flown (cf. IFEU and Öko-Institut 2010).
Allocation of consumption values for kerosene to aircraft types	n	-5	5			x																Aircraft types pursuant to the Federal Statistical Office are assigned emission factors from the EMEP-EEA database. There are four different quality levels for such assignment: a) direct, b) via similar types, c) via regression functions depending on take-off weight, and d) lump-sum EF.
	i	-5	5				x															
SF (LTO / cruise)	n	-6	6					x														Calculated
	i	-6	6						x													Calculated
AR (kerosene) LTO and cruise	n	-13	13							x		x		x		x		x		x		Calculated
	i	-13	13								x		x		x		x		x		x	Calculated
Emission factors (EF)	CO_2	5	5							x	x											IPCC 2006, p.3.69; low uncertainty, since the EF depends only on the C content of the fuel.
	CH_4	-57	100									x	x									IPCC 2006, p.3.69; depends on technology and is thus subject to large uncertainty in combination via the Tier 1 approach
	N_2O	-70	150											x	x							
	SO_2	-10	10													x	x					The emission factor depends only on fuel characteristics (sulphur content).

Individual components		Partial uncertainties		AR (kerosene & avgas)		SF (LTO/ cruise)		AR (kerosene) LTO and cruise		EM (H_2O) LTO and cruise		EM (CH_4) LTO and cruise		EM (N_2O) LTO and cruise		EM (SO_2) LTO and cruise		EM (H_2O) LTO and cruise		Remain-ing EM LTO + cruise		**Source / reason for assumptions**
		[%]		Total	n / i	n	i	n	i	n	i	n	i	n	i	n	i	n	i	n	i	
	H_2O	-5	5															x	x			The emission factor depends only on fuel characteristics. Low values, ranging from -4.9 to 1.6, given in Eurocontrol 2004, p.49.
Remaining EF	n & i	-10	10																	x		Assumption – for NO_X, HC and CO, a mean EF is calculated via TREMOD, on the basis of the EF for individual aircraft types
																					x	
Total uncertainty, *above*				+5	+11	+6	+6	+13	+13	+14	+14	+58	+58	+71	+71	+16	+16	+14	+14	+16	+16	
Total uncertainty, *below*				-5	-11	+6	-6	-13	-13	-14	-14	-101	-101	-150	-150	-16	-16	-14	-14	-16	-16	

n = national share; i = international share

Source: ÖKO-INSTITUT (2009)

19.1.3.2 Derivation of activity rates for road transport (1.A.3.b)

19.1.3.2.1 Harmonisation with the Energy Balance

The basis for CSE data collection for the road-transport sector consists of energy consumption data provided by the Working Group on Energy Balances (AGEB). For each year, the sum of the activity rates for the various individual structural elements must correspond to the Energy Balance data, in TJ. The relevant basic Energy Balance data are shown in Table Table 357 below.

Table 357: Energy inputs in road transports, 1990-2011

Year	Petrol	Diesel fuel	Biodiesel	Bioethanol	LP gas	Natural gas	Petroleum
Energy inputs pursuant to Energy Balances 1990-2009 (last revision: 10/2012), in TJ							
1990	1,330,479	735,920	0	0	138	0	0
1991	1,332,285	785,174	0	0	137	0	0
1992	1,344,129	853,502	0	0	229	0	0
1993	1,350,617	907,787	0	0	184	0	473
1994	1,276,637	932,060	0	0	184	0	559
1995	1,299,982	964,013	1,504	0	138	0	610
1996	1,299,879	964,580	2,046	0	115	0	638
1997	1,297,487	979,586	3,652	0	106	0	357
1998	1,300,463	1,022,794	4,081	0	106	0	637
1999	1,300,602	1,097,036	5,370	0	100	0	637
2000	1,237,055	1,108,105	12,276	0	94	0	414
2001	1,199,318	1,097,416	16,740	0	569	0	471
2002	1,166,381	1,105,842	20,460	0	607	0	472
2003	1,108,989	1,078,352	29,948	0	694	0	0
2004	1,072,720	1,110,931	38,806	1,144	1,887	0	0
2005	992,377	1,078,620	71,824	6,817	2,357	2,843	0
2006	930,834	1,082,042	130,165	13,418	4,605	5,211	0
2007	892,982	1,073,987	143,235	12,061	8,942	4,089	0
2008	854,002	1,102,623	109,393	16,328	15,652	4,882	0
2009	829,227	1,114,939	89,375	23,691	23,842	5,300	0
2010	791,416	1,168,063	88,886	30,577	21,823	8,768	0
Provisional figures pursuant to "Mineralölzahlen 2011" (fossil; "2011 Mineral-Oil Statistics") and Amtliche Mineralöldaten 12/2008 (bio; "Official Mineral-Oil Data 12/2008")							
2011	788,124	1,201,488	83,533	32,363	23,839	9,417	0

Sources: Evaluation tables of the Energy Balances, „Mineralöl-Zahlen 2011“ ("2009 Petroleum Data") of the Association of the German Petroleum Industry (MWV) (MWV, 2012) and „Amtliche Mineralöldaten“ ("Official Petroleum Data").

The Energy Balance is also used to model transport-quantity structures in TREMOD. For example, the German Economic Institute (DIW) carries out a fuel-consumption calculation in order to derive total mileage travelled (DIW, 2002). Some of the results of the calculation, for automobile transports, are entered into TREMOD. The DIW uses a fuel-consumption calculation in order to determine total domestic mileage; TREMOD uses some other sources and assumptions to estimate total domestic mileage – especially for goods transports (cf. the detailed description in IFEU, 2002). This estimate also takes the basic figures of the Energy Balance into account.

On the other hand, due to the many dependencies and uncertainties in the model, and to the basic data that must be taken into account, no feasible means is available for comparing mileage and energy consumption, for each year and each vehicle layer, in such a manner that the results yield the Energy Balance sum and the mileage and mean energy consumption figures in the time series are plausible. For this reason, the TREMOD results for the energy consumption are corrected, at the end of the process, in such a manner that the total for each reference year corresponds to the relevant figure in the Energy Balance.

Since TREMOD calculates energy consumption in tonnes, the results first have to be converted into TJ. For this purpose the net calorific values provided by the Working Group on Energy Balances (AGEB) are used (cf. Table 358).

Table 358: Net calorific values for petrol and diesel fuel

Year	Petrol	Diesel fuel
1990-1992	43.543 MJ/kg	42.704 MJ/kg
since 1993	43.543 MJ/kg	42.960 MJ/kg

Source: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)

The correction factors are derived in TREMOD separately for the various vehicle categories, as follows:

- Firstly, a correction factor for petrol is derived from the calculated petrol consumption for all vehicle categories and from petrol sales pursuant to the Energy Balance.
- The correction factor for petrol is then also used to bring fuel consumption of vehicles with diesel engines, among automobiles and other vehicles ≤ 3.5 t (light duty vehicles (LNF), and of motor homes and motorcycles (MZR)), into line with the Energy Balance.
- The difference between the corrected diesel-fuel consumption of automobiles and of other vehicles ≤ 3.5 t and the Energy Balance is then allocated to heavy duty vehicles and buses.
- The correction factor for heavy duty vehicles and buses is then calculated from their energy consumption, as calculated in accordance with the domestic principle, and the pertinent difference, as calculated for this group, from the Energy Balance.

Table 359 below summarises the correction factors used.

Table 359: Correction factors for harmonisation with the Energy Balance

Year	Area of application	Petrol (including bioethanol)	Diesel fuel (including biodiesel)	
		Automobiles, light duty vehicles, motorcycles	Automobiles, light duty vehicles	Heavy duty vehicles, buses
1990	ABL	1.038	1.038	1.115
1990	NBL	1.066	1.066	1.420
1991	ABL	1.035	1.035	1.110
1991	NBL	1.061	1.061	1.015
1992	ABL	1.039	1.039	1.189
1992	NBL	0.997	0.997	1.200
1993	ABL	1.042	1.042	1.191
1993	NBL	0.976	0.976	1.301
1994	ABL	0.984	0.984	1.181
1994	NBL	0.984	0.984	1.181
1995	D	0.996	0.996	1.205
1996	D	0.997	0.997	1.183
1997	D	0.993	0.993	1.186
1998	D	0.985	0.985	1.248
1999	D	0.986	0.986	1.308
2000	D	0.955	0.955	1.337
2001	D	0.941	0.941	1.240
2002	D	0.935	0.935	1.199
2003	D	0.921	0.921	1.140
2004	D	0.927	0.927	1.088
2005	D	0.916	0.916	1.083
2006	D	0.896	0.896	1.118
2007	D	0.889	0.889	1.061
2008	D	0.892	0.892	1.053
2009	D	0.886	0.886	1.094
2010	D	0.879	0.879	1.137
2011	D	0.888	0.888	1.117

Remark: 1994 correction factors for old German Länder (ABL) and new German Länder (NBL) as for Germany (D) as a whole

19.1.3.2.2 Allocation of biofuels, petroleum, natural gas and LP gas to the structural elements

For the transport sector, the Energy Balance lists data for biofuels, petroleum, natural gas and LP gas. For purposes of importing into the CSE, the results for these fuels are derived as follows:

- Biodiesel is allocated to all structural elements with diesel engines, in keeping with their percentage shares of consumption of conventional diesel fuel.
- Bioethanol is allocated to all structural elements with petrol engines, in keeping with their percentage shares of consumption of conventional petrol.
- Petroleum is allocated to buses on roads outside of municipalities – and, thus, to the structural elements SV BUS KOAO and SV BUS MTAO – in keeping with their percentage shares of consumption of conventional diesel fuel.
- LP gas is allocated to conventional automobiles, with petrol engines, on municipal roads (structural element SV PKWO KOIO).

19.1.3.2.3 Activity rate for evaporation

The activity rate for evaporation emissions is set as total petrol consumption, on municipal roads, pursuant to TREMOD; the corresponding figure for mopeds is the total consumption. The values corrected to the Energy Balance are used.

19.1.3.3 Derivation of emission factors

19.1.3.3.1 Emission factors from TREMOD

In the CSE, emission factors for the "engines" ("Antrieb") category are listed in kg/TJ, while those for the "evaporation" category are given in kg/t. For the subtances "petrol" and "diesel fuel", these values can be derived from TREMOD for all structural elements. To that end, emissions (in tonnes) and energy consumption (in TJ; converted from the results "energy consumption in t", using the net calorific values pursuant to Table 358) are derived from the TREMOD results and allocated to the relevant structural elements. The emission factor for each structural element then results as the quotient produced by dividing emissions, in tonnes per structural element, by the energy consumption, per structural element, in TJ. A similar procedure is used to obtain the emission factors for evaporation (evaporation emissions, in kg / consumption on municipal roads, in t).

For purposes of this derivation, TREMOD results without correction to the Energy Balance are used, since such correction is already contained in the activity rates for the CSE. Use of the corrected values (emissions and energy consumption) leads to the same results, however, since the correction factor cancels out in calculation of mean emission factors (emissions corrected / energy corrected = emissions uncorrected / energy uncorrected).

19.1.3.3.2 Emission factors for biodiesel, bioethanol, petroleum, natural gas and LP gas

In all cases, the emission factors for biodiesel and petroleum are set to the same values as those for conventional diesel fuel. The emission factors for bioethanol are set to the same values as those for conventional petrol.

Exceptions:

- The CO_2 emission factor for biodiesel is set to 70.8 t/TJ;
- The SO_2 emission factor for petroleum is set to 24 kg/TJ for those years in which diesel fuel has a higher value. In all other years, the lower value for diesel fuel is used.

In the past, the TREMOD model has tended to be highly oversimplified and incomplete with regard to liquefied petroleum gas and natural gas. For the present report, the model has now been extensively revised in these areas. For the first time, it has become possible to report emissions from use of both fuels in keeping with Tier 3.

Now, the emission factors for liquefied petroleum gas and natural gas, like those for diesel fuel and petrol, are being taken from the "Handbook for emission factors of road transports 3.1" ("Handbuch für Emissionsfaktoren des Straßenverkehrs 3.1").

19.1.3.4 Derivation of data for western and eastern Germany, 1994

TREMOD distinguishes between old and new German Länder only until 1993. Since the CSE also requires such differentiation for 1994, a relevant breakdown must be made using simplifying assumptions. The framework conditions include:

- The sum total of activity rates for engines (Antrieb) must correspond to the relevant Energy Balance values (in each case, for old and new German Länder).
- In the overall result, emissions resulting from linking activity rates with emission factors must correspond to the TREMOD results for Germany.
- With these framework conditions, a relevant breakdown is possible only under the following assumptions:
- The emission factors for old and new German Länder are set, for all structural elements, to the relevant values for all of Germany in 1994.
- The structural elements' percentage shares of the activity rates, for each fuel, are considered to be the same in each case for the old and new German Länder, and they are the same as the relevant values for all of Germany in 1994.

With these assumptions, the aforementioned conditions are fulfilled. A third framework condition is not fulfilled: the plausibility of emissions results in the time series, in each case, for the old/new German Länder.

19.2 Other detailed methodological descriptions for the source category "industrial processes" (2)

19.2.1 Mineral products (2.A)

19.2.2 Chemical industry (2.B)

19.2.3 Metal production (2.C)

19.2.4 Other production (2.D)

19.2.4.1 Pulp and paper (2.D.1)

The fibre for paper production is produced, via chemical or mechanical processes, either from fresh fibre or from processed recycled paper. A distinction is made between integrated and non-integrated pulp and paper mills. Non-integrated pulp mills (that produce pulp for the market) solely produce pulp for sale on the open market. On the other hand, integrated mills produce both pulp and paper, at the same sites. A paper mill can either produce paper from fibre material produced at other locations or be integrated within complete pulping processes set up at one site.

Sulphate pulp mills normally operate in both integrated and non-integrated modes, whereas sulphite pulp mills are normally only integrated – i.e. part of paper-production chains. In most cases, mechanical pulping and used-paper processing are a fixed part of the paper-production process; in a few cases, such processes are not so integrated, i.e. are carried out separately.

19.2.4.1.1 Fibre-production processes

Sulphate process

The sulphate process is the world's most common pulping process, since it yields higher pulp strengths and can be used with all types of wood. In the two German plants, carbonate is extracted from the circulating lye via bonding with calcium (causticising) and then, in a separate lime oven, is burned to burnt lime, a process that releases CO_2. The burnt lime is then reused for causticising. Pursuant to the *IPCC Good Practice Guidelines*, CO_2 released from $CaCO_3$ is assigned an emission factor of "0", since all of its carbon comes from pulped wood. Calcium loss from the cycle is compensated for solely via addition of burnt lime and thus, for the present purposes, also does not lead to report-relevant CO_2 emissions (the CO_2 released in production of burnt lime is already included in the figures for the lime industry (CRF 2.A.2)).

This process also produces atmospheric emissions in lye recovery (boilers), in bark combustion, from lime ovens, in wood-chip storage, in pulp digestion, in pulp washing, in bleaching, in bleach-chemical processing, in evaporation, in sorting and washing, in processing of circulating water and in operation of various types of tanks. Such emissions include fugitive emissions that occur at various processing points – primarily in lye-recovery boilers, lime ovens and auxiliary boilers. The main components of emissions include nitrogen oxides, sulphur-containing compounds, such as sulphur dioxide, and foul-smelling reduced sulphur compounds.

The two German sulphate-pulping plants are fitted with a system for post-incineration of foul-smelling sulphur compounds and with systems for NO_X-reduced combustion in lye-recovery boilers (>20 % NO_X reduction, as reported by the German Pulp and Paper Association (VDP), September 2004 (VDP, 2004)).

No other types of emissions-reduction equipment are yet being used in Germany:

- *Scrubbers* downstream from recovery boilers (>85 % SO_2 reduction)
- SNCR equipment for NO_X reduction downstream from the auxiliary boiler (>30 % NO_X reduction)
- SNCR equipment for NO_X reduction downstream from the recovery boiler (>30 % NO_X reduction)
- NO_X-reduction systems for combustion in auxiliary boilers (>20 % NO_X reduction)

Sulphite process

Sulphite pulp is produced in 4 of 6 systems in Germany. In such plants, pulping is carried out with various chemicals. The sulphate process and the sulphite process have numerous similarities, including similarities with regard to possibilities for using various internal and external measures to reduce emissions. From the standpoint of environmental protection, the main differences between the two pulp-production processes have to do with chemical aspects of the boiling process, with aspects of preparation and post-processing of chemicals and with bleaching intensity – bleaching in sulphite plants is less intensive, since sulphite pulp is whiter than sulphate pulp.

Atmospheric emissions occur especially in lye recovery (boilers) and in bark combustion. Waste-gas emissions with less-concentrated SO_2 are released in washing and sorting processes, and they are released by ventilation shafts of evaporators and by various tanks.

Such emissions escape – in part, as fugitive emissions – at various points of the process. They consist primarily of sulphur dioxide, nitrogen oxides and dust.

A number of measures are available for reducing consumption of live steam and electrical energy and for increasing plant-internal generation of steam and electricity. Sulphite pulp mills can generate their own heat and electricity by using the thermal energy in concentrated lye, bark and waste wood. Integrated plants require additional amounts of steam and electricity, however; these additional amounts can be generated either in on-site facilities or at off-site locations. Integrated sulphite pulp and paper mills consume 18 - 24 GJ of process heat, and 1.2 - 1.5 MWh of electrical energy, per tonne of pulp.

All four sulphite pulping plants in Germany are operated with SO_2 scrubbers fitted downstream from recovery boilers (>98 % SO_2 reduction). One plant is fitted with equipment for NO_X-reduced combustion in recovery and auxiliary boilers (total of >40 % NO_X reduction).

No other types of emissions-reduction equipment are yet being used in Germany:

- SNCR equipment for NO_X reduction downstream from the auxiliary boiler (>30 % NO_X reduction)
- SNCR equipment for NO_X reduction downstream from the recovery boiler (>30 % NO_X reduction)

Wood pulp

Wood pulp is produced in 9 plants in Germany. In mechanical pulping, wood fibres are separated from each other via mechanical energy applied to the wood matrix. The process is designed to conserve most of the lignin in the wood, in order to maximise yields while ensuring that the pulp has adequate strength and whiteness. Two main processes are differentiated:

- The wood-grinding process, in which pieces of wood are are wettened and pressed against a rotating grinder, and
- The *refiner* process, in which wood chips are broken down into fibres in disk refiners.

Wood-pulp properties can be influenced by increasing the process temperature and, in the case of the *refiner* process, by chemical pre-treatment of the wood chips. The pulping process in which wood is chemically pre-softened and then broken down into fibres, under pressure, is known as *chemi-thermo-mechanical pulping* (CTMP).

In most cases, the waste-gas emissions consist of emissions from heat and energy generation in auxiliary boilers and of emissions of volatile organic carbon (VOC). VOC emissions occur in storage of wood chips, and in removal of air from containers, including containers for washing wood chips. They also occur in connection with condensates that are produced in recovery of steam from *refiners* and contaminated with volatile wood components. Some of these emissions are released as fugitive emissions, from various parts of mills.

The best available technologies for reducing waste-gas emissions include effective recovery of heat from refiners and reduction of VOC emissions from contaminated steam. Along with VOC emissions, mechanical pulping produces waste-gas emissions from on-site energy generation (i.e. non-process-related emissions). Heat and electricity are generated through combustion of various fossil fuels and wood residues (the latter are a renewable resource). The best available technologies for auxiliary boilers are described below.

Recycled fibre

In general, processes that use recycled fibres (processes for processing used paper) can be divided into two main categories:

- Processes that use solely mechanical cleaning, i.e. processes that use no de-inking. Such processes are used for production of test liners, fluting, carton and cardboard;
- Processes that use mechanical and chemical technologies, i.e. that include de-inking. Such processes are used for production of newsprint, tissue, printing and copier paper, magazine papers (SC/LWC) and for some types of carton and commercial DIP (de-inked recycled paper).

The raw materials for paper production from recycled fibre include recycled paper (main component), water, chemical additives and energy in the form of steam and electricity. Waste-gas emissions occur primarily in energy generation through fossil-fuel combustion, in power stations.

Waste-gas emissions from mills that process recycled paper occur primarily in systems for heat production; in some cases, they are also produced by combined heat/power generation (CHP) systems. For this reason, energy efficiency is closely linked to reductions of waste-gas emissions. The energy-generation systems in such mills normally use standard boilers, and thus they may be considered truly similar to all other such power plants. The following measures are considered the best available techniques for reducing energy consumption and emissions into the atmosphere: heat-power cogeneration, modernisation of existing boilers and retrofits (in connection with replacement investments) with more energy-efficient systems.

Energy-efficient mills for processing recycled paper consume process heat and electrical energy on the following scales:

- Integrated mills that process recycled paper, without de-inking (for example, for production of test liners and fluting):
  6 – 6.5 GJ/t process heat and 0.7 – 0.8 MWh/t electrical energy.
- Integrated mills for tissue production, with DIP systems:
  7 -12 GJ/t process heat and 1 – 1.4 MWh/t electrical energy;
- Integrated mills for production of newsprint, and integrated mills for production of printing and writing paper, and including DIP systems:
  4 – 6.5 GJ/t process heat and 1 – 1.5 MWh/t electrical energy.

19.2.4.1.2 Paper and carton production

Paper is made from fibre materials, water and chemical additives. The entire paper-making process consumes large amounts of energy. Electricity is required primarily for operation of various motors and for grinding of fibres. Process heat is used primarily for heating water, other liquids and air, for evaporating water in dry areas of paper machines and for converting steam into electrical energy (with heat/power cogeneration). Large amounts of water are required as process water and for cooling. Various additives are used in paper production, as process aids and to enhance product properties (paper additives).

Most of the waste-gas emissions produced by non-integrated paper mills are produced by steam-production and energy-generation systems. The boilers used in such systems are standard boilers that do not differ from those of other combustion systems. It is assumed that such systems are operated in the same manner as other auxiliary boilers of the same capacity (see below).

Energy-efficient, non-integrated paper mills consume heat and energy on the following scale:

- Non-integrated mills for production of uncoated fine paper consume process heat at a rate of 7 – 7.5 GJ/t and energy at a rate of 0.6 – 0.7 MWh/t;
- Non-integrated mills for production of coated fine paper consume process heat at a rate of 7 – 8 GJ/t and energy at a rate of 0.7 – 0.9 MWh/t;
- Non-integrated mills for production of tissue from fresh fibre consume process heat at a rate of 5.5 – 7.5 GJ/t and electrical energy at a rate of 0.6 – 1.1 MWh/t.

Auxiliary boilers

In considering waste-gas emissions from auxiliary boilers, one must take account of the actual energy balance of the pulp or paper mill concerned, the nature of the fuels that are supplied to the facility and any use of biomass fuels such as bark and waste wood. Pulp and paper mills that produce fibre materials from primary fibres normally use bark-fired boilers. Non-integrated paper mills, and mills that process recycled paper, generate waste-gas emissions primarily via their steam-production and/or energy-generation systems. Such systems normally consist of standard boilers that do not differ from those of other combustion systems. It is assumed that such systems are operated in the same manner in which all other systems of the same capacity are operated. The technologies involved include:

- Heat/power cogeneration, where the prevailing heat/power ratio permits;
- Use of renewable fuels, such as wood and any waste wood that is produced, in order to reduce emissions of fossil CO_2;
- Reduction of NO_X emissions from auxiliary boilers, via control of combustion conditions and installation of burners with low NO_X emissions;
- Reduction of SO_2 emissions through use of bark, gas and low-sulphur fuels, and waste-gas scrubbing to remove sulphur compounds;
- Use of effective electrical filters (or tube filters) to separate dust in auxiliary boilers fired with solid fuels.

Overall, most product-specific waste-gas emissions are site-dependent (for example, they depend on the type of fuel used, the size and type of the relevant facility, whether the plant is integrated or non-integrated, whether it generates electricity). The auxiliary boilers used in Germany cover a wide spectrum of different sizes (from 10 to more than 200 MW). With smaller boilers, the only useful approach is to use low-sulphur fuels and the pertinent combustion technologies, while secondary reduction measures can also be effective with larger boilers.

Further information about activity rates is provided in Chapter 18.

19.3 Other detailed methodological descriptions for the source category "Solvents and other product use" (3)

19.4 Other detailed methodological descriptions for the source category "Agriculture" (4)

19.4.1 Distribution of housing, storage and application procedures, and grazing data (CRF 4.A, 4.B, 4.D)

Table 360, Table 361,Table 362 and Table 363 show the distributions of housing, storage and application procedures on which the German inventory is based, and they provide data on grazing. The tables also include information relative to emission factors (including that for NH_3). For further details, cf. RÖSEMANN et al. (2013).

Table 360: Frequency distributions of animal housing procedures (in %), and pertinent litter quantities and NH_3 emission factors

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	bedding material (straw) kg place d^{-1}	NH_3-N EF for housing, kg NH_3-N per kg TAN in excreta
dairy cattle	tied systems, solid storage	31	31	31	31	16	16	16	16	13	13	13	12	12	12	11	11	10	10	10	9	9	9	5.0	0.066
	tied systems, slurry	37	37	37	37	38	38	38	38	33	33	32	30	29	28	26	25	23	22	21	19	18	18		0.066
	cubicles, solid storage	2	2	2	2	3	3	3	3	3	3	4	4	5	5	6	6	7	7	8	8	9	9	5.0	0.197
	cubicles, slurry	29	29	29	29	42	42	42	42	51	51	52	53	55	56	57	58	59	60	62	63	64	64		0.197
	time spent on pastures (in % of year)	18	19	18	18	14	14	14	14	14	13	13	13	12	12	12	11	11	11	11	11	10	11		
male beef cattle	tied systems, solid storage	4	4	4	4	3	3	3	3	2	2	2	3	3	4	4	5	5	6	6	7	7	7	2,0	0,066
	tied systems, slurry	7	7	7	7	4	4	4	4	3	3	4	4	5	6	6	7	7	8	9	9	10	10		0,066
	loose housing, fully slatted floor, slurry	83	83	83	83	88	88	88	88	91	91	88	84	81	78	75	71	68	65	62	58	55	55		0,099
	loose housing, sloped floor	6	6	6	6	4	4	4	4	3	3	5	8	10	12	14	17	19	21	23	26	28	28	2,5	0,213
	deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0,197
	time spent on pastures (in % of year)	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	3	4	4	4	4	4	4		
heifers	tied systems, solid storage	8	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	10	10	10	10	2,0	0,066
	tied systems, slurry	15	15	15	15	17	17	17	17	17	17	16	16	15	14	14	13	13	12	11	11	10	10		0,066
	loose housing, Fullyslatted floor, slurry	48	48	48	48	49	49	49	49	50	50	50	49	49	48	48	47	47	46	46	45	45	45		0,099
	loose housing, solid storage	28	28	28	28	25	25	25	25	25	25	26	27	27	28	29	30	31	32	32	33	34	34	3,0	0,197
	time spent on pastures (in % of year)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20		
calves	tied systems, solid storage	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0	0	0	0	0	0	0	0	2,5	0,066
	deep litter	50	50	50	50	50	50	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	100	2,5	0,197
	time spent on pastures (in % of year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	bedding material (straw) kg place d^{-1}	NH_3-N EF for housing, kg NH_3-N per kg TAN in excreta
suckler cows	tied systems, solid storage	6	6	6	6	6	6	6	6	7	7	8	8	9	10	11	11	12	13	14	14	15	15	5,0	0,066
	tied systems, slurry	2	2	2	2	2	2	2	2	2	2	2	3	3	3	4	4	5	5	5	6	6	6		0,066
	loose housing, slurry	7	7	7	7	6	6	6	6	5	5	6	7	9	10	11	12	13	14	16	17	18	18		0,197
	deep litter	86	86	86	86	86	86	86	86	86	86	84	81	79	77	75	72	70	68	66	63	61	61	8,0	0,197
	time spent on pastures (in % of year)	41	40	42	42	42	42	43	43	44	44	44	44	45	44	45	45	45	46	46	47	47	47		
mature males	tied systems, solid storage	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	5,0	0,066
	tied systems, slurry	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		0,066
	loose housing, slurry	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34		0,197
	loose housing, solid storage	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	5,0	0,197
	time spent on pastures (in % of year)	35	33	33	34	33	33	33	32	33	33	32	32	32	32	32	33	33	33	34	34	34	34		
fattening pigs / weaners	fully slatted floor, slurry	49	49	49	49	59	59	59	59	60	60	61	62	63	64	65	66	67	68	69	70	71	71		0,3
	partly slatted floor, slurry	40	40	40	40	34	34	34	34	32	32	31	30	29	28	27	27	26	25	24	23	22	22		0,3
	litter based, solid storage	8	8	8	8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0,30 / 0,15	0,4
	deep litter	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1,0 / 0,2	0,4
	time spent on pastures (in % of year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
sows / boars	solid storage	42	42	42	42	26	26	26	26	24	24	23	22	21	20	19	19	18	17	16	15	14	14	0,5	0,34
	slurry	58	58	58	58	74	74	74	74	76	76	77	78	79	80	81	81	82	83	84	85	86	86		0,34
	time spent on pastures (in % of year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	bedding material (straw) kg place a^{-1}	kg NH_3-N per kg TAN in excreta	
laying hens	cages; ≥2010: small group housing systems	95	95	95	95	95	94	92	90	89	88	87	85	84	81	77	73	70	68	62	38	18	14		a	b
	floor management, aviary	4	4	4	4	4	5	5	7	7	7	7	7	7	9	12	14	15	17	22	45	63	64	0,5	a	b
	free range, organic farming	1	1	1	1	1	2	2	4	4	5	7	8	9	10	11	13	14	15	16	18	19	22	0,5	a	b
broilers	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	1,4	0,09	b
pullets	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,8	0,09	b
ducks	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	19,5	0,16	b
geese	floor management and free range	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		0,57	c
turkeys, female	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	10,3	0,22	b
turkeys, male	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	10,3	0,22	b

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	bedding material (straw) kg place d^{-1}	kg NH_3-N per kg TAN in excreta
buffalo	straw based system	NO	NO	NO	NO	NO	NO	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	5,0	0,197
	slurry based system	NO	NO	NO	NO	NO	NO	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50		0,197
	time spent on pastures (in % of year)	NO	NO	NO	NO	NO	NO	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16		
horses	straw based system	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	8.0 / 5.0	0,22
(heavy horses / light horses, ponies)	time spent on pastures (in % of year)	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21		
mules and asses	straw based system	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	5,0	0,22
	time spent on pastures (in % of year)	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21		

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	bedding material (straw) kg place d^{-1}	kg NH_3-N per kg TAN in excreta
sheep without lambs	straw based system	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,4	0,22
	time spent on pastures (in % of year)	52	53	53	53	53	52	53	52	52	52	52	52	52	52	52	52	52	52	52	52	53	53		
lambs	straw based system	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,16	0,22
	time spent on pastures (in % of year)	42	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	40	40		
goats	straw based system	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,4	0,22
	time spent on pastures (in % of year)	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34		

[a] cf. Table 363: Laying hens, housing-specific partial NH3 emission factors

[b] related to N excreted

[c] related to TAN (UAN) excreted

Table 361: Frequency distributions of storage procedures (in %), and pertinent emission factors

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system (leachate / urine)	N_2O EF for storage kg N_2O-N per kg N in storage system	N_2O EF for storage kg N_2O-N per kg N in storage system (leachate / urine)	CH_4 MCF for storage kg CH_4-C per kg C in storage system < 10 °C	maximum CH_4 producing capacity (Bo) m³ per kg CH_4
all cattle, undigested slurry	open tank (% of total undigested slurry)	1	1	1	1	1	1	1	1	1	1	2	2	3	3	4	4	5	5	6	6	7	7	0,150		0,000		0,170	0,230
	solid cover (% of total undigested slurry)	22	22	22	22	22	22	22	22	21	21	21	22	22	22	23	23	23	24	24	24	24	24	0,015		0,005		0,170	0,230
	natural crust (% of total undigested slurry)	38	38	38	38	41	41	41	41	42	42	41	41	40	40	39	39	38	38	37	37	36	36	0,045		0,005		0,100	0,230
	plastic film (% of total undigested slurry)	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0,023		0,000		0,170	0,230
	artificial crust (chaff) (% of total undigested slurry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0,030		0,000		0,170	0,230
	storage below animal confinements > 1 month (% of total undigested slurry)	39	39	39	39	35	35	35	35	35	35	35	34	34	34	34	33	33	33	33	32	32	32	0,045		0,002		0,170	0,230
dairy cows, digested sluryy	share of digested slurry (% of total cattle slurry, related to slurry of dairy cows)	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	5	8	12	14	18	22	27						
	gas tight storage (% of total digested	0	1	2	3	4	5	6	7	8	9	10	11	12	13	15	16	22	27	33	38	44	49	0,000		0,001		0,010	0,230

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system (leachate / urine)	N_2O EF for storage kg N_2O-N per kg N in storage system	N_2O EF for storage kg N_2O-N per kg N in storage system (leachate / urine)	CH_4 MCF for storage kg CH_4-C per kg C in storage system < 10 °C	maximum CH_4 producing capacity (Bo) m³ per kg CH_4
	cattle slurry) open tank (% of total digested cattle slurry)	100	99	98	97	96	95	94	93	92	91	90	89	88	87	85	84	78	73	67	62	56	51	0,150		0,001		0,017	0,230
dairy cattle, solid	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,600	0,013	0,013	0,005	0,020	0,230
male beef cattle, solid	solid storage (% of total solid manure)	40	40	40	40	43	43	43	43	40	40	29	27	23	25	22	23	21	22	21	21	20	20	0,600	0,013	0,013	0,005	0,020	0,230
	deep bedding / sloped floor (% of total solid manure)	60	60	60	60	57	57	57	57	60	60	71	73	77	75	78	77	79	78	79	79	80	80	0,600		0,010		0,170	0,230
heifers, solid	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,600	0,013	0,013	0,005	0,020	0,230
calves, solid	solid storage (% of total solid manure)	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0,600	0,013	0,013	0,005	0,020	0,230
	deep bedding (% of total solid manure)	50	50	50	50	50	50	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	100	0,600		0,010		0,170	0,230
suckler cows, solid	solid storage (% of total solid manure)	7	7	7	7	7	7	7	7	8	8	9	9	10	11	13	13	15	16	18	18	20	20	0,600	0,013	0,013	0,005	0,020	0,230
	deep bedding (% of total solid manure)	93	93	93	93	93	93	93	93	92	92	91	91	90	89	87	87	85	84	83	82	80	80	0,600		0,010		0,170	0,230
mature males, solid	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,600	0,013	0,013	0,005	0,020	0,230
all pigs,	open tank	47	47	47	47	27	27	27	27	27	27	25	24	22	20	19	17	15	14	12	10	9	9	0,150		0,000		0,250	0,300

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system (leachate / urine)	N_2O EF for storage kg N_2O-N per kg N in storage system	N_2O EF for storage kg N_2O-N per kg N in storage system (leachate / urine)	CH_4 MCF for storage kg CH_4-C per kg C in storage system < 10 °C	maximum CH_4 producing capacity (Bo) m³ per kg CH_4
undigested slurry	(% of total undigested slurry)																												
	solid cover (% of total undigested slurry)	18	18	18	18	22	22	22	22	22	22	22	23	23	23	24	24	24	25	25	25	26	26	0,015		0,005		0,250	0,300
	natural crust (% of total undigested slurry)	3	3	3	3	13	13	13	13	13	13	14	16	17	19	20	22	23	25	26	28	29	29	0,105		0,005		0,150	0,300
	plastic film (% of total undigested slurry)	0	0	0	0	7	7	7	7	7	7	6	6	5	4	4	3	3	2	1	1	0	0	0,023		0,000		0,250	0,300
	artificial crust (chaff) (% of total undigested slurry)	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	3	3	3	4	4	4	4	0,030		0,000		0,250	0,300
	storage below animal confinements > 1 month (% of total undigested slurry)	32	32	32	32	30	30	30	30	31	31	31	31	31	31	31	32	32	32	32	32	32	32	0,105		0,002		0,250	0,300
fattening pigs, digested slurry	share of digested slurry (% of total pig slurry, related to slurry of fattening pigs)	0	0	0	0	0	0	0	0	0	0	1	1	2	2	2	5	8	11	13	16	21	25						
	gas tight storage (% of total digested pig slurry)	0	1	2	3	4	5	6	7	8	9	10	11	12	14	16	17	23	29	34	40	46	52	0,000		0,001		0,010	0,300
	open tank (% of total	100	99	98	97	96	95	94	93	92	91	90	89	88	86	84	83	77	71	66	60	54	48	0,150		0,001		0,021	0,300

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system (leachate / urine)	N_2O EF for storage kg N_2O-N per kg N in storage system	N_2O EF for storage kg N_2O-N per kg N in storage system (leachate / urine)	CH_4 MCF for storage kg CH_4-C per kg C in storage system < 10 °C	maximum CH_4 producing capacity (Bo) m³ per kg CH_4
	digested pig slurry)																												
fattening pigs / weaners, solid	solid storage (% of total solid manure)	73	73	73	73	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	0,600	0,030	0,013	0,005	0,030	0,300
	deep bedding (% of total solid manure)	27	27	27	27	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	0,600		0,010		0,250	0,300
sows / boars, solid	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,600	0,030	0,013	0,005	0,030	0,300
Laying hens	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,140		0,001		0,015	0,390
broilers	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,170		0,001		0,015	0,360
pullets	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,170		0,001		0,015	0,390
ducks	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,240		0,001		0,015	0,360
geese	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,160		0,001		no calculation of VS	no calculation of VS
turkeys, female	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,240		0,001		0,015	0,360
turkeys, male	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,240		0,001		0,015	0,360
buffalo	slurry, with natural crust	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,045		0,005		0,100	0,100

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system (leachate / urine)	N_2O EF for storage kg N_2O-N per kg N in storage system	N_2O EF for storage kg N_2O-N per kg N in storage system (leachate / urine)	CH_4 MCF for storage kg CH_4-C per kg C in storage system < 10 °C	maximum CH_4 producing capacity (Bo) m³ per kg CH_4
	(% of total slurry) solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,600	0,013	0,013	0,005	0,02	0,100
horses (heavy horses / light horses, ponies)	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,600	0,013	0,013	0,005	0,02	0,300
mules and asses	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,600	0,013	0,013	0,005	0,02	0,330
all sheep	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,280		0,013		0,02	0,190
goats	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,280		0,013		0,02	0,180

Table 362: Frequency distributions of application procedures (in %), and pertinent emission factors

livestock category	application type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	NH_3-N EF for application, kg NH_3-N per kg TAN applied
all cattle, undigested slurry	broadcast, without incorporation	9	9	9	9	2	2	2	2	2	2	2	2	1	1	1	1	1	1	0	0	0	0	0,50
	broadcast, incorporation < 1 h	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	0,10
	broadcast, incorporation < 4h	0	0	0	0	1	1	1	1	1	1	2	3	4	5	6	6	7	8	9	10	11	11	0,26
	broadcast, incorporation < 6h	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,35
	broadcast, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	3	4	4	5	5	6	6	0,40
	broadcast, incorporation < 12h	0	0	0	0	19	19	19	19	20	20	18	17	15	13	11	10	8	6	5	3	1	1	0,43
	broadcast, incorporation < 24h	33	33	33	33	11	11	11	11	11	11	10	9	8	7	6	5	4	3	2	1	0	0	0,46
	broadcast, incorporation < 48h	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,50
	broadcast, vegetation	0	0	0	0	0	0	0	0	0	0	1	3	4	6	7	9	10	12	13	15	16	16	0,50
	broadcast, grassland	45	45	45	45	43	43	43	43	41	41	42	42	42	42	42	43	43	43	43	43	44	44	0,60
	trailing hose, without incorporation	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0,46
	trailing hose, incorporation < 1 h	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	0,04
	trailing hose, incorporation < 4h	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0,15
	trailing hose, incorporation < 6h	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,20
	trailing hose, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0,24
	trailing hose, incorporation < 12h	0	0	0	0	8	8	8	8	8	8	7	7	6	5	5	4	3	2	2	1	0	0	0,30
	trailing hose, incorporation < 24h	1	1	1	1	3	3	3	3	3	3	2	2	2	2	1	1	1	1	0	0	0	0	0,39
	trailing hose, incorporation < 48h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,46
	trailing hose, vegetation	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	3	3	3	4	4	4	0,35
	trailing hose, short vegetation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,50
	trailing hose, grassland	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	2	2	0,54
	trailing shoe	0	0	0	0	2	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	0,36
	open slot	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0,24
	injection (Grubber)	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	0,05
dairy cattle, digested slurry	broadcast, without incorporation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,25
	broadcast, incorporation < 1 h	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0,04
	broadcast, incorporation < 4h	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	0,09
	broadcast, incorporation < 8h	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0,13
	broadcast, incorporation < 12h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0,16
	broadcast, vegetation	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	0,25
	broadcast, grassland	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	0,30
	trailing hose, without incorporation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,18
	trailing hose, incorporation < 1 h	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0,02
	trailing hose, incorporation < 4h	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0,06
	trailing hose, incorporation < 8h	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0,09

livestock category	application type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	NH_3-N EF for application, kg NH_3-N per kg TAN applied
	trailing hose, incorporation < 12h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0,11
	trailing hose, vegetation	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	0,13
	trailing hose, grassland	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0,21
	trailing shoe	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0,12
	open slot	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0,06
	injection (Grubber)	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	0,03
all cattle, solid manure	broadcast, without incorporation	13	13	13	13	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0,90
	broadcast, incorporation < 1 h	6	6	6	6	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	0,09
	broadcast, incorporation < 4h	0	0	0	0	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0,45
	broadcast, incorporation < 12h	7	7	7	7	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37	37	37	37	0,81
	broadcast, incorporation < 24h	47	47	47	47	19	19	19	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0,90
	broadcast, incorporation < 48h	6	6	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,90
	broadcast, vegetation	22	22	22	22	27	27	27	27	25	25	25	25	25	25	25	25	25	25	25	25	25	25	0,90
all pigs, undigested slurry	broadcast, without incorporation	8	8	8	8	5	5	5	5	4	4	4	4	3	3	2	2	2	1	1	0	0	0	0,25
	broadcast, incorporation < 1 h	4	4	4	4	8	8	8	8	8	8	8	7	7	7	7	7	7	6	6	6	6	6	0,04
	broadcast, incorporation < 4h	0	0	0	0	1	1	1	1	1	1	1	2	3	4	5	5	6	7	8	9	9	9	0,09
	broadcast, incorporation < 6h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,11
	broadcast, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	3	4	4	4	5	5	0,13
	broadcast, incorporation < 12h	0	0	0	0	27	27	27	27	27	27	25	22	20	18	15	13	11	8	6	3	1	1	0,16
	broadcast, incorporation < 24h	47	47	47	47	5	5	5	5	5	5	4	4	3	3	3	2	2	1	1	0	0	0	0,21
	broadcast, incorporation < 48h	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,25
	broadcast, vegetation	32	32	32	32	23	23	23	23	24	24	24	24	24	24	24	23	23	23	23	23	23	23	0,25
	broadcast, grassland	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	3	3	3	3	3	0,30
	trailing hose, without incorporation	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0,18
	trailing hose, incorporation < 1 h	0	0	0	0	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	0,02
	trailing hose, incorporation < 4h	0	0	0	0	1	1	1	1	1	1	2	2	2	3	3	4	4	5	5	6	6	6	0,06
	trailing hose, incorporation < 6h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,08
	trailing hose, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	0,09
	trailing hose, incorporation < 12h	0	0	0	0	10	10	10	10	9	9	9	8	7	6	5	5	4	3	2	1	1	1	0,11
	trailing hose, incorporation < 24h	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0,14
	trailing hose, incorporation < 48h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,17
	trailing hose, vegetation	0	0	0	0	0	0	0	0	0	0	3	5	8	11	13	16	19	21	24	27	29	29	0,13
	trailing hose, short vegetation	1	1	1	1	8	8	8	8	9	9	8	7	6	5	5	4	3	2	2	1	0	0	0,25
	trailing hose, grassland	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0,21
	trailing shoe	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	0,12
	open slot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0,06
	injection (Grubber)	0	0	0	0	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	0,03

livestock category	application type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	NH_3-N EF for application, kg NH_3-N per kg TAN applied
fattening pigs, digested slurry	broadcast, without incorporation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,25
	broadcast, incorporation < 1 h	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0,04
	broadcast, incorporation < 4h	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	0,09
	broadcast, incorporation < 8h	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0,13
	broadcast, incorporation < 12h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0,16
	broadcast, vegetation	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	0,25
	broadcast, grassland	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	0,30
	trailing hose, without incorporation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,18
	trailing hose, incorporation < 1 h	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0,02
	trailing hose, incorporation < 4h	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0,06
	trailing hose, incorporation < 8h	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0,09
	trailing hose, incorporation < 12h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0,11
	trailing hose, vegetation	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	0,13
	trailing hose, grassland	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0,21
	trailing shoe	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0,12
	open slot	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0,06
	injection (Grubber)	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	0,03
all pigs, solid manure	broadcast, without incorporation	20	20	20	20	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	0,90
	broadcast, incorporation < 1 h	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,09
	broadcast, incorporation < 4h	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0,45
	broadcast, incorporation < 12h	0	0	0	0	51	51	51	51	52	52	52	52	52	52	52	52	52	52	52	52	52	52	0,81
	broadcast, incorporation < 24h	70	70	70	70	13	13	13	13	12	12	12	12	12	12	12	12	12	12	12	12	12	12	0,90
	broadcast, incorporation < 48h	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,90
	broadcast, vegetation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,90
all cattle and pigs, leachate	broadcast, without incorporation	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,20
	broadcast, incorporation < 1 h	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,02
	broadcast, incorporation < 4h	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,07
	broadcast, incorporation < 8h	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,12
	broadcast, incorporation < 12h	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,14
	broadcast, vegetation	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,20
	broadcast, grassland	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,20
	trailing hose, without incorporation	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,18
	trailing hose, incorporation < 1 h	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,01
	trailing hose, incorporation < 4h	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,05
	trailing hose, incorporation < 8h	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,09

livestock category	application type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	NH_3-N EF for application, kg NH_3-N per kg TAN applied
	trailing hose, incorporation < 12h	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,12
	trailing hose, vegetation	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0,15
	trailing hose, grassland	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	0,14
	trailing shoe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0,08
	injection (Grubber)	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	3	3	3	3	3	0,02
laying hens, solid manure	broadcast, without incorporation	8	8	8	8	5	5	5	5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0,90
	broadcast, incorporation < 1 h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,00
	broadcast, incorporation < 4h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,18
	broadcast, incorporation < 12h	0	0	0	0	11	11	11	11	21	21	21	21	21	21	21	21	21	21	21	21	21	21	0,40
	broadcast, incorporation < 24h	92	92	92	92	83	83	83	83	70	70	70	70	70	70	70	70	70	70	70	70	70	70	0,45
poultry, except laying hens, solid manure	broadcast, incorporation < 24 h	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,45
all other animals, solid manure *)	broadcast, without incorporation	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0,90

*) (horses, mules and asses, sheep, goats, buffalo)

Table 363: Laying hens, housing-specific partial NH_3 emission factors

[in kg NH_3-N per excreted kg N]	≤ 2000	2001 - 2009	≥2010
Cage housing; as of 2010: small-group housing	0.164		0.066
Floor management, aviary	0.351	linear interpolation	0.090
intensive outdoor management, free-range management, organic production	0,099		

Source: RÖSEMANN et al., 2013

19.5 Other detailed methodological descriptions for the source/sink category "Land-use change and forestry" (5)

19.5.1 Land-use matrix

19.5.1.1 Justification of the decision in favour of a sample-based system

Germany has a range of spatially explicit data available for annual determination of land-use changes. Each of the different sets of data involved has specific advantages and disadvantages, in terms of such aspects as:

- Periodic vs. annual surveys
- Regional surveys vs. national, complete surveys
- Surveys with complete area coverage vs. incomplete surveys with gaps (with incompleteness system-based)
- Focus on surveying (actual) states vs. focus on surveying changes
- Detection of only a single land-use category (such as Forest land)

Owing to the aforementioned differences between sets of data, the following questions arise in connection with any further use of data:

- Do the data take adequate account of all types of land use?
- In their definitions of land-use and land-use-change classes, do the different data records agree among themselves – and with national or international definitions?
- Are the data updated?
- Do their underlying survey methods continue to improve?
- Are any new sources of information available, etc.?

In many cases, development and establishment of GIS-based map systems that are both substantially comprehensive and spatially explicit and complete did not begin until the 1990s. Gradually, the available database was built, and its quality was successively improved. As a result, information about land uses in 1990 – or in periods before or after that year – is not available for every area and every sample point. For that reason, a flexible system has been developed that draws information from the greatest possible number of data sources, for the following purposes:

- Obtaining comprehensive and complete land-use-change information,
- Taking account of the qualitative differences between the different data sources,
- Taking account of the spatial and qualitative development of the data,
- Verifying changes shown via comparison of different data sources,
- Ensuring that the definitions of land-use categories in the time series are consistent, and
- Allowing additional (own) research.

In light of the data available in Germany, only a sample-based system can achieve these purposes, since such a system

- Can verify data sources,
- Can quantify different error sources,
- Considers changes on a point-wise basis, rather than on an area-wise basis. For these reasons, a sample-based system

5. is more robust in handling minor degrees of imprecision, in area-boundary delimitation, that result from differences between different data sources, and
6. does not need to provide 100% accuracy in georeferencing (which cannot be attained anyway) (FULLER 2003).

- Can verify the plausibility of land-use changes, and
- Can integrate data sources that are available only in sample form, meaning that the database can be expanded.

The National Forest Inventory (Bundeswaldinventur – BWI) is such a sample-based system. In place since 1987, it periodically, and very precisely, surveys land-use changes from and to forest land. The BWI network is now being used systematically for determination of all land-use changes. In addition to providing consistency in area calculations, that system achieves full consistency between reporting under the UN Framework Convention on Climate Change and reporting within the framework of Article 3.3/3.4 of the Kyoto Protocol. In May 2011, Germany's decision in favour of a sample-based system was approved by a national workshop for experts. Subsequently, it was presented and discussed in the context of an international workshop for experts. The international experts who took part in that event found the system to be well-suited for current and future use.

19.5.1.2 Justification of the decision in favour of the BWI grid

Some of the 31 LULUCF classes (main land-use classes with no changes to "Other Land") account for very small total areas in Germany. For that reason, a simulation was carried out to determine whether such areas can be surveyed precisely enough with the current nation-wide basic 4km x 4km grid, and with the current (state-) Land-specific higher-resolution 2km x 2km grid areas, or whether the resolution of the BWI network needs to be further increased. To that end, a systematic, simple sampling network with 100m x 100m grid cells was generated. From that network, up to 25 sub-networks were derived for each of the following grid cell sizes: 200m x 200m, 500m x 500m, 1,000m x 1,000m and 2,000m x 2,000m. From a statistical perspective, it is desirable for each of the 31 LULUCF classes to be covered if at all possible. At the same time, no requirement has been imposed to the effect that estimates of the area shares of even the smallest LULUCF classes have to differ significantly from zero. The test results indicate that a 1km x 1km network has the optimal resolution. If one ignores the manner in which the 217,603 BWI cluster-sample points used nationwide are arranged into clusters and higher-resolution areas, then each cluster-sample point represents an area of 1.644km^2 which, in a quadratic arrangement, about corresponds to a network density of 1,280m x 1,280m. From a statistical perspective, the decision in favour of the current BWI 2012 network thus represents a good compromise. The number of sample points actually used is near to the number that one would have with a systematic 1km x 1km network. Since the correlation between the cluster-sample points is smaller than 1, the probability increases that a single cluster will cover several land-use-change classes, and this also applies to clusters covering land-use-change classes with very small area shares. At the same time, the number of extremely small sampling elements is smaller with a cluster sample than it is with a simple sample, if the same number of sample points is used in each case. The sampling error thus has been conservatively estimated.

In light of requirements pertaining to reporting, the BWI 2012 network can be considered optimal, since:

- an internally consistent land-use matrix can be prepared only with the BWI network,

- including a matrix that is consistent with the BWI forest-area estimates,
- and is consistent with the BWI carbon- stock-change estimates.

The approach thus fulfills the stringent quality criteria required especially in the KP-reporting context.

19.5.1.3 Implementation of transition time

Step 1

The following holds for points that originally belonged to a "remaining" category:

Event	Description	Formula	Variables
1st case: no change			
The area remains completely in the "remaining" category		$A_{year} = A_{point}$	A_{year} is the share of the point in the category of the year currently being treated by the calculation algorithm A_{point} is the area represented by the point
2nd case: Change to another land use			
Year within the change period	Increase phase, i.e. the area disappears from the "remaining" category, in keeping with the relevant annual changes	$A_{year} = A_{point} - \left(\frac{A_{point}}{time\ period} * (year - starting\ year)\right)$	**Time period =** Duration of change period **Year =** The year currently being considered via the calculation algorithm **Starting year =** Beginning of the transition time for this point
Year after the change period	The area has already disappeared from the "remaining" category	$A_{year} = o$	
3rd case: Change from another land use to the land use under consideration			
Year earlier, or the same year, as the starting year + 20 years	The area has not yet completely "arrived" in the new "remaining" category	$A_{year} = o$	
Year later than the starting year + 20 years (but still within the blocked period)	Piece by piece, in keeping with the relevant annual changes, the area is gradually added to the new "remaining" category	$A_{year} = A_{point} * \left(\frac{year - (start.year + 20)}{time\ period}\right)$	

Step 2

The following holds for points that belong to a land-use-change category:

Event	Description	Formula	Variables
1st case: Year within the change period (increase phase)			
For each point monitored, total changes throughout the entire change period are broken down into annual-change increments	In other words, in each case the change area increases each year by the relevant annual increment until, at the end of the change period, the change area encompasses the relevant point's entire area.	$A_{year} = A_{point} * \left(\frac{year - start.year}{time\ period}\right)$	
2nd case: Time from the end of the change period until 20 years after the beginning of the change period (plateau phase)			
The area remain in the relevant change category		$A_{year} = A_{point}$	
3rd case: Time from a) 20 years after the beginning of the change period until b) 20 years after the end of the change period (decrease phase)			
Area remaining within the change category	decreases each year by an annual change amount	$A_{year} = A_{point} * \left(\frac{end\ year - year}{time\ period}\right)$	**End year** = the year in which the transition time for the relevant point ends

Step 3

Now, all the area values for the sample points are summed, for each land-use category and each land-use-change category, and for each year, throughout the period 1991 to 2011.

Step 4

Then, the area sums have to be corrected for all years through 2010 to take account of changes from previous years (1970-1990) that are currently within a transition time. The following holds for the "remaining" categories:

$$\sum A_{year,\mathrm{corr.}} = \sum A_{year} + \left((2010 - year) * \sum growth\right)$$

where $\sum A_{year}$ = the sum, as calculated in step 3, of all areas within the land-use / land-use-change category considered, and $\sum growth$ = the area sums, as extrapolated into the period 1970-1990, of the annual changes for all land-use-change categories that, following the end of the transition time, bring about area growth within the land-use category under consideration, for the reference period 1990-2000.

The following holds for the land-use-change categories:

$$\sum A_{year,\mathrm{corr.}} = \sum A_{year} + \left(\sum A_{reference\ year} * (2010 - year)\right)$$

where $\sum A_{reference\ year}$ = the area sum, extrapolated into the period 1970-1990, of annual land-use changes in the area under consideration, for the reference period 1990-2000.

For the years after 2010, the area sums do not have to be corrected, since the transition time for all changes prior to 1990 ends in 2010. Consequently, for subsequent years, the area sums from step 3 are reported.

19.5.2 Determination of emission factors for mineral soils

The following data sources provide the basis for determination of the mean carbon stocks in mineral soils, weighted by climate region, and considered from a complete-coverage perspective, as a function of land use:

7. Soil-overview map (Bodenübersichtskarte; BÜK), scaled to 1:1,000,000 (BÜK 1000; BGR 1995, 1997, 2007)
8. Estimator profiles from the BÜK 1000 n 2.3; FISBo BGR (BGR 2011)
9. "Gehalte an organischer Substanz in Oberböden Deutschlands – Bericht über länderübergreifende Auswertung von Punktinformationen im FISBo BGR" ("Concentrations of organic matter in Germany's topsoils – report on Länder-overarching evaluation of point data in the FISBo BGR") (DÜWEL et al. 2007)
10. Results of the Forest Soil Inventory II (BZE II; vTI 2011)
11. Data records of the Basic Digital Landscape Model (Basis-Digitalen Landschaftsmodell; B-DLM) of the ATKIS® official topographic-cartographic information system, for the years 2000, 2005, 2010 (AdV 2000; 2005; 2010)
12. IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 - Agriculture, Forestry and Other Land Use (IPCC 2006)

The emission factors for the various land-use categories were determined with the help of a fallback system. This means that

- where specifically collected soil data are available for a given land-use category (BZE II data; data from the BGR study (DÜWEL et al. 2007)), those data have been used, either by themselves or in combination with data from the BÜK 1000, for determination of the soil carbon stocks in the relevant categories.
- Where such data are not available, determination has been based on estimates from the BÜK 1000.

In keeping with the different data situations for the various land-use categories, the area-weighted, use-specific and soil-specific carbon stocks were determined separately for the various categories.

19.5.2.1 Forest Land

The mean value, as determined in Forest Soil Inventory II (BZE II), for carbon stocks in mineral soils, to a soil depth of 30 cm, was assigned to areas that the National Forest Inventory treats as "forest land", within the meaning of the definition of the Federal Forest Act and of the IPCC definition chosen by Germany.

The BZE II, a systematic sampling survey, was carried out for the purpose of collecting basic information about the condition of forest soils and the changes taking place in them. Its aims included collecting data on key soil characteristics. To that end, the various Länder intensively studied the soil and site characteristics at a total of some 2,000 points distributed throughout a complete-coverage 8 x 8 km grid. The effort was carried out in accordance with standardised work instructions that had been developed and defined via a cooperative effort of the Federal Government and the Länder (cf. Chapters 7.2.2.2 and 7.2.4.4).

Upon being completed, the work made it possible, for the first time, to base LULUCF inventory calculations (in the present case, for the 2013 Submission) on the final results of the Forest Soil Inventory II (BZE II) relative to soil carbon stocks and their rate of change.

That survey found the mean carbon stocks for mineral soils, to a depth of 30 cm, to be 61.1 ± 3.4 Mg ha^{-1} for the year 2006. The mean annual rate of change determined for the period between the two soil inventories amounts to 0.27 ± 0.18 Mg ha^{-1} a^{-1} (TI-WO, oral communication; cf. Chapter 7.2.2.2). To determine the carbon stocks of forest mineral soils for the various years covered by the report, the mean rate of change was added to / deducted from the average mineral-soil carbon stocks for all of Germany's forest soils determined for the year 2006. This yielded the following time series for the report period beginning in 1990 (Table 364):

Table 364: Mean carbon stocks [to 30 cm soil depth, in MgC ha^{-1} ± 1.96 * standard error] in Germany's mineral forest soils, 1990 – 2011

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Carbon stocks [Mg C ha^{-1}]	56.78 ± 3.10	57.05 ± 3.11	57.32 ± 3.13	57.59 ± 3.14	57.86 ± 3.16	58.13 ± 3.17	58.40 ± 3.18	58.67 ± 3.20	58.94 ± 3.21	59.21 ± 3.23	59.48 ± 3.24
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Carbon stocks [Mg C ha^{-1}]	59.75 ± 3.26	60.02 ± 3.27	60.29 ± 3.29	60.56 ± 3.30	60.83 ± 3.32	61.10 ± 3.33	61.37 ± 3.35	61.64 ± 3.36	61.91 ± 3.38	62.18 ± 3.39	62.45 ± 3.41

In each case, the value shown for a year serves as the basis for all relevant calculations in the framework of inventory preparation.

19.5.2.2 The land-use categories cropland, grassland, wetlands, settlements and other land

19.5.2.2.1 General information relative to 5.B - 5.F

The BÜK 1000 soil overview map divides Germany's soils into 71 different characteristic soil categories / legend units. Those units, known as "dominant soil associations" (DSA), comprise dominant and secondary soil types. They are characterised on the basis of dominant soil types that are representative for the areas in question and that have been assigned selected soil profiles. Along with descriptive parameters, the profile descriptions include information about key soil characteristics, such as humus and nitrogen content and physical soil parameters (DÜWEL et al. 2007). For example, the data set on which the present calculations are based includes derived specific measurements for carbon (C_t), inorganic carbon (C_i), nitrogen (N_t), rock content and raw $density_{dry}$, as well as ranges for those values, in the form of class information pursuant to KA 4 (AG BODEN 1994).

The mean carbon stocks of a dominant soil association can be calculated from these data by multiplying the carbon content by soil mass and correcting for skeleton and carbonate content. For determination of the mean carbon stocks in mineral soils of the categories cropland, grassland, wetlands, settlements and other land, the BÜK 1000 was merged with the Basis-DLM (Chapter 7.1.3.2.1). The use-specific area data and soil-characteristics data of the BÜK 1000 (bulk density, skeleton content) were combined with the organic-carbon data produced by the BGR study "Gehalte organischer Substanz in Oberböden Deutschlands: Länderübergreifende Auswertung von Punktinformationen im FISBo BGR" ("Concentrations of organic matter in Germany's topsoils – report on Länder-overarching evaluation of point data in the FISBo BGR") (DÜWEL et al. 2007).

DÜWEL et al. 2007 list typical concentrations of organic matter (C_{org}) and humus in Germany's topsoils, for a total of 15 groups of soil parent material and 4 climate zones.

Those listings are based on complete-coverage evaluation of data for ca. 14,000 profiles, broken down by use (cropland, grassland and forest) and by climate region.

In addition, that study assigns the 71 legend units of the BÜK, on the basis of their pedo-lithological characteristics, to those 15 groups of soil parent material (DÜWEL et al. 2007), with the result that those groups serve as links to the legend-unit information of the BÜK 1000.

19.5.2.2.2 Cropland

Cropland with annual crops

For cropland with annual crops, the BGR study asserts that its values are valid to a soil depth of 30 cm. As a result, it was possible to apply the carbon-content data from the BGR study to all dominant soil associations of the BÜK 1000.

Table 365: Area [ha], mean area-based carbon stocks [Mg C ha^{-1}] and pertinent uncertainties (upper and lower bounds in %) for croplands in Germany with annual crops

Mineral soils	Carbon stocks [Mg C ha^{-1}]	Bounds	
		upper [%]	lower [%]
Cropland$_{annual}$	59.77	50.07	32.67

Cropland with perennial crops

With regard to croplands with perennial crops (such as fruit trees, grapevines), it was assumed that such areas are not plowed and are covered to a degree of 75 % with grass. For that reason, calculations of mean carbon stocks for such areas were based on the profile characteristics for grassland. The relevant approach is described in Chapter 19.5.2.2.3. Table 366 shows the values obtained for such areas.

Table 366: Area [ha], mean area-based carbon stocks [Mg C ha^{-1}] and pertinent uncertainties (upper and lower bounds in %) for croplands in Germany with perennial crops

Mineral soils	Carbon stocks [Mg C ha-1]	Bounds	
		upper [%]	lower [%]
Cropland with perennial crops	72.64	68.18	46.40

Carbon stocks for cropland

The mean carbon stocks for mineral soils in cropland are obtained as follows:

$$C_{Min\ cropland} = \frac{(C_{croplandannual} * A_{crop.annual} + C_{crop.perennial} * A_{crop.perennial})}{A_{crop.annual} + A_{crop.perennial}}$$

$C_{min\_cropland}$: Mean area-related carbon stocks for all of Germany's mineral cropland soils [Mg ha^{-1}]
$C_{cropland\_annual}$: Mean area-related carbon stocks for all of Germany's mineral cropland soils with annual crops [Mg ha^{-1}]
$C_{cropland\_perennial}$: Mean area-related carbon stocks for all of Germany's mineral cropland soils with perennial crops [Mg ha^{-1}]
$A_{cropland\_annual}$: Area of mineral-soil lands in Germany under cropland with annual crops [ha]
$A_{cropland\_perennial}$: Area of mineral-soil lands in Germany under cropland with perennial crops [ha]

Table 367 shows the mean carbon stocks, for mineral soils under cropland, that have been used as a basis for all pertinent calculations within the inventory.

Table 367: Mean area-based carbon stocks [Mg C ha^{-1}] and pertinent uncertainties (upper and lower bounds in %) for croplands in Germany

Mineral soils	Carbon stocks [Mg C ha^{-1}]	Bounds		Distribution function
		upper [%]	lower [%]	
Cropland	60.03	50.50	32.99	Log-normal

19.5.2.2.3 Grassland

The land-use category "grassland" comprises the sub-categories "grassland in a strict sense" and "woody grassland" (cf. Chapter 7.1.4). Calculations for both sub-categories are carried out on the basis of the same data. The differences between the carbon stocks of these sub-categories thus result only from differences in spatial distribution of land uses and, thus, differences in percentage shares of soil-parent-material groups and climate zones.

For grassland areas, the BGR study asserts that its values are valid to a depth of 10 cm (DÜWEL et al. 2007). The soil carbon stocks were correlated with the characteristics of the mineral-soil profiles of the BÜK 1000 via relationships with soil-parent-material groups, as follows: The soil-carbon-stocks data of the BGR study (DÜWEL et al. 2007) were assigned to the uppermost horizon, in keeping with the thickness as listed (maximum thickness of 10 cm). For that horizon, the bulk density and the skeleton content were taken from the BÜK 1000, as were the data for all characteristics and thicknesses of deeper horizons and depth layers, to a depth of 30 cm. The relevant results are shown in Table 368.

Table 368: Mean area-based carbon stocks [Mg C ha^{-1}] and pertinent uncertainties (upper and lower bounds in %) for grasslands in Germany

Mineral soils	Carbon stocks [Mg C ha^{-1}]	Bounds		Distribution function
		upper [%]	lower [%]	
Grassland in a strict sense	77.43	77.87	45.93	Log-normal
Woody grassland	73.18	83.27	42.94	Log-normal

19.5.2.2.4 Terrestrial wetlands, settlements and other land

The mean carbon stocks of mineral soils in terrestrial wetlands (the "wetlands" category is subdivided into terrestrial wetlands and waters) were determined via a procedure similar to that used for grassland. Consequently, the procedure is described in Chapter 19.5.2.2.3. Differences in carbon stocks, between grassland and terrestrial wetlands, result solely from differences in spatial distribution of category areas.

The grassland carbon-stock values for A horizons were also assigned to soils under settlements and other land. At the same time, it was assumed that such soils have been disturbed and are not as deeply developed as are grassland sites. Therefore, the horizons of middle dominant profiles and of forest soils were assumed to apply. For a total of 44 of the 71 dominant soil profiles, this approach leads to changes in carbon stocks in comparison with grassland.

The mean carbon-stocks values are listed in Table 369.

Table 369: Mean area-based carbon stocks [Mg C ha^{-1}], and pertinent uncertainties (upper and lower bounds in %), in mineral soils under terrestrial wetlands, settlements and other land

Mineral soils	Carbon stocks [Mg C ha^{-1}]	Bounds upper [%]	lower [%]	Distribution function
Terrestrial wetlands	73.99	52.48	43.85	Log-normal
Settlements	58.67	84.97	45.11	Log-normal
Other land	55.60	92.86	44.56	Log-normal

The emission factors derived from these mean carbon stocks, which are weighted by climate region, land use and areas, are listed in Table 235 and Table 236 in Chapter 7.1.5. The emission factors are listed with statistical indexes, for description of uncertainties, in Table 283 and Table 288 in Chapter 7.5.5 and 7.6.5, respectively.

19.5.2.2.5 Uncertainties

Since individual profiles do not support conclusions relative to the heterogeneity of soil parameters within the legend units (DÜWEL et al. 2007), relevant extreme constellations of class values were constructed for purposes of estimating the potential ranges of carbon and nitrogen stocks in dominant soil associations (DSA) – and, thus, for purposes of determining the relevant uncertainties:

DSA carbon stocks$_{maximum}$: C_{org} content$_{maximum}$, bulk density$_{maximum}$, skeleton content$_{minimum}$

DSA carbon stocks$_{minimum}$: C_{org} content$_{minimum}$, bulk density$_{minimum}$, skeleton content$_{maximum}$

The values for bulk density, skeleton content and carbon stocks in horizons for which no corresponding values were available from the topsoil study of the BGR (DÜWEL et al. 2007) were derived, with the help of KA 4, in accordance with pertinent class information from the dominant-profile descriptions in the BÜK 1000 (BGR 1997).

The so-determined minimum and maximum carbon stocks form the relevant upper and lower boundaries and, in combination with the location scale, show the typical steep-left distribution that is typical for such data.

The carbon-stocks data from the BGR study (DÜWEL et al. 2007) are backed by descriptive statistics. The values for the 25th and 75th percentiles, i.e. the upper and lower threshold values for the carbon stocks, were derived from those statistics.

19.5.2.3 Planned improvements

The values listed in the above chapters are the best data now available in complete-coverage form. Major inventories for determination of the carbon and nitrogen stocks in mineral soils have been carried out, and are being carried out, in Germany, with a view to improving such data:

- The Forest Soil Inventory II (BZE II Wald), for all forest soils (the analysis has been completed) (cf. Chapter 7.2.8.2); the final results were used, for the first time, in the present Submission
- The Agricultural Soil Inventory (Bodenzustandserhebung Landwirtschaft), for cropland and grassland soils (cf. Chapter 7.3.8)

Those two major inventories cover about 84 % of Germany's total surface area, or about 88 % of its mineral-soil area.

- The results of the Agricultural Soil Inventory are gradually being integrated within the LULUCF inventory, for purposes of determining precise emission factors.

19.5.3 Derivation of calculation figures (emission factors) for biomass

19.5.3.1 Perennial crops

In the framework of the research project "Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth" ("Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen"), country-specific carbon-stock data are being collected for orchards, vineyards and Christmas-tree plantations in Germany. From that data, carbon stocks are being derived for both above-ground and below-ground biomass.

19.5.3.1.1 Fruit trees

In the framework of the above-mentioned research project, a total of 100 fruit trees (91 apple trees, 6 cherry trees and 3 plum trees) of different ages and varieties, from Germany's two main fruit-cultivation regions ("Altes Land" in northern Germany and the Lake Constance region in southern Germany), were destructively tested. In addition, the following data was collected from 210 living apple trees:

- Diameter at trunk base
- Diameter at breast height
- Height

A regression procedure applied to all collected data yielded a highly significant link between tree age and mean trunk diameter (=(diameter at trunk base + diameter at breast height)/2):

Equation 49: Regression equation for estimating mean trunk diameter [cm] of apple trees, as a function of tree age [a]

$$S_{mean\ apple} = 19.1645 * \left(1 - e^{(-0.0357x)}\right)$$

S_{mean_apple}: Mean trunk diameter, apple tree [cm]
x: Tree age [a]
Statistical indexes:
r^2 =0.5855
n = 300
p < 0.0001
Standard error of estimation = 1.4318 ≙ 19.72 %

Equation 50: Regression equation for estimating mean trunk diameter [cm] of cherry and plum trees, as a function of tree age [a]

$$S_{mean\ cherry/plum} = 53.8165 * \left(1 - e^{(-0.0252x)}\right)$$

$S_{mean\_cherryplum}$: Mean trunk diameter, cherry/plum tree [cm]
x: Tree age [a]
Statistical indexes:
r^2 =0.9486
n = 9
p < 0.0001
Standard error of estimation = 1.2963 ≙ 11.14 %

Via destructive testing, the masses, water content and carbon content of the fruit trees were separately determined for the compartments above-ground biomass (trunk and branches) and below-ground biomass (roots). The ages of the so-tested apple trees were 6 and 9, while the ages of the cherry and plum trees were 4, 12 and 14.

The trees' biomasses were adjusted to take account for the water content measured during drying at 105°C and then, to determine the carbon stocks of the trees' parts / whole trees, were multiplied by the carbon-content percentage of the $biomass_{dry}$.

From the resulting data, highly significant relationships were derived between mean trunk diameter and carbon stocks of the entire plant [Equation 51 (apple); Equation 53 (cherry/plum)] and between mean trunk diameter and carbon stocks of the above-ground biomass [Equation 52 (apple); Equation 54 (cherry/plum)].

Equation 51: Regression equation for estimating carbon stocks of the entire biomass of apple trees, as a function of mean trunk diameter

$$\ln C_{total\ apple} = -2.1774 + 1.7565 * \ln x$$

ln C_{total_apple}: Logarithm for carbon stocks in total apple-tree biomass [kg $plant^{-1}$]
ln x: Logarithm for mean trunk diameter [cm]
Statistical indexes:
r^2 =0.8011
n = 90
$p < 0.0001$
Standard error of estimation = 0.1915

Equation 52: Regression equation for estimating carbon stocks in the above-ground biomass of apple trees, as a function of mean trunk diameter

$$\ln C_{above\ apple} = -2.7521 + 1.9533 * \ln x$$

ln C_{above_apple}: Logarithm for carbon stocks in above-ground plant parts [kg $plant^{-1}$]
ln x: Logarithm for mean trunk diameter [cm]
Statistical indexes:
r^2 =0.9321
n = 90
$p < 0.0001$
Standard error of estimation = 0.1953

Equation 53: Regression equation for estimating carbon stocks of the entire biomass of cherry and plum trees, as a function of mean trunk diameter

$$C_{total\ cherry/plum} = 0.0369\ x^{2.2725}$$

$C_{total\_cherryplum}$: Carbon stocks of entire cherry/plum tree biomass [kg $plant^{-1}$]
x: Mean trunk diameter, cherry/plum tree [cm]
Statistical indexes:
r^2 =0.9608
n = 9
$p < 0.0001$
Standard error of estimation = 1.8582 (15 %)

Equation 54: Regression equation for estimating carbon stocks in the above-ground biomass of cherry and plum trees, as a function of mean trunk diameter

$$C_{above\ cherry/plum} = 0.0238\ x^{2.3586}$$

$C_{above\_cherryplum}$: Carbon stocks of above-ground cherry/plum tree biomass [kg $plant^{-1}$]
x: Mean trunk diameter, cherry/plum tree [cm]
Statistical indexes:
r^2 =0.9321
n = 9
$p < 0.0001$
Standard error of estimation = 2.025 (20.31 %)

For each variety, the difference between the carbon stocks of the entire plant and the stocks of its above-ground parts yields the root C stocks (cf. Equation 55).

Equation 55: Estimation of the carbon stocks in the root mass of fruit trees of the same variety

$$C_{below} = C_{total} - C_{above}$$

C_{below}: Below-ground carbon stocks [kg plant^{-1}]
C_{total}: Carbon stocks of entire plant [kg plant^{-1}]
C_{above}: Above-ground carbon stocks [kg plant^{-1}]

The absolute C-stocks of all of Germany's fruit trees were calculated with the help of the results of the last exhaustive statistical survey of fruit cultivation (STATISTISCHES BUNDESAMT 2007). On the basis of that survey's results, the Federal Statistical Office determined total numbers of apple, pear, sweet cherry / sour cherry, plum / prune, mirabelle and greengage trees, in different age classes, as well as the areas under cultivation with trees in the various age classes (cf. Table 370).

Table 370: Results of the last exhaustive statistical survey of fruit trees (2007) carried out by the Federal Statistical Office (STATISTISCHES BUNDESAMT 2007)

Age class		Fruit trees, total	Apple	Pear	Sweet cherry	Sour cherry	Plum, prune	Mirabelle, greengage
1	Area [ha]	6,337	2,610	558	1,669	569	561	89
	Number [n]	77,908,784	1,959,650	374,357	349,898	309,888	174,950	25,268
1-4	Area [ha]	1,314	1,283	30	125	9	142	8
	Number [n]	3,493,397	3,460,242	51,926	92,723	6,720	98,538	4,372
5-9	Area [ha]	7,403	5,159	252	859	330	713	90
	Number [n]	15,410,632	13,645,705	466,895	563,239	234,410	452,011	48,372
10-14	Area [ha]	10,606	7,275	350	783	866	1,186	146
	Number [n]	19,740,123	17,334,084	581,720	458,483	579,748	722,909	63,179
15-19	Area [ha]	10,321	7,603	454	763	372	1,057	71
	Number [n]	19,602,081	17,527,552	831,342	322,364	260,231	632,286	28,306
20-24	Area [ha]	8,599	5,995	338	764	791	621	91
	Number [n]	12,899,071	11,365,689	443,150	219,989	543,127	290,899	36,217
25	Area [ha]	3,333	1,837	119	519	507	284	66
	Number [n]	3,348,345	2,569,271	126,438	143,442	351,826	130,916	26,452

To determine the total carbon stocks in fruit trees, the carbon stocks – either measured or determined via regression – in the above-ground and below-ground biomass of individual trees of each age class were multiplied by the relevant total numbers of trees. In the process, the values obtained for apple trees were also assigned to pear trees, while those obtained for cherry and plum trees were also assigned to prune, mirabelle and greengage trees.

The area-related emission factors for the various tree varieties were calculated, in each case, via division by the relevant area under cultivation.

Table 371: Area-related carbon stocks [Mg ha^{-1}] (range, or ± half of the 95 % confidence interval) in the biomass of Germany's fruit trees

Fruit tree	Carbon stocks [Mg C ha^{-1}]			Area [ha]
	Bio_{above}	Bio_{below}	Bio_{total}	
Apple	7.50 (2.2 – 18.6)	1.21 (0.5 – 2.5)	8.70 (2.5 – 21.5)	31,762
Pear	4.70 (1.4 – 11.7)	0.73 (0.3 – 1.5)	5.43 (1.6 – 13.4)	2,101
Sweet cherry	8.44 ± 3.87	1.47 ± 0.42	9.91 ± 3.70	5,482
Sour cherry	25.66 ± 11.77	4.10 ± 1.20	29.76 ± 11.12	3,444
Plum/prune	13.01 ± 5.97	2.36 ± 0.69	15.37 ± 5.74	4,564
Mirabelle/greengage	12.46 ± 5.72	2.06 ± 0.60	14.53 ± 5.43	561

19.5.3.1.2 Christmas-tree plantations

In Germany today, Christmas trees are cultivated on a total of about 14,000 – 15,000 ha of agricultural land outside of forests (STATISTISCHES BUNDESAMT 2007). With an average planting density of 6,000 plants per ha, about 50 t of biomass (dry) are produced per ha (PÖPKEN 2011). Of that quantity, 45.6 % is root mass. That value was obtained from an overview study of MOKANY et al. (2006), who derived root / shoot ratios, for numerous different types of vegetation, as a function of biomass, climate parameters and site parameters. Their root / shoot ratios were adopted as default values in the 2006 IPCC Guidelines (IPCC 2006).

Table 372: Area-related carbon stocks [Mg ha^{-1}] (± half of the 95 % confidence interval) of biomass of Germany's Christmas trees (in plantations)

Tree	Carbon stocks [Mg C ha^{-1}]			Area [ha]
	Bio_{above}	Bio_{below}	Bio_{total}	
Christmas trees	17.3 ± 8.6	5.2 ± 2.6	22.5 ± 11.3	14,666

19.5.3.1.3 Grapevines (wine)

In the project "Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth" ("Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen") (PÖPKEN 2011), a total of 74 grapevines were destructively tested for the purpose of deriving a country-specific mean value for carbon stocks of grapevines. The ages of the vines tested were 15 and 25 (years). In the testing, the vines' weights, and the water and carbon content of the above-ground and below-ground plant parts, were determined (PÖPKEN 2011). The carbon stocks of grapevines and of parts of vines are calculated via Equation 56.

Equation 56: Calculation of the carbon stocks in grapevines

$$C_{vine} = C_{cont\ above} * M_{105\ bio\ above} + C_{cont\ below} * M_{105\ bio\ below} + M_{cut\ fresh} * WC_{\emptyset} * C_{\emptyset}$$

C_{vine}: Carbon stocks of one grapevine [kg]
$C_{cont\ above}$: Carbon content of the above-ground vine [by weight]
$M_{105\ bio\ above}$: Dry biomass of the vine [kg]
$C_{cont\ below}$: Carbon content of below-ground biomass [by weight]
$M_{105\ bio\ below}$: Dry biomass of below-ground biomass [kg]
$M_{cut\ fresh}$: Fresh weight of cut wood, per plant [kg]

The annual quantity of cut wood was not taken into account in determination of the biomass of grapevines, since the annual growth is basically the same as the quantity cut, and thus a temporary equilibrium occurs. In the previous submission, cut-wood quantities were erroneously included in calculations of biomass carbon stocks of grapevines. In the present submission, the relevant values have been corrected accordingly.

Since vineyards in Germany contain an average of 4,000 grapevines per ha (PÖPKEN 2011), the carbon stocks per area unit (ha) were calculated by multiplying the C stocks of individual plant compartments / total plants by 4,000. The absolute carbon stocks are calculated by multiplying the pertinent emission factors by the total vineyard area. The resulting values are shown in Table 373.

Table 373: Area-related carbon stocks [Mg ha^{-1}] (± half of the 95 % confidence interval) in grapevine biomass in Germany

Woody plant	Carbon stocks [Mg C ha^{-1}]			Area [ha]
	Bio_{above}	Bio_{below}	Bio_{total}	
Grapevine	1.12 ± 0.06	0.54 ± 0.04	1.66 ± 0.09	102,026

19.5.3.1.4 Mean carbon stocks in the biomass of woody plants cultivated on cropland

For calculation of the mean area-related carbon stocks in woody plants cultivated on cropland, the absolute carbon stocks of the various crop types were calculated, by compartments, summed and then divided by the relevant area. The results are shown in Table 374.

Table 374: Determination of area-weighted carbon stocks, in absolute [Mg] and area-related [Mg ha^{-1}] formats, for woody plants cultivated on cropland in Germany (carbon stocks 2 ± half of the 95 % confidence interval)

Fruit trees	Carbon stocks in Mg			Carbon stocks in Mg ha^{-1}			ha
	Bio_{above}	Bio_{below}	Bio_{total}	Bio_{above}	Bio_{below}	Bio_{total}	Area
Apple	238,132	38,300	276,432	7.50	1.21	8.70	31,762
Pear	9,880	1,531	11,411	4.70	0.73	5.43	2,101
Sweet cherry	46,261	8,068	54,328	8.44	1.47	9.91	5,482
Sour cherry	88,374	14,135	102,508	25.66	4.10	29.76	3,444
Plum / prune	59,385	10,763	70,148	13.01	2.36	15.37	4,564
Mirabelle / greengage	6,992	1,158	8,150	12.46	2.06	14.53	561
Christmas trees	253,224	76,761	329,985	17.27	5.23	22.50	14,666
Grapevines	114,766	54,600	169,366	1.12	0.54	1.66	102,026
Total	**817,013 ± 367,831**	**205,315 ± 67,349**	**1,022,328 ± 432,101**				**164,606**
Area-weighted carbon-stocking rates for cultivated trees (carbon stocks 2)				**4.96 ± 2.23**	**1.25 ± 0.41**	**6.21 ± 2.63**	

Since in Germany woody plants cultivated on cropland are always mixed with grass, the total biomass carbon stocks per area unit for such areas are calculated via Equation 57:

Equation 57:

$$C\ stocks_{cro2} = C\ stocks_{fruit\ trees} + biomass_{grassland} * 0.75$$

The factor for grassland biomass arises in that only the areas directly under the woody plants concerned are kept free of vegetative cover. In orchards and vineyards, grass grows only between rows of the cultivated woody plants. The value for grassland ("in a strict sense") is used as a basis for determining such biomass. Table 375 shows the carbon stocks for areas with woody plants cultivated on cropland.

Table 375: Area-weighted mixed value for carbon stocks [Mg ha^{-1}] of woody plants cultivated on cropland (± half of the 95 % confidence interval)

Woody plant	Carbon stocks [Mg C ha^{-1}]		
	Bio_{above}	Bio_{below}	Bio_{total}

Areas with woody plants cultivated on cropland	11.23 ± 2.91	8.23 ± 2.24	2.99 ± 1.31

19.5.4 Uncertainties

The uncertainties for the German LULUCF inventory were determined in accordance with the provisions of the IPCC (2000; IPCC – Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories). The uncertainty statistics commonly given for a normal distribution include the 95 % confidence interval, ± half of the 95 % confidence interval and 1.96 x the standard error, in % of the mean.

In the case of non-symmetric distributions – normally, data with log-normal distributions, as in the present case – the uncertainties are expressed as percentages of the position scale, and as upper and lower bounds. As a rule, they are determined via the quantiles (p = 0.025 and p = 0.975). Pursuant to the IPCC (2000), in such cases propagation of uncertainties is to be calculated via a conservative estimation in which the distance between the extreme value of the sloping axis section and the position scale is defined as half of the 95 % confidence interval.

Table 376 shows the results of uncertainties calculation for all pools and sub-categories of the German LULUCF inventory. The total uncertainty of the German LULUCF inventory is thus 17.36 % with respect to the emissions level and 4.95 % with respect to the emissions trend. The land-use category Forest Land remaining Forest Land contributes significantly to the total emissions and total uncertainty in the LULUCF inventory. The mineral-soils, biomass, litter and dead-wood pools contribute significantly to that inventory's total uncertainty. Mineral soils, with an emission-factor uncertainty of 65 % and CO_2 emissions of -10,280 Gg CO_2-eq., account for the largest contribution to that uncertainty, followed by litter, whose contribution depends largely on the level of its emission factor (125 %) and of its biomass quantity (due to the absolute size of the pertinent sink; -16,534 Gg CO_2-eq.). The largest contribution to the LULUCF inventory's total uncertainty comes from organic soils in the final-use categories of the cropland and grassland i.s.s. categories, due to the absolute level of the pertinent emissions (34,088 Gg CO_2-eq.) and to the uncertainty of the relevant emission factor (50 %). In all other land-use and transition categories, the only significant contributions to the inventory's total uncertainty come from uncertainties and emissions/removals in connection with biomass in the sub-category woody grassland. All other pools and categories have only a marginal influence.

Table 376: Uncertainty Calculation for the German GHG Emissions from Sector 5.B - 5.F (LULUCF)

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category	Pool	Gas	Base year emissions [CO_2- eq.]	Year 2011 emissions [CO_2- eq.]	Activity data uncertainty (half the 95% confidence interval)	Emission factor uncertainty (half the 95% confidence interval)	Combined uncertainty (half the 95% confidence interval)	Combined uncertainty as % of total national emissions in year 2011	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			[Gg a^{-1}]	[Gg a^{-1}]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
5.A.1 Forest Land remaining Forest Land	Mineral soil	CO_2	-9,905.41	-10,280.17	1.34	65.33	65.35	7.58	0.03	0.07	1.86	0.14	1.87
5.A.1 Forest Land remaining Forest Land	Organic soil	CO_2	497.30	562.91	1.34	180.88	180.89	1.15	0.00	0.00	0.32	0.01	0.32
5.A.1 Forest Land remaining Forest Land	EF Biomass	CO_2	-63,110.69	-16,533.63	1.34	13.37	13.44	2.51	0.17	0.12	2.30	0.23	2.31
5.A.1 Forest Land remaining Forest Land	EF litter	CO_2	1,870.90	1,945.13	1.34	125.40	125.41	2.75	0.01	0.01	0.68	0.03	0.68
5.A.1 Forest Land remaining Forest Land	EF dead wood	CO_2	-3,507.86	-3,647.03	1.34	60.43	60.45	2.49	0.01	0.03	0.61	0.05	0.62
5.A.1 Forest Land remaining Forest Land	Organic soil	N_2O	58.30	65.99	1.34	300.00	300.00	0.22	0.00	0.00	0.06	0.00	0.06
5.A.1 Forest Land remaining Forest Land	Forest fires / wildfires	N_2O	2.08	0.30	15.00	35.00	38.08	0.00	0.00	0.00	0.00	0.00	0.00
5.A.1 Forest Land remaining Forest Land	Forest fires / wildfires	CH_4	9.08	1.32	15.00	35.00	38.08	0.00	0.00	0.00	0.00	0.00	0.00
5.A.2.1 Cropland converted to Forest Land	Mineral soil	CO_2	184.58	19.99	9.75	24.91	26.75	0.01	0.00	0.00	0.02	0.00	0.02
5.A.2.1 Cropland converted to Forest Land	Organic soil	CO_2	14.25	8.98	9.75	180.88	181.14	0.02	0.00	0.00	0.00	0.00	0.00
5.A.2.1 Cropland converted to Forest Land	EF Biomass	CO_2	-2,520.62	-1,702.80	9.75	10.52	14.34	0.28	0.00	0.01	0.01	0.17	0.17
5.A.2.1 Cropland converted to Forest Land	EF litter	CO_2	-304.76	-181.15	9.75	3.64	10.40	0.02	0.00	0.00	0.00	0.02	0.02
5.A.2.1 Cropland converted to Forest Land	EF dead wood	CO_2	0.00	0.00	9.75	6.12	11.51	0.00	0.00	0.00	0.00	0.00	0.00
5.A.2.2 Grassland i.s.s. converted to Forest Land	Mineral soil	CO_2	697.31	312.80	10.93	43.17	44.53	0.16	0.00	0.00	0.04	0.03	0.05
5.A.2.2 Grassland i.s.s. converted to Forest Land	Organic soil	CO_2	23.54	13.20	10.93	180.88	181.21	0.03	0.00	0.00	0.00	0.00	0.00
5.A.2.2 Grassland i.s.s. converted to Forest Land	EF Biomass	CO_2	-2,423.24	-1,465.04	10.93	17.66	20.77	0.34	0.00	0.01	0.01	0.16	0.16
5.A.2.2 Grassland i.s.s. converted to Forest Land	EF litter	CO_2	-295.13	-156.07	10.93	3.64	11.52	0.02	0.00	0.00	0.00	0.02	0.02
5.A.2.2 Grassland i.s.s. converted to Forest Land	EF dead wood	CO_2	0.00	0.00	10.93	6.12	12.52	0.00	0.00	0.00	0.00	0.00	0.00
5.A.2.2 Woody Grassland converted to Forest Land	Mineral soil	CO_2	347.84	132.50	12.67	45.00	46.75	0.07	0.00	0.00	0.03	0.02	0.03
5.A.2.2 Woody Grassland converted to Forest Land	Organic soil	CO_2	9.20	4.58	12.67	180.88	181.33	0.01	0.00	0.00	0.00	0.00	0.00
5.A.2.2 Woody Grassland converted to Forest Land	EF Biomass	CO_2	-685.28	-763.23	12.67	170.81	171.28	1.47	0.00	0.01	0.40	0.10	0.41
5.A.2.2 Woody Grassland converted to Forest Land	EF litter	CO_2	-176.68	-83.04	12.67	3.64	13.18	0.01	0.00	0.00	0.00	0.01	0.01
5.A.2.2 Woody Grassland converted to Forest Land	EF dead wood	CO_2	0.00	0.00	12.67	6.12	14.07	0.00	0.00	0.00	0.00	0.00	0.00
5.A.2.3 Terr. Wetlands converted to Forest Land	Mineral soil	CO_2	51.29	19.22	32.93	28.57	43.59	0.01	0.00	0.00	0.00	0.01	0.01
5.A.2.3 Terr. Wetlands converted to Forest Land	Organic soil	CO_2	34.37	16.45	32.93	180.88	183.86	0.03	0.00	0.00	0.01	0.01	0.01
5.A.2.3 Terr. Wetlands converted to Forest Land	EF Biomass	CO_2	-321.49	-203.33	32.93	120.08	124.51	0.29	0.00	0.00	0.00	0.07	0.07
5.A.2.3 Terr. Wetlands converted to Forest Land	EF litter	CO_2	-47.56	-21.48	32.93	125.40	129.65	0.03	0.00	0.00	0.01	0.01	0.01
5.A.2.3 Terr. Wetlands converted to Forest Land	EF dead wood	CO_2	0.00	0.00	32.93	6.12	33.49	0.00	0.00	0.00	0.00	0.00	0.00

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category	Pool	Gas	Base year emissions [CO_2- eq.] [Gg a^{-1}]	Year 2011 emissions [CO_2- eq.] [Gg a^{-1}]	Activity data uncertainty (half the 95% confidence interval) [%]	Emission factor uncertainty (half the 95% confidence interval) [%]	Combined uncertainty (half the 95% confidence interval) [%]	Combined uncertainty as % of total national emissions in year 2011 [%]	Type A sensitivity [%]	Type B sensitivity [%]	Uncertainty in trend in national emissions introduced by emission factor uncertainty [%]	Uncertainty in trend in national emissions introduced by activity data uncertainty [%]	Uncertainty introduced into the trend in total national emissions [%]
5.A.2.3 Waters converted to Forest Land	**Mineral soil**	**CO_2**	**0.00**	**0.00**	**70.08**	**5.45**	**70.29**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
5.A.2.3 Waters converted to Forest Land	**Organic soil**	**CO_2**	**0.30**	**0.17**	**70.08**	**180.88**	**193.98**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
5.A.2.3 Waters converted to Forest Land	EF Biomass	CO_2	-27.36	-15.35	70.08	23.80	74.01	0.01	0.00	0.00	0.00	0.01	0.01
5.A.2.3 Waters converted to Forest Land	EF litter	CO_2	-3.06	-1.62	70.08	125.40	143.65	0.00	0.00	0.00	0.00	0.00	0.00
5.A.2.3 Waters converted to Forest Land	EF dead wood	CO_2	0.00	0.00	70.08	6.12	70.35	0.00	0.00	0.00	0.00	0.00	0.00
5.A.2.4 Settlements converted to Forest Land	Mineral soil	CO_2	58.02	-2.07	21.16	41.25	46.36	0.00	0.00	0.00	0.01	0.00	0.01
5.A.2.4 Settlements converted to Forest Land	Organic soil	CO_2	5.20	3.08	21.16	180.88	182.12	0.01	0.00	0.00	0.00	0.00	0.00
5.A.2.4 Settlements converted to Forest Land	EF Biomass	CO_2	-931.81	-644.26	21.16	124.41	126.19	0.92	0.00	0.00	0.04	0.14	0.15
5.A.2.4 Settlements converted to Forest Land	EF litter	CO_2	-124.45	-69.61	21.16	125.40	127.17	0.10	0.00	0.00	0.01	0.01	0.02
5.A.2.4 Settlements converted to Forest Land	EF dead wood	CO_2	0.00	0.00	21.16	6.12	22.02	0.00	0.00	0.00	0.00	0.00	0.00
5.A.2.5 Other Land converted to Forest Land	Mineral soil	CO_2	0.74	-2.36	88.07	43.83	98.37	0.00	0.00	0.00	0.00	0.00	0.00
5.A.2.5 Other Land converted to Forest Land	Organic soil	CO_2	0.18	0.20	88.07	180.88	201.18	0.00	0.00	0.00	0.00	0.00	0.00
5.A.2.5 Other Land converted to Forest Land	EF Biomass	CO_2	-45.40	-50.69	88.07	23.80	91.23	0.05	0.00	0.00	0.00	0.05	0.05
5.A.2.5 Other Land converted to Forest Land	EF litter	CO_2	-5.08	-5.35	88.07	125.40	153.23	0.01	0.00	0.00	0.00	0.00	0.01
5.A.2.5 Other Land converted to Forest Land	EF dead wood	CO_2	0.00	0.00	88.07	6.12	88.28	0.00	0.00	0.00	0.00	0.00	0.00
Liming			**116.78**	**64.32**	**5.00**	**1.77**	**5.30**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
5.B.1 Cropland remaining Cropland	Mineral soil	CO_2	0.00	0.00	1.06	50.50	50.52	0.00	0.00	0.00	0.00	0.00	0.00
5.B.1 Cropland remaining Cropland	Organic soil	CO_2	22,255.68	23,433.34	1.06	50.00	50.01	13.22	0.07	0.17	3.32	0.25	3.33
5.B.1 Cropland remaining Cropland	EF Biomass	CO_2	0.00	0.00	1.06	8.43	8.50	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.1 Forest Land converted to Cropland	Mineral soil	CO_2	-88.40	-10.79	9.75	24.91	26.75	0.00	0.00	0.00	0.01	0.00	0.01
5.B.2.1 Forest Land converted to Cropland	Organic soil	CO_2	176.03	84.83	9.75	50.00	50.94	0.05	0.00	0.00	0.01	0.01	0.01
5.B.2.1 Forest Land converted to Cropland	EF Biomass	CO_2	459.94	15.27	9.75	30.46	31.98	0.01	0.00	0.00	0.06	0.00	0.06
5.B.2.1 Forest Land converted to Cropland	EF DOM	CO_2	322.41	12.82	9.75	3.22	10.26	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.1 Forest Land converted to Cropland	N_2O-N	N_2O	0.00	0.03	9.75	83.83	84.40	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.2 Grassland i.s.s. converted to Cropland	Mineral soil	CO_2	1,245.45	1,448.37	8.30	49.10	49.79	0.81	0.00	0.01	0.23	0.12	0.26
5.B.2.2 Grassland i.s.s. converted to Cropland	Organic soil	CO_2	1,122.86	1,305.81	8.30	50.00	50.68	0.75	0.00	0.01	0.21	0.11	0.24
5.B.2.2 Grassland i.s.s. converted to Cropland	EF Biomass	CO_2	42.62	-107.42	8.30	12.99	15.42	0.02	0.00	0.00	0.01	0.01	0.02
5.B.2.2 Grassland i.s.s. converted to Cropland	N_2O-N	N_2O	163.07	189.64	8.30	106.35	106.67	0.23	0.00	0.00	0.07	0.02	0.07
5.B.2.2 Woody Grassland converted to Cropland	Mineral soil	CO_2	237.62	122.83	15.64	51.10	53.44	0.07	0.00	0.00	0.01	0.02	0.02
5.B.2.2 Woody Grassland converted to Cropland	Organic soil	CO_2	120.99	62.54	15.64	50.00	52.39	0.04	0.00	0.00	0.01	0.01	0.01
5.B.2.2 Woody Grassland converted to Cropland	EF Biomass	CO_2	759.56	71.98	15.64	162.84	163.59	0.13	0.00	0.00	0.48	0.01	0.48
5.B.2.2 Woody Grassland converted to Cropland	N_2O-N	N_2O	32.28	16.69	15.64	107.29	108.42	0.02	0.00	0.00	0.00	0.00	0.00

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category	Pool	Gas	Base year emissions [CO_2- eq.] [Gg a^{-1}]	Year 2011 emissions [CO_2- eq.] [Gg a^{-1}]	Activity data uncertainty (half the 95% confidence interval) [%]	Emission factor uncertainty (half the 95% confidence interval) [%]	Combined uncertainty (half the 95% confidence interval) [%]	Combined uncertainty as % of total national emissions in year 2011 [%]	Type A sensitivity [%]	Type B sensitivity [%]	Uncertainty in trend in national emissions introduced by emission factor uncertainty [%]	Uncertainty in trend in national emissions introduced by activity data uncertainty [%]	Uncertainty introduced into the trend in total national emissions [%]
5.B.2.3 Terr. Wetlands converted to Cropland	Mineral soil	CO_2	6.74	3.33	73.09	36.76	81.81	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.3 Terr. Wetlands converted to Cropland	Organic soil	CO_2	79.12	39.04	73.09	50.00	88.55	0.04	0.00	0.00	0.00	0.03	0.03
5.B.2.3 Terr. Wetlands converted to Cropland	EF Biomass	CO_2	11.77	0.00	73.09	108.83	131.10	0.00	0.00	0.00	0.01	0.00	0.01
5.B.2.3 Terr. Wetlands converted to Cropland	N_2O-N	N_2O	0.73	0.36	85.51	101.25	132.53	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.3 Terr. Wetlands converted to Cropland	Mineral soil	CO_2	0.00	0.00	85.51	51.10	99.61	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.3 Waters converted to Cropland	Organic soil	CO_2	3.43	3.47	85.51	50.00	99.05	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.3 Waters converted to Cropland	EF Biomass	CO_2	-1.80	-2.76	85.51	8.43	85.92	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.3 Waters converted to Cropland	N_2O-N	N_2O	0.00	0.00	85.51	0.00	85.51	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.4 Settlements converted to Cropland	Mineral soil	CO_2	-34.37	-22.39	12.68	49.15	50.76	0.01	0.00	0.00	0.00	0.00	0.00
5.B.2.4 Settlements converted to Cropland	Organic soil	CO_2	548.00	357.04	12.68	50.00	51.58	0.21	0.00	0.00	0.00	0.05	0.05
5.B.2.4 Settlements converted to Cropland	EF Biomass	CO_2	202.79	37.10	12.68	108.85	109.58	0.05	0.00	0.00	0.07	0.00	0.07
5.B.2.4 Settlements converted to Cropland	N_2O-N	N_2O	0.00	0.00	12.68	0.00	12.68	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.5 Other Land converted to Cropland	Mineral soil	CO_2	-1.49	-0.67	73.58	51.78	89.97	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.5 Other Land converted to Cropland	Organic soil	CO_2	6.49	2.92	73.58	50.00	88.96	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.5 Other Land converted to Cropland	EF Biomass	CO_2	-2.25	0.00	73.58	8.43	74.06	0.00	0.00	0.00	0.00	0.00	0.00
5.B.2.5 Other Land converted to Cropland	N_2O-N	CO_2	0.00	0.00	73.58	0.00	73.58	0.00	0.00	0.00	0.00	0.00	0.00
Liming		CO_2	1,158.93	1,775.87	5.00	2.95	5.80	0.12	0.01	0.01	0.02	0.09	0.09
5.C.1 Grassland i.s.s. remaining Grassland i.s.s.	Mineral soil	CO_2	0.00	0.00	1.78	77.87	77.89	0.00	0.00	0.00	0.00	0.00	0.00
5.C.1 Grassland i.s.s. remaining Grassland i.s.s.	Organic soil	CO_2	11,169.08	10,655.03	1.78	50.00	50.03	6.01	0.03	0.08	1.27	0.19	1.28
5.C.1 Grassland i.s.s. remaining Grassland i.s.s.	EF Biomass	CO_2	0.00	0.00	1.78	24.51	24.58	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.1 Forest Land converted to Grassland i.s.s.	Mineral soil	CO_2	-308.94	-149.88	16.19	43.17	46.11	0.08	0.00	0.00	0.01	0.02	0.03
5.C.2.1 Forest Land converted to Grassland i.s.s.	Organic soil	CO_2	88.76	54.32	16.19	50.00	52.56	0.03	0.00	0.00	0.00	0.01	0.01
5.C.2.1 Forest Land converted to Grassland i.s.s.	EF Biomass	CO_2	399.92	28.32	16.19	30.68	34.69	0.01	0.00	0.00	0.05	0.00	0.05
5.C.2.1 Forest Land converted to Grassland i.s.s.	EF DOM	CO_2	285.86	22.98	16.19	3.22	16.51	0.00	0.00	0.00	0.00	0.00	0.01
5.C.2.2 Cropland converted to Grassland i.s.s.	Mineral soil	CO_2	0.00	0.00	0.00	49.10	49.10	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.2 Cropland converted to Grassland i.s.s.	Organic soil	CO_2	0.00	0.00	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.2 Cropland converted to Grassland i.s.s.	EF Biomass	CO_2	0.00	0.00	0.00	12.99	12.99	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.25 Woody Grassland converted to Grassland i.s.s.	Mineral soil	CO_2	-62.52	-48.17	16.06	56.92	59.14	0.03	0.00	0.00	0.00	0.01	0.01
5.C.2.25 Grassland converted to Grassland i.s.s.	Organic soil	CO_2	66.55	51.28	16.06	50.00	52.51	0.03	0.00	0.00	0.00	0.01	0.01
5.C.2.25 Woody Grassland converted to Grassland i.s.s.	EF Biomass	CO_2	618.78	132.90	16.06	162.74	163.53	0.25	0.00	0.00	0.31	0.02	0.31
5.C.2.3 Terr. Wetlands converted to Grassland i.s.s.	Mineral soil	CO_2	-4.67	-2.80	42.23	47.36	63.45	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.3 Terr. Wetlands converted to Grassland i.s.s.	Organic soil	CO_2	109.53	65.62	42.23	50.00	65.45	0.05	0.00	0.00	0.00	0.03	0.03
5.C.2.3 Terr. Wetlands converted to Grassland i.s.s.	EF Biomass	CO_2	32.96	3.28	42.23	108.81	116.72	0.00	0.00	0.00	0.01	0.00	0.01

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category	Pool	Gas	Base year emissions [CO_2- eq.]	Year 2011 emissions [CO_2- eq.]	Activity data uncertainty (half the 95% confidence interval)	Emission factor uncertainty (half the 95% confidence interval)	Combined uncertainty (half the 95% confidence interval)	Combined uncertainty as % of total national emissions in year 2011	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			[$Gg\ a^{-1}$]	[$Gg\ a^{-1}$]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
5.C.2.3 Waters converted to Grassland i.s.s.	Mineral soil	CO_2	0.00	0.00	41.01	77.87	88.01	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.3 Waters converted to Grassland i.s.s.	Organic soil	CO_2	12.97	20.32	41.01	50.00	64.67	0.01	0.00	0.00	0.00	0.01	0.01
5.C.2.3 Waters converted to Grassland i.s.s.	EF Biomass	CO_2	-7.35	-6.53	41.01	24.51	47.78	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.4 Settlements converted to Grassland i.s.s.	Mineral soil	CO_2	-372.04	-434.09	13.59	57.48	59.07	0.29	0.00	0.00	0.08	0.06	0.10
5.C.2.4 Settlements converted to Grassland i.s.s.	Organic soil	CO_2	138.92	162.09	13.59	50.00	51.81	0.09	0.00	0.00	0.03	0.02	0.03
5.C.2.4 Settlements converted to Grassland i.s.s.	EF Biomass	CO_2	142.60	132.76	13.59	108.89	109.73	0.16	0.00	0.00	0.03	0.02	0.04
5.C.2.5 Other Land converted to Grassland i.s.s.	Mineral soil	CO_2	-64.19	-50.66	40.86	59.67	72.32	0.04	0.00	0.00	0.00	0.02	0.02
5.C.2.5 Other Land converted to Grassland i.s.s.	Organic soil	CO_2	12.72	10.04	40.86	50.00	64.57	0.01	0.00	0.00	0.00	0.00	0.00
5.C.2.5 Other Land converted to Grassland i.s.s.	EF Biomass	CO_2	-20.51	-4.90	40.86	24.51	47.64	0.00	0.00	0.00	0.00	0.00	0.00
5.C.1 Woody Grassland remaining Woody Grassland	Mineral soil	CO_2	0.00	0.00	5.80	83.27	83.47	0.00	0.00	0.00	0.00	0.00	0.00
5.C.1 Woody Grassland remaining Woody Grassland	Organic soil	CO_2	33.08	36.67	5.80	180.88	180.98	0.07	0.00	0.00	0.02	0.00	0.02
5.C.1 Woody Grassland remaining Woody Grassland	EF Biomass	CO_2	0.00	0.00	5.80	185.89	185.98	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.1 Forest Land converted to Woody Grassland	Mineral soil	CO_2	-254.26	-99.85	16.43	45.00	47.91	0.05	0.00	0.00	0.02	0.02	0.03
5.C.2.1 Forest Land converted to Woody Grassland	Organic soil	CO_2	13.96	7.22	16.43	180.88	181.63	0.01	0.00	0.00	0.00	0.00	0.00
5.C.2.1 Forest Land converted to Woody Grassland	EF Biomass	CO_2	-174.26	-27.74	16.43	110.67	111.89	0.04	0.00	0.00	0.07	0.00	0.07
5.C.2.1 Forest Land converted to Woody Grassland	EF DOM	CO_2	290.65	40.85	16.43	3.22	16.75	0.01	0.00	0.00	0.00	0.01	0.01
5.C.2.2 Cropland converted to Woody Grassland	Mineral soil	CO_2	-114.24	-269.98	20.75	51.10	55.15	0.17	0.00	0.00	0.07	0.06	0.09
5.C.2.2 Cropland converted to Woody Grassland	Organic soil	CO_2	3.74	8.85	20.75	180.88	182.07	0.02	0.00	0.00	0.01	0.00	0.01
5.C.2.2 Cropland converted to Woody Grassland	EF Biomass	CO_2	-365.61	-875.67	20.75	162.84	164.16	1.62	0.00	0.01	0.75	0.18	0.78
5.C.2.25 Grassland i.s.s. converted to Woody Grassland	Mineral soil	CO_2	13.45	37.96	29.62	56.92	64.17	0.03	0.00	0.00	0.01	0.01	0.02
5.C.2.25 Grassland i.s.s. converted to Woody Grassland	Organic soil	CO_2	1.74	4.91	29.62	180.88	183.29	0.01	0.00	0.00	0.00	0.00	0.01
5.C.2.25 Grassland i.s.s. converted to Woody Grassland	EF Biomass	CO_2	-132.51	-545.09	29.62	162.74	165.42	1.02	0.00	0.00	0.54	0.16	0.56
5.C.2.3 Terr. Wetlands converted to Woody Grassland	Mineral soil	CO_2	0.08	0.05	146.88	49.10	154.87	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.3 Terr. Wetlands converted to Woody Grassland	Organic soil	CO_2	0.24	0.15	146.88	180.88	233.01	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.3 Terr. Wetlands converted to Woody Grassland	EF Biomass	CO_2	-2.95	-3.28	146.88	115.68	186.96	0.01	0.00	0.00	0.00	0.00	0.01
5.C.2.3 Waters converted to Woody Grassland	Mineral soil	CO_2	0.00	0.00	111.14	83.27	138.87	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.3 Waters converted to Woody Grassland	Organic soil	CO_2	0.15	0.16	111.14	180.88	212.30	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.3 Waters converted to Woody Grassland	EF Biomass	CO_2	-6.85	-22.95	111.14	185.89	216.58	0.06	0.00	0.00	0.02	0.03	0.04
5.C.2.4 Settlements converted to Woody Grassland	Mineral soil	CO_2	-55.65	-71.65	36.80	59.71	70.14	0.06	0.00	0.00	0.02	0.03	0.03
5.C.2.4 Settlements converted to Woody Grassland	Organic soil	CO_2	2.13	2.75	36.80	180.88	184.59	0.01	0.00	0.00	0.00	0.00	0.00
5.C.2.4 Settlements converted to Woody Grassland	EF Biomass	CO_2	-133.88	-89.93	36.80	149.05	153.52	0.16	0.00	0.00	0.00	0.03	0.03
5.C.2.5 Other Land converted to Woody Grassland	Mineral soil	CO_2	-7.90	-7.20	89.64	62.02	109.00	0.01	0.00	0.00	0.00	0.01	0.01
5.C.2.5 Other Land converted to Woody Grassland	Organic soil	CO_2	0.35	0.32	89.64	180.88	201.88	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2.5 Other Land converted to Woody Grassland	EF Biomass	CO_2	-22.32	0.00	89.64	185.89	206.38	0.00	0.00	0.00	0.02	0.00	0.02

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category	Pool	Gas	Base year emissions [CO_2- eq.] [Gg a^{-1}]	Year 2011 emissions [CO_2- eq.] [Gg a^{-1}]	Activity data uncertainty (half the 95% confidence interval) [%]	Emission factor uncertainty (half the 95% confidence interval) [%]	Combined uncertainty (half the 95% confidence interval) [%]	Combined uncertainty as % of total national emissions in year 2011 [%]	Type A sensitivity [%]	Type B sensitivity [%]	Uncertainty in trend in national emissions introduced by emission factor uncertainty [%]	Uncertainty in trend in national emissions introduced by activity data uncertainty [%]	Uncertainty introduced into the trend in total national emissions [%]
5.D.1 Terr. Wetlands remaining Terr. Wetlands	Mineral soil	CO_2	0.00	0.00	21.00	52.48	56.52	0.00	0.00	0.00	0.00	0.00	0.00
5.D.1 Terr. Wetlands remaining Terr. Wetlands	Organic soil	CO_2	0.00	0.00	21.00	38.99	44.28	0.00	0.00	0.00	0.00	0.00	0.00
5.D.1 Peat extraction remaining Peat extraction	Organic soil	CO_2	2,044.09	2,020.67	2.82	38.99	39.09	0.89	0.01	0.01	0.20	0.06	0.21
5.D.2.1 Forest Land converted to Terr. Wetlands	Mineral soil	CO_2	-7.53	-3.53	79.50	28.57	84.47	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.1 Forest Land converted to Terr. Wetlands	Organic soil	CO_2	0.00	0.00	79.50	0.00	79.50	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.1 Forest Land converted to Terr. Wetlands	EF Biomass	CO_2	7.56	0.00	79.50	59.66	99.39	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.1 Forest Land converted to Terr. Wetlands	EF DOM	CO_2	10.32	0.00	79.50	3.22	79.56	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.2 Cropland converted to Terr. Wetlands	Mineral soil	CO_2	-3.54	-2.84	68.25	36.76	77.52	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.2 Cropland converted to Terr. Wetlands	Organic soil	CO_2	0.00	0.00	68.25	0.00	68.25	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.2 Cropland converted to Terr. Wetlands	EF Biomass	CO_2	-5.12	0.00	68.25	108.83	128.46	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.3 Grassland i.s.s. converted to Terr. Wetlands	Mineral soil	CO_2	0.95	3.02	77.05	47.36	90.44	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.3 Grassland i.s.s. converted to Terr. Wetlands	Organic soil	CO_2	0.00	0.00	77.05	0.00	77.05	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.3 Grassland i.s.s. converted to Terr. Wetlands	EF Biomass	CO_2	-6.88	-26.30	77.05	108.81	133.33	0.04	0.00	0.00	0.02	0.02	0.03
5.D.2.3 Woody Grassland converted to Terr. Wetlands	Mineral soil	CO_2	-0.08	-0.06	162.33	49.10	169.59	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.3 Woody Grassland converted to Terr. Wetlands	Organic soil	CO_2	0.00	0.00	162.33	0.00	162.33	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.3 Woody Grassland converted to Terr. Wetlands	EF Biomass	CO_2	4.90	0.00	162.33	115.68	199.33	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.35 Wetlands 2 converted to Terr. Wetlands	Mineral soil	CO_2	0.00	0.00	146.69	52.48	155.79	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.35 Wetlands 2 converted to Terr. Wetlands	Organic soil	CO_2	0.00	0.00	146.69	0.00	146.69	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.35 Wetlands 2 converted to Terr. Wetlands	EF Biomass	CO_2	-2.21	0.00	146.69	144.77	206.10	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.4 Settlements converted to Terr. Wetlands	Mineral soil	CO_2	0.00	0.00	0.00	47.63	47.63	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.4 Settlements converted to Terr. Wetlands	Organic soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.4 Settlements converted to Terr. Wetlands	EF Biomass	CO_2	0.00	0.00	0.00	108.55	108.55	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.5 Other Land converted to Terr. Wetlands	Mineral soil	CO_2	-0.86	-0.39	130.95	49.85	140.12	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.5 Other Land converted to Terr. Wetlands	Organic soil	CO_2	0.00	0.00	130.95	0.00	130.95	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.5 Other Land converted to Terr. Wetlands	EF Biomass	CO_2	-2.94	0.00	130.95	144.77	195.21	0.00	0.00	0.00	0.00	0.00	0.00
5.D.1 Waters remaining Waters	Mineral soil	CO_2	0.00	0.00	6.19	0.00	6.19	0.00	0.00	0.00	0.00	0.00	0.00
5.D.1 Waters remaining Waters	Organic soil	CO_2	0.00	0.00	6.19	0.00	6.19	0.00	0.00	0.00	0.00	0.00	0.00
5.D.1 Waters remaining Waters	EF Biomass	CO_2	0.00	0.00	6.19	0.00	6.19	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.1 Forest Land converted to Waters	Mineral soil	CO_2	0.00	0.00	49.56	5.45	49.86	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.1 Forest Land converted to Waters	Organic soil	CO_2	0.00	0.00	49.56	0.00	49.56	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.1 Forest Land converted to Waters	EF Biomass	CO_2	45.95	0.00	49.56	36.62	61.62	0.00	0.00	0.00	0.01	0.00	0.01
5.D.2.1 Forest Land converted to Waters	EF DOM	CO_2	26.55	0.00	49.56	3.22	49.67	0.00	0.00	0.00	0.00	0.00	0.00

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category	Pool	Gas	Base year emissions [CO_2- eq.] [Gg a^{-1}]	Year 2011 emissions [CO_2- eq.] [Gg a^{-1}]	Activity data uncertainty (half the 95% confidence interval) [%]	Emission factor uncertainty (half the 95% confidence interval) [%]	Combined uncertainty (half the 95% confidence interval) [%]	Combined uncertainty as % of total national emissions in year 2011 [%]	Type A sensitivity [%]	Type B sensitivity [%]	Uncertainty in trend in national emissions introduced by emission factor uncertainty [%]	Uncertainty in trend in national emissions introduced by activity data uncertainty [%]	Uncertainty introduced into the trend in total national emissions [%]
5.D.2.2 Cropland converted to Waters	Mineral soil	CO_2	0.00	0.00	33.09	50.50	60.38	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.2 Cropland converted to Waters	Organic soil	CO_2	0.00	0.00	33.09	0.00	33.09	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.2 Cropland converted to Waters	EF Biomass	CO_2	28.52	22.14	33.09	8.43	34.15	0.01	0.00	0.00	0.00	0.01	0.01
5.D.2.3 Grassland i.s.s. converted to Waters	Mineral soil	CO_2	0.00	0.00	45.12	77.87	90.00	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.3 Grassland i.s.s. converted to Waters	Organic soil	CO_2	0.00	0.00	45.12	0.00	45.12	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.3 Grassland i.s.s. converted to Waters	EF Biomass	CO_2	13.44	35.93	45.12	24.51	51.35	0.02	0.00	0.00	0.00	0.02	0.02
5.D.2.3 Woody Grassland converted to Waters	Mineral soil	CO_2	0.00	0.00	86.22	83.27	119.87	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.3 Woody Grassland converted to Waters	Organic soil	CO_2	0.00	0.00	86.22	0.00	86.22	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.3 Woody Grassland converted to Waters	EF Biomass	CO_2	30.95	28.72	86.22	185.89	204.92	0.07	0.00	0.00	0.01	0.03	0.03
5.D.2.35 Terr. Wetlands converted to Waters	Mineral soil	CO_2	0.00	0.00	76.95	52.48	93.14	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.35 Terr. Wetlands converted to Waters	Organic soil	CO_2	0.00	0.00	76.95	0.00	76.95	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.35 Terr. Wetlands converted to Waters	EF Biomass	CO_2	8.80	0.00	76.95	144.77	163.95	0.00	0.00	0.00	0.01	0.00	0.01
5.D.2.4 Settlements converted to Waters	Mineral soil	CO_2	0.00	0.00	44.39	84.97	95.86	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.4 Settlements converted to Waters	Organic soil	CO_2	0.00	0.00	44.39	0.00	44.39	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.4 Settlements converted to Waters	EF Biomass	CO_2	40.28	50.73	44.39	162.74	168.69	0.10	0.00	0.00	0.03	0.02	0.04
5.D.2.5 Other Land converted to Waters	Mineral soil	CO_2	0.00	0.00	197.20	92.86	217.97	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.5 Other Land converted to Waters	Organic soil	CO_2	0.00	0.00	197.20	0.00	197.20	0.00	0.00	0.00	0.00	0.00	0.00
5.D.2.5 Other Land converted to Waters	EF Biomass	CO_2	0.00	0.00	197.20	0.00	197.20	0.00	0.00	0.00	0.00	0.00	0.00
5.E.1 Settlements remaining Settlements	Mineral soil	CO_2	0.00	0.00	2.82	84.97	85.01	0.00	0.00	0.00	0.00	0.00	0.00
5.E.1 Settlements remaining Settlements	Organic soil	CO_2	1600.42	1665.33	2.82	50.00	50.08	0.94	0.00	0.01	0.23	0.05	0.24
5.E.1 Settlements remaining Settlements	EF Biomass	CO_2	0.00	0.00	2.82	162.74	162.77	0.00	0.00	0.00	0.00	0.00	0.00
5.E.2.1 Forest Land converted to Settlements	Mineral soil	CO_2	-39.40	3.21	22.68	41.25	47.08	0.00	0.00	0.00	0.01	0.00	0.01
5.E.2.1 Forest Land converted to Settlements	Organic soil	CO_2	21.52	14.15	22.68	50.00	54.90	0.01	0.00	0.00	0.00	0.00	0.00
5.E.2.1 Forest Land converted to Settlements	EF Biomass	CO_2	194.19	56.10	22.68	54.03	58.59	0.04	0.00	0.00	0.03	0.01	0.03
5.E.2.1 Forest Land converted to Settlements	EF DOM	CO_2	182.28	61.43	22.68	3.22	22.91	0.02	0.00	0.00	0.00	0.01	0.01
5.E.2.2 Cropland converted to Settlements	Mineral soil	CO_2	83.66	143.38	9.54	49.15	50.07	0.08	0.00	0.00	0.03	0.01	0.03
5.E.2.2 Cropland converted to Settlements	Organic soil	CO_2	155.07	265.77	9.54	50.00	50.90	0.15	0.00	0.00	0.06	0.03	0.07
5.E.2.2 Cropland converted to Settlements	EF Biomass	CO_2	-460.75	-718.38	9.54	108.85	109.27	0.89	0.00	0.01	0.33	0.07	0.34
5.E.2.3 Grassland i.s.s. converted to Settlements	Mineral soil	CO_2	259.08	414.17	19.38	57.48	60.66	0.28	0.00	0.00	0.10	0.08	0.13
5.E.2.3 Grassland i.s.s. converted to Settlements	Organic soil	CO_2	55.57	88.84	19.38	50.00	53.62	0.05	0.00	0.00	0.02	0.02	0.03
5.E.2.3 Grassland i.s.s. converted to Settlements	EF Biomass	CO_2	-96.53	-195.86	19.38	108.89	110.60	0.24	0.00	0.00	0.11	0.04	0.11
5.E.2.3 Woody Grassland converted to Settlements	Mineral soil	CO_2	37.89	61.05	41.85	59.71	72.92	0.05	0.00	0.00	0.02	0.03	0.03
5.E.2.3 Woody Grassland converted to Settlements	Organic soil	CO_2	5.87	9.46	41.85	50.00	65.20	0.01	0.00	0.00	0.00	0.00	0.00
5.E.2.3 Woody Grassland converted to Settlements	EF Biomass	CO_2	89.54	278.33	41.85	149.05	154.81	0.49	0.00	0.00	0.24	0.12	0.27

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category	Pool	Gas	Base year emissions [CO_2- eq.] [Gg a^{-1}]	Year 2011 emissions [CO_2- eq.] [Gg a^{-1}]	Activity data uncertainty (half the 95% confidence interval) [%]	Emission factor uncertainty (half the 95% confidence interval) [%]	Combined uncertainty (half the 95% confidence interval) [%]	Combined uncertainty as % of total national emissions in year 2011 [%]	Type A sensitivity [%]	Type B sensitivity [%]	Uncertainty in trend in national emissions introduced by emission factor uncertainty [%]	Uncertainty in trend in national emissions introduced by activity data uncertainty [%]	Uncertainty introduced into the trend in total national emissions [%]
5.E.2.4 Terr. Wetlands converted to Settlements	Mineral soil	CO_2	9.23	5.14	53.21	47.63	71.42	0.00	0.00	0.00	0.00	0.00	0.00
5.E.2.4 Terr. Wetlands converted to Settlements	Organic soil	CO_2	213.97	119.12	53.21	50.00	73.02	0.10	0.00	0.00	0.01	0.06	0.06
5.E.2.4 Terr. Wetlands converted to Settlements	EF Biomass	CO_2	18.36	1.63	53.21	108.55	120.89	0.00	0.00	0.00	0.01	0.00	0.01
5.E.2.4 Waters converted to Settlements	Mineral soil	CO_2	0.00	0.00	104.07	52.48	116.55	0.00	0.00	0.00	0.00	0.00	0.00
5.E.2.4 Waters converted to Settlements	Organic soil	CO_2	3.20	2.26	104.07	50.00	115.46	0.00	0.00	0.00	0.00	0.00	0.00
5.E.2.4 Waters converted to Settlements	EF Biomass	CO_2	-10.49	-8.19	104.07	162.74	193.17	0.02	0.00	0.00	0.00	0.01	0.01
5.E.2.5 Other Land converted to Settlements	Mineral soil	CO_2	-3.00	-1.96	130.95	62.80	145.24	0.00	0.00	0.00	0.00	0.00	0.00
5.E.2.5 Other Land converted to Settlements	Organic soil	CO_2	1.30	0.85	130.95	50.00	140.18	0.00	0.00	0.00	0.00	0.00	0.00
5.E.2.5 Other Land converted to Settlements	EF Biomass	CO_2	-13.26	-9.81	130.95	162.74	208.89	0.02	0.00	0.00	0.00	0.01	0.01
5.F.1 Other Land remaining Other Land	Mineral soil	CO_2	0.00	0.00	24.14	0.00	24.14	0.00	0.00	0.00	0.00	0.00	0.00
5.F.1 Other Land remaining Other Land	Organic soil	CO_2	0.00	0.00	24.14	0.00	24.14	0.00	0.00	0.00	0.00	0.00	0.00
5.F.1 Other Land remaining Other Land	EF Biomass	CO_2	0.00	0.00	24.14	0.00	24.14	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.1 Forest Land converted to Other Land	Mineral soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.1 Forest Land converted to Other Land	Organic soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.1 Forest Land converted to Other Land	EF Biomass	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.1 Forest Land converted to Other Land	EF DOM	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.2 Cropland converted to Other Land	Mineral soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.2 Cropland converted to Other Land	Organic soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.2 Cropland converted to Other Land	EF Biomass	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.3 Grassland i.s.s. converted to Other Land	Mineral soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.3 Grassland i.s.s. converted to Other Land	Organic soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.3 Grassland i.s.s. converted to Other Land	EF Biomass	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.3 Woody Grassland converted to Other Land	Mineral soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.3 Woody Grassland converted to Other Land	Organic soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.3 Woody Grassland converted to Other Land	EF Biomass	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.4 Terr. Wetlands converted to Other Land	Mineral soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.4 Terr. Wetlands converted to Other Land	Organic soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.4 Terr. Wetlands converted to Other Land	EF Biomass	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.4 Waters converted to Other Land	Mineral soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.4 Waters converted to Other Land	Organic soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.4 Waters converted to Other Land	EF Biomass	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.5 Settlements converted to Other Land	Mineral soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.5 Settlements converted to Other Land	Organic soil	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.F.2.5 Settlements converted to Other Land	EF Biomass	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category	Pool	Gas	Base year emissions [CO_2- eq.]	Year 2011 emissions [CO_2- eq.]	Activity data uncertainty (half the 95% confidence interval)	Emission factor uncertainty (half the 95% confidence interval)	Combined uncertainty (half the 95% confidence interval)	Combined uncertainty as % of total national emissions in year 2011	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			[Gg a^{-1}]	[Gg a^{-1}]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
Total			138896.87	88634.62				17.36					4.95

19.6 Other detailed methodological descriptions for the source category "Waste and wastewater" (6)

19.6.1 Solid waste disposal on land (6.A)

19.6.2 Wastewater (6.B) – Data for determination of emission factors for wastewater and sewage-sludge treatment (6.B.2)

The remarks made in Chapter 14.6.2 of the NIR 2008 apply.

19.6.3 Determination of nitrous oxide emissions from wastewater treatment (6.B.2)

The remarks made in Chapter 14.6.3 of the NIR 2008 apply.

.

20 Annex 4: CO_2 Reference Approach, a comparison of that approach with the sectoral approach, and relevant information on the national Energy Balance

In recent years, efforts to improve German reporting on greenhouse-gas emissions have included methodological work on the CO_2 reference approach (reference method). Initial extensive revision was carried out in the framework of a study, conducted by the firm Prognos AG, aimed at determining country-specific emission factors and carbon-content levels and incorporating them within calculations.

The resulting adjusted procedure was used for the first time for the 2008 Submission. Unfortunately, since it was not possible to transfer all of the pertinent detailed country-specific input data into the CRF Reporter, which imposes a structurally and functionally restrictive system (with specified fuels / fuel groups and, in the case of non-energy-related consumption, specified materials / material groups), no significant improvements were achieved with regard to the comparability of results obtained via the reference approach and those obtained via the sectoral approach. In fact, the increased complexity of the resulting procedure tended to reduce transparency and clarity. For this reason, as of the 2012 Submission, the country-specific emission factors and carbon-content levels have been reset to the default values of the IPCC.

Since then, further revision of allocations of activity data has been carried out, gradually. Significantly, this work has eliminated systematic inconsistencies and errors and has improved and simplified the overall procedure with regard to transparency and clarity.

At the maximum-aggregation level, the work has led to excellent agreement between the two calculation approaches. At the same time, discrepancies still persist in sub-structures, for the relevant above-mentioned reasons, that can be attributed – at least partly – to country-specific aspects, but that cannot be satisfactorily eliminated at the present time.

The reference approach will thus continue to offer potential for further improvements, although such improvements are currently hampered, in many areas, by the systemic requirements imposed by the CRF Reporter. Along with review and revision of the country-specific carbon-content levels used for the area of non-energy-related consumption – work that is planned next in this overall process – extensive flexibilization of data management in the CRF Reporter would also enhance the comparability of the two approaches.

Further information on the CO_2 reference approach, a comparison of that approach with the sectoral approach and relevant information on the national Energy Balance are provided in Chapter 3.2.1.1.

21 ANNEX 5: ASSESSMENT OF COMPLETENESS, AND ASSESSMENT OF POTENTIALLY EXCLUDED SOURCES AND SINKS OF GREENHOUSE GAS EMISSIONS

The following two tables show the sources for greenhouse gases that have not been included in Germany's greenhouse-gas inventories to date. The tables also include explanations of the reasons for such omission. Thie table is a summary of CRF Table 9(a), which contains a more detailed overview of non-included sources and sinks. Additional information is presented in Chapter 1.8.

Table 377: Overview, for completeness, of sources and sinks whose emissions are not estimated (NE)

Source category	Greenhouse gas (GG)	Explanation
5.A.1 Forest Land remaining Forest Land	CH_4	According to IPCC GPG (2003, p.1.11) countries are not required "to prepare estimates for categories contained in appendices,..." -
5.D.2 Land converted to Wetlands	CH_4, N_2O	Emissions from this source category are currently not being reported according appendix 3a.3 IPCC GPG.
5.E Settlements	CH_4, CO_2, N_2O	
5.E.1 Settlements remaining Settlements	CH_4, N_2O	No data available
5.E.2 Land converted to Settlements	CH_4, N_2O	No data available
5 Forest Land converted to Other Land-Use Categories	CH_4	No reliable data is available for reporting on CH_4, NO_X, CO, NMVOC emissions.
5 Grassland converted to Other Land-Use Categories	CH_4	No reliable data is available for reporting on NMVOC, CH_4, NO_X and CO.
5.G Harvested Wood Products	CH_4, CO_2, N_2O	According to IPCC GPG 2003 HWP do not have to be reported (p.1.11 chp.1.7).

Table 378: Overview, for completeness, of sources and sinks that are reported elsewhere (included elswhere, IE)

Source/sink category	GHG	Allocation used by the Party / Explanation
1.AA.2.A Iron and Steel	CO_2	Emissions are part of the carbon balance and were reported under blast furnace gas incineration (solid fuels).
1.AA.2.B Non-Ferrous Metals	CH_4, CO_2, N_2O	Reported in source category 1.A.2.f other, because of confidential data.
1.AA.2.C Chemicals	CH_4, CO_2, N_2O	Reported in source category 1.A.2.f other.
1.AA.2.D Pulp, Paper and Print	CH_4, CO_2, N_2O	Reported in source category 1.A.2.f other.
1.AA.2.E Food Processing, Beverages and Tobacco	CH_4, CO_2, N_2O	Reported in source category 1.A.2.f other, because of confidential data.
1.AA.3.B Road Transportation	CH_4	CH_4 emissions from lubricants supposed to be included in corresponding emissions from liquid fuels consumed!
1.AA.3.B Road Transportation	N_2O	N_2O emissions from lubricants supposed to be included in corresponding emissions from liquid fuels consumed!
1.AA.3.C Railways	CH_4	CH_4 emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
1.AA.3.C Railways	CO_2	CO_2 emissions from biodiesel are set to zero to be not included in national totals! but thus also not included in total CO2 from biomass!
1.AA.3.C Railways	N_2O	N_2O emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
1.AA.3.D Navigation	CH_4	CH_4 emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
1.AA.3.D Navigation	CO_2	CO_2 emissions from biodiesel are set to zero to be not included in national totals! but thus also not included in total CO2 from biomass!
1.AA.3.D Navigation	N_2O	N_2O emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
1.B.1.A.2.2 Post-Mining Activities	CH_4	considered in 1.B.1.A.2.1
1.B.1.B Solid Fuel Transformation	CO_2	considered in 1.A.1.C
1.B.2.A.4 Refining / Storage	CO_2	CO_2 from flares are reported under 1.B.2.c
1.B.2.B.1 Exploration	CH_4, CO_2	considered in 1.B.2.a.i

Source/sink category	GHG	Allocation used by the Party / Explanation
1.B.2.C.1.1 Oil	CH_4, CO_2	included in 1.B.2.A.ii
1.B.2.C.1.2 Gas	CH_4, CO_2	included in 1.B.2.B.iv
1.B.2.C.1.3 Combined	CH_4, CO_2	included in 1.B.2.A.ii and in 1.B.2.B.iv
1.B.2.C.2.3 Combined	CH_4, CO_2, N_2O	considered in 1.B.2.C.2.1. and 1.B.2.C.2.2.
1.C1.B Marine	CH_4	CH_4 emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
1.C1.B Marine	N_2O	N_2O emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
2.A.3 Limestone and Dolomite Use	CO_2	allocation: 1.A.1.a, 2.A.1 and 2.A.2, 2.A.7, 2.C.1
2.A.7.2a - Ceramic production	CO_2	see 2.A.7.2b bricks an tiles
2.C.1.2 Pig Iron	CH_4	is considered in CRF 1.A.2
2.C.1.2 Pig Iron	CO_2	is considered in oxygen steel
2.C.1.3 Sinter	CH_4, CO_2	is considered in CRF 1.A.2
2.C.1.4 Coke	CH_4, CO_2	is considered in CRF 1.A.1.c
2.F.1 Refrigeration and Air Conditioning Equipment	HFCs, PFCs	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
2.F.2 Foam Blowing	HFCs	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
2.F.3 Fire Extinguishers	HFCs	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
2.F.4 Aerosols/ Metered Dose Inhalers	HFCs	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
2.F.5 Solvents	HFCs	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
2.F.7 Semiconductor Manufacture	HFCs, PFCs	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
2.F.7 Semiconductor Manufacture	SF_6	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
2.F.8 Electrical Equipment	SF_6	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
2.F.P2.2 In products	SF_6	Because of wrong allocation the emissions were reallocated.
3.D.3 N2O from Aerosol Cans	N_2O	Emissions of N_2O used in Aerosol cans of cream are aggregated in technical use of N2O in 3.D.4 Other Use of N_2O.
5.A.1 C from liming forests	CO_2	As data cannot be differentiated with regard to types of application (dolomite or lime) dolomite use is included in limestone use.
5.A.1 Forest Land remaining Forest Land	Carbon	Losses are included in Gains.
5.A.1 Forest Land remaining Forest Land	CO_2	Due to the stock change method used for the estimation of carbon stock changes in biomass, CO_2-emissions are included in category 5.A. carbon stock change in biomass.
5.A.2 Land converted to Forest Land	CH_4	Area burned under Land converted to Forest Land cannot be differentiated from Area burned reported under Forest Land remaining Forest Land, therfore it is included in the latter category.
5.A.2 Land converted to Forest Land	CO_2, N_2O	Area burned under Land converted to Forest Land cannot be differentiated from Area burned reported under Forest Land remaining Forest Land, therfore it is included in the latter category.
5.B.1 Cropland remaining Cropland	CO_2	As data cannot be differentiated with regard to types of application (dolomite or lime) dolomite use is included in limestone use.
5.B.2.1 Forest Land converted to Cropland	N_2O	Reported under 4.D. (see NIR 7.3.4.4)
5.B.2.2 Grassland converted to Cropland	N_2O	Reported under 4.D. (see NIR 7.3.4.4)
5.B.2.3 Wetlands converted to Cropland	N_2O	Reported under 4.D. (see NIR 7.3.4.4)

Source/sink category	GHG	Allocation used by the Party / Explanation
5.B.2.5 Other Land converted to Cropland	N_2O	Reported under 4.D. (see NIR 7.3.4.4)
5.C.1 Grassland remaining Grassland	CO_2	As it is not possible to distinguish between the application on Cropland and on Grassland, lime application is reported under Cropland.
5.C.1 Grassland remaining Grassland	CO_2	As it is not possible to distinguish between the application on Cropland and on Grassland, lime application is reported under Cropland. Dolomite is included in limestone.
6.B.1 Industrial Wastewater	CH_4	CH_4 is generated, but it is covered or flared off. Covered CH_4 is included in 1.A.2. Emissions from leakage are assumed to be very low - thus negligible.
6.B.2.1 Domestic and Commercial (w/o human sewage)	CH_4	CH_4 is generated, but it is covered or flared off. Covered CH_4 is included in 1.A.1+2. Emissions from leakage are assumed to be very low - thus negligible.
AWACS maintenance	SF_6	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
Car Tyres	SF_6	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
Cement	CH_4, CO_2, N_2O	Reported in source category 1.A.2.f other, because of confidential data.
Ceramics	CH_4, CO_2, N_2O	Reported in source category 1.A.2.f other, because of confidential data.
Double glaze windows	SF_6	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
Glass Wares	CH_4, CO_2, N_2O	Reported in source category 1.A.2.f other, because of confidential data.
lime	CH_4, CO_2, N_2O	Reported in source category 1.A.2.f other, because of confidential data.
Magnesium production	SF_6	The confidential emissions are reported in 2G.
Military use	CH_4	CH_4 emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
Military use	N_2O	N_2O emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
N_2O for Medical Using	N_2O	The emissions from the production of N_2O for the use as anaesthetic are included in the emissions from the use of aneasthetics in 3.D
Optical Glass Fibre	SF_6	The confidential emissions are reported in 2G.
Other non-specified	CH_4	is considered in steel
Other non-specified	CH_4	
Other non-specified	N_2O	
Other non-specified	SF_6	Confidential SF_6-emissions of the use in AWACs, Sport shoes and for Welding are reported in "Unspecified mix of HFCs" to keep confidentiality of these data.
Shoes	PFCs, SF_6	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
Solar Technology	PFCs, SF_6	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
Trace gas	SF_6	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.
Welding	SF_6	The potential emissions are not disaggregated into the subcategories. Such detailled informations are because of confidential and technical reasons not possible.

22 ANNEX 6: ADDITIONAL INFORMATION TO BE CONSIDERED AS PART OF THE NIR SUBMISSION (WHERE RELEVANT) OR OTHER USEFUL REFERENCE INFORMATION

22.1 Additional information relative to inventory preparation and to the National System

22.1.1 Definitions in the "National System" principles paper on emissions reporting

In the "National System" principles paper on emissions reporting, state secretaries of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU); Federal Ministry of the Interior (BMI); Federal Ministry of Defence (BMVg); Federal Ministry of Finance (BMF); Federal Ministry of Economics and Technology (BMWi); Federal Ministry of Transport, Building and Urban Affairs (BMVBS) and Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) defined responsibilities pertaining to the various relevant source and sink groups and to the necessary financing for 2008. The agreement reads as follows:

BMU, BMI, BMVg, BMF, BMWi, BMVBS, BMELV Berlin, 5 June 2007

"National System" principles paper on emissions reporting

The state secretaries of the ministries concerned have determined as follows, by common consent, with regard to the issue of the "National System" for emissions reporting pursuant to Art. 5(1) Kyoto Protocol:

1. *The Federal Environmental Agency, Section I 4.6*[131] *"Emissions Situation", is the responsible "Single national entity" (national co-ordinating agency) for reporting pursuant to the UN Framework Convention on Climate Change and the Kyoto Protocol. A country's Single National Entity is responsible for preparing the country's national inventory, working for continual improvement of the inventory, supporting those persons involved in the national system and preparing decisions of the Co-ordinating Committee.*

2. *A Co-ordinating Committee, representing all affected departments, has been established to deal with all questions arising in the framework of the National System, and to be responsible for official discussion and approval of the inventories and the reports required pursuant to Articles 5, 7 and 8 of the Kyoto Protocol. The Committee shall support all pertinent processes in this framework and, in particular, it shall clarify any pertinent uncertainties – for example, in connection with definition of individual emission factors.*

   In particular, the Committee shall define key source and sink categories, and the minimum requirements pertaining to quality control and quality assurance for data collection and processing and to the annual quality control and quality assurance plan.

   As necessary, the Committee may specify the methods to be used for calculating emissions in the various source categories and for calculating storage in sink categories. The Committee is chaired by the BMU. The Committee shall meet whenever at least one department sees a need for such a meeting. Subordinate authorities and other institutions involved in inventory preparation may be included in meetings as necessary.

[131] Author's remark: currently, I 2.6.

3. *For preparation of the national inventory, such data shall be used, for calculations of emissions and reductions, as are required pursuant to the provisions of Art. 3 (1) of decision 280/2004/EC and of Art. 2 (1) of the Ground rules for calculating emissions in source categories and storage in sink categories. Inventories shall be prepared on an annual basis. In addition, quality assurance in keeping with the requirements of Art. 12 of the rules shall be carried out. Furthermore, reliable documentation and archiving shall be required.*

Existing data-transfer arrangements, such as those made on the basis of voluntary agreements or legal provisions, should not be fundamentally changed; they should only be completed and improved as necessary in order to provide a reliable database. For this reason, the aforementioned responsibilities do not necessarily include data collection and forwarding. With regard to division of responsibilities between BMU/UBA, BMVBS and BMWI, attention is called especially to Annex 1.

The responsibilities for ensuring proper data delivery to the Single National Entity, and for quality control, documentation and data archiving, shall be distributed as follows among the various relevant departments:

a) For source category 1 (Energy) – with the exception of source categories 1.A.3 (Transport) und 1.A.5a (Energy: other), where emissions sources of the German Federal Armed Forces (Bundeswehr) are concerned – the Federal Ministry of Economics and Technology (BMWi) has responsibility.

b) For source categories 2 (Production processes) and 3 (Use of solvents and other products), the Federal Ministry of Economics and Technology (BMWi) has responsibility.

c) For source category 1.A.3 (Transport), the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) has responsibility.

d) For source category 1.A.5a (Energy: other), where emissions sources of the German Federal Armed Forces (Bundeswehr) are concerned – the Federal Ministry of Defence (BMVg) has responsibility. Where data are subject to secrecy provisions, the Federal Environment Agency shall take the relevant secrecy requirements into account.

e) For source and sink categories 4 (Agriculture) and 5 (Land use, land-use changes and forestry), the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) has responsibility.

f) For source category 6 (Waste) and source category 7, and well as for issues related to greenhouse-gas emissions from biomass combustion, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has responsibility.

g) The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) is also responsible for preparing tables in the standardised reporting format pursuant to Art. 2 (2) letter a of Decision 2005/166/EC (implementation rules) in source and sink categories 4 and 5.

In addition, the relevant authorities, as determined by the pertinent statistics regulations, are responsible for tasks relative to official statistics, including data delivery, quality assurance and data documentation and archiving. Co-operation between a) the statistical offices of the Federal Government and the Länder and b) the agencies concerned with reporting is co-ordinated via the Federal Statistical Office. In the process, secrecy requirements pertaining to statistics are to be observed.

4. *The responsible departments shall clarify, in the short term, how proper data provision is to be permanently assured, to the extent such clarification has not already been completed. In particular, this requirement shall apply to agreements, ordinances or laws needed for institutionalisation of the National System. In general, for purposes of emissions reporting, voluntary agreements with associations and/or individual companies shall have the same status as pertinent legal provisions. In addition, as agreed in the co-ordination discussion on 12 September 2006, the Federal Environment Agency and the Federal Statistical Office shall determine what data can be provided, for reporting purposes, from the official statistical system, as well as what additional data should be collected via the official statistical system. The various relevant departments, the Federal Environment Agency and the Federal Statistical Office shall send their pertinent proposals to the BMU by 15 July 2007.*

5. *By 31 July 2007, the BMU shall invite participating departments to co-ordinate pertinent proposals and to establish a schedule for implementing the required instruments. The responsible departments, and the Federal Government, shall arrange for the establishment of the required instruments as quickly as possible.*

6. *Where additional funding is required for execution of the responsibilities mentioned under 3., such funding shall be provided from proceeds from sale of AAUs, via an expansion of the state secretaries' agreement of 22 December 2006 relative to Article 3.4 of the Kyoto Protocol.*

   To this end, a budget item for relevant income shall be established within Individual Plan 16 (Einzelplan 16) as of the 2008 fiscal year. Following review by the Federal Ministry of Finance (BMF), the additional requirements requiring financing shall be listed as expenditures within the departments' individual budgets. The departments' additional requirements in this regard must be submitted to the BMF by 6 June 2007.

   Should additional budget funding be required in coming years, in addition to the additional requirements determined in connection with the 2008 budget, then suitable relevant amounts of additional AAUs shall be sold in subsequent years.

[…]

Annex: Division of responsibilities between BMU/UBA, BMVBS and BMWI

The BMU, BMVBS and BMWi have agreed that the existing emissions-reporting structures are to be retained and that the Federal Environment Agency (UBA) shall continue to perform its existing tasks with regard to the source categories 1, 1.A.3, 2 and 3. The BMVBS and the BMWi shall ensure that any gaps in the data for those source categories for which they are responsible are closed.

Specifically:

BMWi:

With regard to source category 1: The inventories in this area shall be prepared by the Federal Environment Agency, on a basis that shall include energy data provided by the agency contracted by the BMWi for preparation of energy balances, as well as on the basis of additional relevant statistics and association information.

With regard to source category 2: The inventories in this area shall be produced by the Federal Environment Agency on the basis of data that shall include data from statistics of the manufacturing sector (Produzierendes Gewerbe – ProdGewStatG) and from communications of relevant associations / individual companies.

With regard to source category 3: The inventories in this area shall be produced by the Federal Environment Agency on the basis of data that shall include data from statistics of the manufacturing sector (Produzierendes Gewerbe – ProdGewStatG), from foreign trade statistics and from communications of relevant associations / individual companies.

Existing requirements for further optimisation shall be clarified, in the short term, by BMWi, BMU and UBA, working in co-ordination. Where data optimisation is required via changes in existing surveys based on the Environmental Statistics Act (UStatG) or on the 13th Ordinance on the Execution of the Federal Immission Control Act (13. BimSchV), the BMU shall be responsible. The Federal Environment Agency shall assume responsibility for recording and archiving data received by the Federal Environment Agency.

BMVBS:

Emissions relative to source category 1.A.3 (Transport) shall be calculated by the Federal Environment Agency, using the TREMOD model. The BMVBS shall provide data/calculations as needed to close data gaps and determine emissions relative to international air transports or shall ensure that such data/calculations are provided by third parties. At present, emissions from ship transports may be calculated from Energy Balance data, using default emission factors. The Federal Environment Agency shall assume responsibility for recording and archiving data received by the Federal Environment Agency.

22.1.2 Additional information about the Quality System of Emissions Inventories

22.1.2.1 Minimum requirements pertaining to a system for quality control and assurance

As described above in the main section, the requirements pertaining to the system for quality control and quality assurance (QC/QA system) and to measures for quality control and quality assurance are defined primarily by Chapter 8 of the *IPCC Good Practice Guidance*.

From those provisions, the Federal Environment Agency has derived its own "General minimum requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting" ("Allgemeine Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der Treibhausgasemissionsberichterstattung"; last revision: November 2007). These are described below.

22.1.2.1.1 Introduction

Representatives of the departments participating in the co-ordinating committee for the National System of Emissions Inventories define the general minimum requirements, which are described in the present document, for quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions. Such minimum requirements serve as the basis for collection, processing and forwarding of, and reporting on, all data that support the process of reporting on greenhouse-gas emissions.

These minimum QC/QA requirements must be adhered to on all levels of inventory preparation. In many cases, relevant efforts can draw on existing processes and systems, such as the quality standards for public statistics. Annex 1 of the present document describes, by way of example, implementation of the minimum QC/QA requirements and the

QC/QA system within the Federal Environment Agency. All participating institutions are required to submit suitable descriptions of their implementation of these minimum requirements; such descriptions are to be published with the inventory report in the framework of reporting in 2009. On request, the Federal Environment Agency supports participating ministries in preparing QC/QA systems in their relevant areas of responsibility.

22.1.2.1.2 System for quality control and quality assurance

The *rules (Commission Decision 2005/166/EC) implementing Decision 280/2004/EC* require national greenhouse-gas inventories to conform to the QC/QA requirements of the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC Good Practice Guidance) and the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (IPCC Good Practice Guidance for LULUCF).

The *IPCC Good Practice Guidance* specifies that QC/QA systems must be introduced, with the aim of enhancing transparency, consistency, comparability, completeness and precision of national emissions inventories and, especially, that such inventories must fulfill requirements pertaining to "good inventory practice". A QC/QA system comprises the following:

- An agency responsible for co-ordinating QC/QA activities
- Development and implementation of a QC/QA plan
- General QC procedures
- Source-category-specific QC procedures
- QA procedures and
- Reporting procedures
- Documentation and archiving procedures

QC/QA measures can conflict with requirements for punctuality and cost-effectiveness. Available time, and available staffing and financial resources, should thus be taken into account in any QC/QA-system development. In good practice, more stringent data-quality requirements are applied to key categories. For other source categories, not all source-category-specific QC procedures have to be implemented. In addition, not all measures have to be carried out on an annual basis; for example, data-collection methods have to be reviewed only once in detail. Thereafter, it suffices to carry out periodic controls to determine whether the prerequisites for application of relevant methods are still being fulfilled. Data uncertainty is another factor that enters into requirements pertaining to QC/QA measures. In order to reduce an inventory's overall uncertainty, those source categories that have high levels of uncertainty should be reviewed in detail.

22.1.2.1.3 Agency responsible for co-ordinating QC/QA activities

As the Single National Entity (national co-ordinating agency), the Federal Environment Agency is responsible for the QC/QA system for the national greenhouse-gas inventory. In this function, it has established the position of co-ordinator for the Quality System for Emissions Inventories (QSE). In good practice, each company and organisation involved in inventory preparation appoints a QC/QA co-ordinator and notifies the QSE co-ordinator of such appointment.

A QC/QA co-ordinator has responsibility for ensuring that a relevant QC/QA system is developed and implemented. Such implementation should be suitably institutionalised – for example, by means of an in-house directive or association agreement.

In order to ensure that the Single National Entity can efficiently carry out its supporting tasks, the persons responsible for the following additional functions should be announced (by name) to the QSE co-ordinator:

Responsible expert (Fachverantwortlicher) – Person responsible for data collection, data entry and pertinent calculation, in keeping with the prescribed methods, as well as for carrying out QC measures and preparing a relevant textual contribution for the National Inventory Report.

Quality control manager (Qualitätskontrollverantwortlicher) – Person responsible for checking and approving data and report sections (the QC/QA co-ordinator may also perform this function).

22.1.2.1.4 QC/QA plan

The purpose of the QC/QA plan is to ensure that QC/QA measures are properly organised and executed. It includes a description of all required QC/QA measures and a schedule for implementation of such measures. The QC/QA plan also defines the primary emphases of such measures. The criteria for selection of source categories for detailed review include the following:

- The source category's relevance (key category yes/no, uncertainties high/low)
- The time of the last detailed QC/QA measure for the source category, and the results of such measure
- Changes in methods or the pertinent database
- Results of annual inventory review in keeping with the UN Framework Convention on Climate Change and the Kyoto Protocol
- Available resources for execution of QC/QA measures

Good practice calls for establishing a QC/QA plan and then reviewing and updating it each year after the latest inventory has been prepared.

On the basis of the results of annual inventory review, and of the results of QC/QA measures of which it is aware, the Single National Entity prepares an improvement plan for the entire inventory. On this basis, in turn, it derives proposals for a binding inventory plan for the next report year. Such proposals are then submitted to the co-ordinating committee for approval. The QC/QA co-ordinator, working in co-operation with the QSE co-ordinator in the Single National Entity, defines the procedures, scheduling and scope for inclusion of his institution's QC/QA measures in the inventory plan for the overall inventory.

22.1.2.1.5 General quality control

Pursuant to the definition used by the IPCC (Chapter 8.1 *Good Practice Guidance*), quality control (QC) comprises a system of routine specialised measures for measuring and checking the quality of inventories in preparation.

Consequently, a QC system should achieve the following:

- Facilitate routine, standardised checks in the interest of data integrity, correctness and completeness;

- Identify and eliminate errors and omissions;
- List and archive inventory material and record all QC activities.

Table 8.1 of the *IPCC Good Practice Guidance* includes a complete list of general QC measures. Requirements pertaining to general, Tier-1 QC procedures can be derived from the requirements mentioned in Chapter 8.6 of the *IPCC Good Practice Guidance*. Typical general quality control measures in activity-rate determination include checking data for transfer errors, checking data for completeness, checking formulae for combining data and carrying out plausibility checks with the help of external data sources and earlier calculations. Suppliers of emissions calculations have to carry out additional QC measures – for example, checking formulae for emissions calculation.

Required quality controls should be recorded in checklists. Such lists should include at least the checking measures carried out, the results of checking, any pertinent corrections made and the name of the person(s) responsible for the measures. Annex 2 of the present document includes a sample checklist of the Federal Environment Agency.

Not all quality controls have to be carried out on an annual basis; some may be implemented at longer regular intervals. This applies especially to aspects of data collection that do not change from year to year. Requirements pertaining to the frequency and completeness of QC measures are more stringent for key categories than for other source categories. It should be ensured that all source categories undergo detailed quality control at least periodically.

22.1.2.1.6 Source-category-specific quality control

Available resources permitting, particularly relevant source categories (such as key categories), in addition to undergoing Tier 1 procedures, should undergo Tier 2 quality control with regard to determination of activity rates, emissions and uncertainties (cf. Chapter 8.7 *Good Practice Guidance*). The chapters of the IPCC Good Practice Guidance that pertain to the various individual source categories (Chapter 5) include additional information relative to source-category-specific QC measures. Such guidelines must be observed in preparation of any QC/QA plan: :

Where combined **activity data** from secondary sources are used, good practice calls for evaluating pertinent QC measures in connection with preparation of such secondary sources. If the level of such measures is adequate, it suffices to call attention to this fact in the documentation. Where secondary sources do not fulfill minimum requirements pertaining to quality control, suitable QC/QA checks should be carried out by the institution that uses the data. Results of subsequent QC/QA checks should enter into determination of uncertainties for activity rates. In addition, wherever possible, a range of different sources should be compared for purposes of determining data quality.

In use of facility-specific activity data, it is good practice to review the methods and QC/QA standards applied to data collection. Where such methods and standards do not meet minimum requirements, the advisability of using the data should be reconsidered and the uncertainties should be adjusted as necessary.

With regard to **emissions data**, it is good practice to review the emission factors that have been used. Such efforts include using national emission factors for key categories and reviewing the validity of IPCC standard factors under the applicable national circumstances.

Where emissions data are obtained via direct measurements, it is good practice to review the relevant measurement methods and the quality standards applied. Emissions data and emission factors should be reviewed in light of data from previous years, and from independent sources, and any resulting discrepancies should be explained.

Quality control for uncertainties includes checking to determine whether calculations are free of errors and whether documentation for reproduction of results is adequate. In use of experts' assessments, the pertinent experts' qualifications and estimation methods should be reviewed and documented.

22.1.2.1.7 Quality assurance procedures

While the primary aim of quality control is to ensure that methods are correctly applied, the primary purpose of quality assurance is to examine methods as such and improve them as necessary.

Pursuant to the relevant IPCC definition (Chapter 8.1 Good Practice Guidance), measures for **quality assurance** (QA) are based *"on a planned system of reviews by persons who are not directly involved in preparing the inventory. Such reviews – which are best carried out by independent third parties – should be applied to completed inventories, after QC procedures have been carried out. Such measures accomplish the following:*

- Verify that data-quality criteria are fulfilled,
- Ensure that the inventory takes account of the best available estimates of emissions and sinks, in keeping with the latest scientific findings and available data, and
- Promote the efficiency of the QC system".

The required instrument for quality assurance is the peer review. While use of audits is encouraged, audits are not required.

22.1.2.1.8 Reporting procedures

The Single National Entity is responsible for initiating and co-ordinating reporting and carrying out relevant overall organisation. Provision of data and reports by third parties must conform to applicable requirements pertaining to the scope, form and scheduling of/for such provision.

22.1.2.1.9 Documentation and archiving

As a general requirement, all data and information used for inventory calculation must be documented (i.e. recorded) and archived, for each report year. The purpose of such documentation (i.e. recording) is to make it possible to completely reconstruct all emissions calculations after the fact. The general requirements pertaining to documentation and archiving for the entire process of preparation of greenhouse-gas inventories are described in Chapter 8.10.1 of the *IPCC Good Practice Guidance*.

Consequently, data providers have the obligation to keep records of the following information relative to data they supply to the Federal Environment Agency, for purposes of inventory calculations:

Data providers:

- Publication / source of activity data, with detailed referencing of the relevant Table numbers and names, and of the relevant pages in the original sources;
- Survey contents (definitions of the surveyed characteristics, delimitations used, survey units used) and survey methods;
- The legal foundations and ordinances on which surveys are based;
- Chronological and spatial comparability with previous-year data, and any changes with regard to definitions, scopes of validity, cut-off points, sources of activity rates or data-collection methods;
- Any revision of previously published data;
- The accuracy or quantitative error of activity data, methods used to estimate errors and the names of experts who have carried out error estimation.
- Secrecy and data protection: suitable notification with regard to any individual data items that are considered secret.

Such materials should be provided to the Federal Environment Agency on an annual basis, together with pertinent data, and they are centrally archived by the Federal Environment Agency.

Quality control (QC)

The records kept in the framework of quality control should include the names of the persons responsible for managing and carrying out relevant actions, the types of quality control carried out, the dates on which quality control measures were carried out, the pertinent results, and the corrections and modifications triggered by quality control measures. In each case, record-keeping and archiving for quality control measures are carried out internally, by the institution supplying the pertinent data. A general description of regularly executed quality control measures is provided to the Federal Environment Agency for purposes of the national inventory report and inventory review.

Providers of emissions calculations

For providers of emissions calculations, the minimum requirements pertaining to record-keeping also include the following:

- Description of the pertinent calculation methods and reasons why the methods were selected;
- Assumptions and criteria pertaining to selection of activity data and emission factors;
- Documentation pertaining to emission factors and their sources, with detailed references to the relevant numbers and pages in original sources;
- Calculation models;
- Calculation files, calculation software.

Points 1-4 are recorded and archieved along with descriptions provided for the national inventory report. Separate documentation pertaining to calculation models must be provided, in keeping with general scientific practice, and along with internal documentation in the form of manuals or guides. Data suppliers archive calculation files and calculation software, and keep pertinent records, on an internal basis. Such materials should be provided to the Federal Environment Agency as necessary in the framework of inventory review.

Quality assurance

In addition to carrying out quality control measures, providers of emissions calculations are obligated to carry out quality assurance. The records kept in the framework of quality assurance should include the names of the persons responsible for managing and carrying out relevant actions, the types of quality assurance carried out, the dates on which quality assurance measures were carried out, the pertinent results, and the corrections and modifications triggered by quality assurance measures. In addition, records should be kept of source-category-specific quality controls.

In each case, record-keeping and archiving relative to pertinent quality assurance are carried out internally, by the relevant data-supplying institution. In addition, pertinent quality assurance measures are summarised in the national inventory report.

Confidential data / secrecy

In general, confidential data must be designated as such when they are provided, to ensure that the proper precautions are taken when they are used.

In inventory review, general obligations apply whereby confidential data must be disclosed in cases in which inventory reviewers consider such disclosure to be necessary to ensure that emissions calculations are transparent and clear. The extent to which such disclosure actually must involve disclosure of individual data items should be clarified on a case-by-case basis with the institution providing the data.

22.1.2.1.10 Annex 1: Minimum requirements pertaining to quality control and quality assurance in emissions reporting in the Federal Environment Agency

22.1.2.1.10.1 Introduction

The general minimum requirements, as approved by the co-ordinating committee for the National System of Emissions Inventories, pertaining to quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions apply to all participants. These requirements are the basis for collecting, processing, forwarding and reporting of/on all data that support reporting on greenhouse-gas emissions. They are thus binding for all working groups involved, in the Federal Environment Agency, in fulfillment of this reporting task.

22.1.2.1.10.2 System for quality control and quality assurance

In addition to the general minimum requirements, approved by the co-ordinating committee for the National System of Emissions Inventories, pertaining to quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions, the specific provisions of in-house directive (Hausanordnung) No. 11/2005 also apply at the Federal Environment Agency. Pursuant to that directive, the pertinent procedure defined in the QSE manual is binding for all Federal Environment Agency personnel involved in emissions reporting (Rules of procedure of the Federal Environment Agency (Geschäftsordnung des Umweltbundesamtes), Volume II, Numeral XV).

The in-house directive fully implements the requirements of Chapter 8 of the *IPCC Good Practice Guidance*. Suitable UBA-specific instruments have been established to ensure effective identification and execution of measures for continual inventory improvement (improvement plan and inventory plan; cf. 22.1.2.1.10.3). That work has led to the development of the Quality System for Emissions Inventories (QSE), via which the points mentioned in Chapter 22.1.2.1.2 have been implemented.

22.1.2.1.10.2.1 Agency responsible for co-ordinating QC/QA activities in the Federal Environment Agency

Pursuant to in-house directive No. 11/2005, section FG I 2.6, "Emissions Situation", is the "Single National Entity" (SNE) within the Federal Environment Agency. In the Federal Environment Agency's organisational diagramme, the so-defined SNE is thus included in the Federal Environment Agency's group of "focal points" and liaison offices for international organisations. In addition, this assignment of responsibility was confirmed by the relevant ministries via a state secretaries' resolution of 5 June 2007.

The roles and responsibilities of the Single National Entity, and of the specialised departments participating in emissions reporting, are described in Chapter 3.2, "Roles and responsibilities", of the QSE manual. The Single National Entity is responsible for updating and managing the QSE manual and its appendices and annexes. In carrying out this responsibility, the SNE is assisted by the contact persons named to it by the relevant specialised departments. The version of the QSE manual and its co-applicable documents published on the Single National Entity's intranet is the binding version of these materials.

22.1.2.1.10.2.2 Reporting procedures

In many cases, complex activities comprise numerous different, but related and cumulative, activities (processes) that lead to the production of a single product. To manage such processes effectively, one must strive to understand the manner in which the processes function (or should function), to describe such functioning in logical, realistic ways (activities, dependencies, responsibilities, and many more) and to interrelate the processes in a useful way.

In practice, workflows of complex processes cannot always be fit smoothly into the hierarchical, traditional structures of companies and institutions. The required processes are often diametrally opposed to such structures, since they have to cut across different organisational units. To organise interrelated work processes in a manner oriented to production of the desired product, one must look outside of rigid hierarchies and redefine the processes with a view to improvement.

For this reason, emissions reporting was first described as a process that, via a number of interrelated activities, leads to a product (NIR and inventories) (cf. Figure 82). Additional relevant information is provided in the QSE manual, Chapter 4.3.

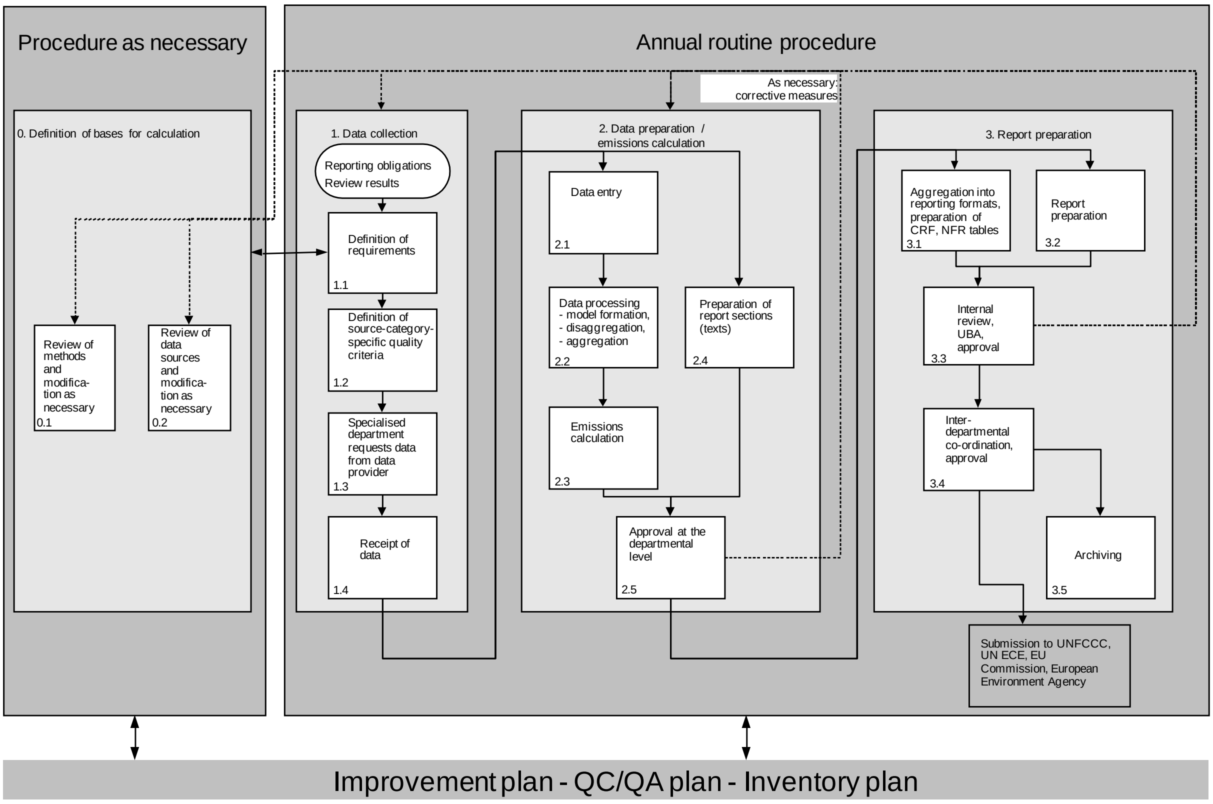


Figure 82: Overview of the overall emissions-reporting process

Via a role concept, suitable responsibilities have been assigned to cover the activities within the main processes and sub-processes shown. Each responsibility thus involves execution of pertinent processes. To understand this approach, it is useful to consider the situation in which many different people carry out the same basic activities even though they work in different work units and source categories. In the present case, this situation was approached by defining a certain group of persons (persons with a specific role – for example, responsible experts). That group was then seen to be subordinate to another group of persons (with a different role – for example, specialised contact persons) that ensures that the first group observes and fulfills the requirements pertaining to its work. In addition, a QSE co-ordinator was appointed, in keeping with relevant requirements of the IPCC (cf. Chapter 22.1.2.1.2), to ensure that the system is refined and improved as necessary.

Overall, a comprehensive role concept was developed that addresses the many different requirements applying to the Federal Environment Agency in its task as Single National Entity. The roles involved include the following:

1. Responsible expert at the operational level (FV)

- Main responsibilities: data collection, data entry, calculations with prescribed methods, execution of QC measures, preparation of the NIR text

2. Quality control manager (QKV)

- Is the superior for the FV
- Main responsibilities: checking and approving data and report sections

3. Specialised contact person (FAP)

- Member of the Single National Entity's staff

- Main responsibilities: providing source-category-specific support for involved experts (inventory work and report preparation) and quality control / quality assurance relative to pertinent source categories in the NIR and CSE.

4. Co-ordinator for the national inventory report (NIRK)

- Member of the Single National Entity's staff
- Main responsibilities: co-ordination of supporting textual work, preparation of the NIR from the various relevant contributions, overarching QC and QA for the NIR

5. CSE co-ordinator (ZSEK)

- Member of the Single National Entity's staff
- Main responsibilities: maintenance of databases, emissions calculation and aggregation, overarching QC and QA in connection with data entries and calculations for the inventory

6. QSE co-ordinator (QSEK)

- Member of the Single National Entity's staff
- Main responsibilities: maintenance and refinement of the QSE (system, checklists, improvement plan, inventory plan, QC/QA plan and QSE manual)

7. NaSE co-ordinator (NaSEK)

- Member of the Single National Entity's staff
- Main responsibilities: schedule-conformal, requirements-conformal reporting, providing for involvement of national institutions, establishing/recording legal agreements

As a rule, each of the above-described roles will have tasks in several different main and sub-processes of emissions reporting.

22.1.2.1.10.3 QC plan, QA plan and inventory plan

To ensure that all potential improvements identified during the course of inventory work are systematically implemented, identified improvements must be listed in a co-ordinated way. In the process, identified potential improvements should be listed together with all relevant information (origin of the potential improvement, source category, pertinent responsibility, priority, etc.) needed for efficient further processing. Planning and arrangements for implementing identified potential improvements (required actions / corrective measures, deadlines, etc.) should then be made on the basis of such information.

In the interest of proper control and record-keeping in the framework of the NaSE and the QSE (cf. Figure 83), procedures have been defined for processing identified potential improvements for their systematic management and further use. The overall aim is to answer the central question of WHO should do WHAT, HOW, WHEN and WHY:

WHO: This provides the reference to the role concept: A certain person xy is responsible – for example, in the role of responsible expert (FV)

WHAT: This provides the reference to the object that is to be improved – for example, the CO_2 calculation in source category xy needs to be improved

HOW: This provides the reference to the aim that is to be achieved – for example, a certain improvement, pursuant to an inventory plan or checklist.

WHEN: This provides the reference to the time by which the improvement must be completed, pursuant to the inventory plan

WHY: This provides the reference to the origin of the necessary action – for example, the improvement must be carried out as a result of a recommendation via the UNFCCC review process

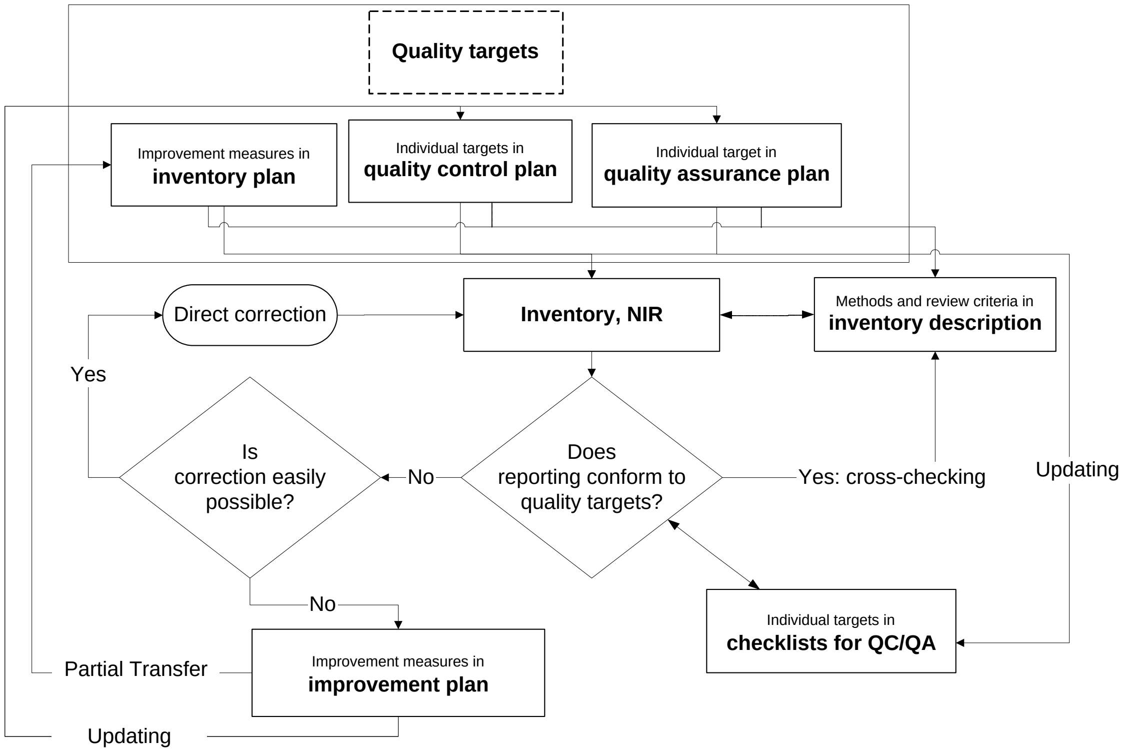


Figure 83: Control and documentation in the framework of the NaSE and the QSE

The **quality targets** have been derived from the general quality aims of the IPCC Good Practice Guidance (transparency, consistency, accuracy, comparability, completeness). In addition, operational individual objectives, relative to quality control and quality assurance, for the various source categories, have to be derived from comparison of the requirements from the *IPCC Good Practice Guidance*, the results of independent inventory review (UNFCCC and EU) and assessment of inventory realities.

In an **improvement plan**, all potential improvements and criticisms resulting from independent inventory review are collected and assigned potential corrective measures. The Single National Entity categorises the corrective measures, prioritises them and then, via consultations with the relevant responsible experts, integrates them as necessary within the **inventory plan**. There, they are linked with deadlines and responsibilities. As an annex to the NIR, the inventory plan undergoes a co-ordination and release process in the Federal Environment Agency and in the co-ordinating committee. It is thus a binding set of specifications for improvements to be carried out in future.

In the interest of transparent, effective control and execution of inventory-improvement measures, such measures, in keeping with the *IPCC Good Practice Guidance* (Chapter 8.5) are defined role-specifically, as well as source-category-specifically as necessary, in the

quality control plan / quality assurance plan (QC/QA plan). The QC plan is oriented solely to quality control aims for the inventory. In the QA plan, quality assurance objectives may be focused on the inventory, the reporting process or the QSE itself. Furthermore, the quality assurance plan includes scheduling of quality assurance measures to be performed by external third parties.

The **checklists for quality control and quality assurance** list all individual objectives in the emissions-reporting process, in keeping with the pertinent quality control and quality assurance plans. The checklists, which are designed to facilitate review of achievement of individual objectives, are made available to all persons responsible for quality control and quality assurance. The checklists are used to record execution of measures for quality control and quality assurance. Where individual objectives are not achieved and direct correction is not possible, a pertinent entry must be made in the improvement plan (see above).

22.1.2.1.10.4 Procedures for general and source-category-specific quality control

From the requirements set forth in the IPCC Good Practice Guidance, the Federal Environment Agency has developed a checklist concept via which quality requirements are formulated as specific targets. Every effort should be made to achieve such targets. When a target is achieved, such achievement is noted and described in the checklists. The possible entries for such records include "yes" (the target was achieved), "not relevant" (the target as formulated does not correspond to the special situation for the source category in question; this answer is seldom a viable option) and "no" (it was not possible to achieve the target).

Each checklist includes a general section that reflects all Tier 1 QC requirements from IPCC Good Practice Guidance and that is used in connection with every instance of reporting. In addition, each checklist contains a source-category-specific section (Tier 2) that provides concrete objectives for the relevant key category area.

Checklists are provided only for the first five roles within the role concept. Where different roles are responsible for different main and sub- processes of emissions reporting (cf. Chapter 22.1.2.1.10.2.2), pertinent checklists will also be oriented to several different main and sub- processes of emissions reporting. They thus represent a cross-section of emissions reporting. The checklists of the FV and the FAP include a basic common set of goals. The FAP are responsible for checking the work of the FV, and such checking is most effective when both roles are oriented to the same goals.

22.1.2.1.10.5 Quality assurance procedures

In the role concept, procedures are designed to ensure that quality assurance is always supported by a "four-eyes" principle. The specialised contact persons (FAP) have the task of ensuring that the emissions calculations and textual work of the responsible experts (FV) are of the proper quality.

In its section on "Expert Peer Review", the IPCC notes that the (above-described) formal procedure selected by the Federal Environment Agency can complement, but not replace, expert peer review (Good Practice Guidance; Chapter 8.8). In one solution found for addressing the justified call for inclusion of external experts, within the framework of available resources, detailed review of specific issues is carried out by external third parties via research projects and studies. In general, the two sides involved (i.e. FV and FAP) jointly manage the process of commissioning third parties. In another means found for addressing the need for third-party inclusion, workshops on the National System are held at irregular intervals. For such workshops, national experts are invited to come to the Federal Environment Agency for discussion with Federal Environment Agency experts (FV) on current inventory issues relative to selected source categories.

No audits have been carried out in the Federal Environment Agency to date, and none are planned at present. According to the Good Practice Guidance, audits are not absolutely required.

22.1.2.1.10.6 Documentation and archiving

Standardised record-keeping and archiving procedures are to be used in preparation of German greenhouse-gas inventories. At the same time, it is important to differentiate between the central record-keeping and archiving carried out by the Single National Entity and the non-central record-keeping and archiving carried out by the specialised departments of the Federal Environment Agency and of other institutions.

Record-keeping procedures for data and context information vary in accordance with specific requirements. In their information storage, they overlap to some degree, with such overlapping consisting partly of redundancies and partly of storage of similar items at differing levels of detail. On a regular basis, consistency must be ensured for both types of overlapping.

To ensure that all of the Federal Environment Agency's working units use basically consistent procedures, the specifications applying to the instruments used in such procedures – including both general specifications and specifications developed especially for emissions reporting – must be complied with. For purposes of "documentation" (i.e. record-keeping), the Federal Environment Agency has access to the instruments described in Table 379. The specifications pertaining to each type of document / record must be observed. Where no special specifications apply, the provisions from the "General minimum requirements for quality control and quality assurance in reporting on greenhouse-gas emissions" ("Allgemeine Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der Treibhausgasemissionsberichterstattung") apply.

Table 379: Documentation / record-keeping instruments at the Federal Environment Agency

Instrument	Specifications
Publicly available	
National inventory (CRF tables, CRF-Reporter)	Annex 2, QSE manual: instructions for carrying out recalculations in the CRF tables
National inventory report	Annex 3, QSE manual: specifications for preparing report sections in the context of the National System
Publication	Rules of procedure of the Federal Environment Agency: Point 6.2 Publications
Published manuals, guides	For IT descriptions: procedural model of the Federal Environment Agency; otherwise: no special specifications
Centralised, and internally available, at the Single National Entity	
CSE database	Annex 5, QSE manual: specifications for data recording within the CSE
Inventory description	Annex 4, QSE manual: requirements pertaining to documentation (record-keeping) and archiving
De-centralised, and internally available	
Files of the central registry	Rules of procedure of the Federal Environment Agency: Point 4.2.10 Handling of files
Reference files	no special specifications
Internal manuals, guides	For IT descriptions: procedural model of the Federal Environment Agency; otherwise: no special specifications

An integrated documentation / record-keeping concept defines what key content should be stored in the aforementioned documentation instruments. It also defines how a suitable referencing system is to be used to ensure consistency and transparency throughout all such instruments (cf. Annex 4, QSE manual).

22.1.2.1.11 Annex 2: Example of a general checklist for the responsible-expert role

The example presented below (last revision: CHKL 2010) includes only the relevant requirements. Detailed information has been removed in the interest of clarity.

Table 380: General checklist for responsible experts

Process No.	Sub-process name	Individual goal	Optional goal
Main process: 0. Definition of bases for calculation			
0.1	Review of methods, and modification as necessary	The calculation method is in conformance with current key-category analysis.	
0.1	Review of methods, and modification as necessary	The calculation method has been selected in accordance with, or accords with, the pertinent decision tree of the IPCC Good Practice Guidance.	Departures from the decision tree of the IPCC Good Practice Guidance have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.
0.1	Review of methods, and modification as necessary	The calculation method has been selected in keeping with requirements from the inventory plan.	Departures from the inventory plan have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.

0.1	Review of methods, and modification as necessary	The selected calculation method can be applied to the entire time series as of 1990, or is already being consistently applied.	In cases of changes of methods in the time series, recalculation pursuant to the QSE manual (Annex 2), and proper pertinent documentation, are assured.
0.1	Review of methods, and modification as necessary	Departures from the objectives required via 0.1.01-0.1.04 have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.	
0.2	Review of data sources, and modification as necessary	Have new data sources been used?	
0.2	Review of data sources, and modification as necessary	The data source(s) is / are / will be available throughout the long term (for example, on the basis of legal provisions, long-term agreements [> 3 years], etc.).	
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	Gaps in the data available for time series as of 1990 have been properly and logically explained, and have been duly documented.
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	A suitable procedure (interpolation/ extrapolation) has been chosen for dealing with data gaps, in conformance with IPCC Good Practice Guidance (Chap. 7.3.2.2), and the procedure has been logically documented. Note: Continued use of the same value is not extrapolation !
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	Following closure of data gaps, time-series recalculation has been carried out as necessary, pursuant to QSE manual (Annex 2), and such recalculation has been documented and substantiated in the NIR and CRF.

Process No.	Sub-process name	Individual goal	Optional goal
0.2	Review of data sources, and modification as necessary	The data source(s) completely cover the source category.	The incomplete coverage has been addressed in an extrapolation and has been taken into account in the uncertainties calculation. All steps have been documented and justified clearly and logically.
0.2	Review of data sources, and modification as necessary	Uncertainties information (amount and distribution) is available for the data source(s).	
0.2	Review of data sources, and modification as necessary	The EF and the AD agree in terms of the manner in which they are tailored to the source category.	In the case of discrepancies between the EF and AD, other data sources can establish agreement between the two values. Alternatively, the lack of agreement has been taken into account in an extrapolation, and in the uncertainties calculation, and the entire process has been properly and logically documented.
0.2	Review of data sources, and modification as necessary	The procedures for calculating outset data are clearly described.	
0.2	Review of data sources, and modification as necessary	The data source(s) have been selected in keeping with requirements from the inventory plan.	Any discrepancies have been clearly and logically justified and documented.

0.2	Review of data sources, and modification as necessary	The assumptions and criteria upon which the relevant data source(s) have been selected have been clearly and logically documented.	
0.2	Review of data sources, and modification as necessary	The data provider has carried out routine quality controls of the data source(s). For one-time projects, one-time quality controls have been carried out. Execution of the controls has been duly documented.	
0.2	Review of data sources, and modification as necessary	In use of one/more new data sources, a recalculation pursuant to the QSE manual (Annex 2) was carried out on the basis of this/these other data source(s).	
0.2	Review of data sources, and modification as necessary	In use of IPCC default EF, the manner in which the EF were generated has been reviewed in light of national circumstances, and the EF may be used for Germany. The result of such review has been duly documented.	For IPCC default values that do not fit with national circumstances, the discrepances have been taken into account in the uncertainties and documented.
0.2	Review of data sources, and modification as necessary	In use of EF other than the IPCC default EF, use of such EF has been clearly and logically justified and substantiated. Note: Use of other EF is permissible only when such EF permit more precise calculation of country-specific emissions.	
0.2	Review of data sources, and modification as necessary	The AD used have been compared with other data sources (for example, EU-ETS, IEA, EPER, etc.), and the result has been duly documented.	
	Main process: 1. Data collection		
1.1	Definition of requirements	The requirements pertaining to data reflect the information and indications from the inventory plan and the inventory reviews (for example, S&A Report, Centralized Review).	

Process No.	Sub-process name	Individual goal	Optional goal
1.3	The relevant specialised department requests the data from the pertinent data provider(s)	The requirements pertaining to QC and data formats have been forwarded to the data suppliers and/or contracting entities, and such forwarding has been duly documented. Note: Where data suppliers are involved via NaSE agreements, this objective has been achieved.	The data supplier (for example, an association) carries out its own routine quality controls, and the results have been duly documented.
1.4	Receipt of data	The data provider or contracting entity has carried out the required quality controls and made proper records of such action.	The data supplier (for example, an association) carries out its own routine quality controls, and the results have been duly documented.
1.4	Receipt of data	The received data are complete, without any gaps.	All data gaps in the time series as of 1990 have been closed, in accordance with the IPCC Good Practice Guidance, via extrapolation/interpolation (Chapter 7.3.2.2) and duly documented and justified. Note: Continued use of the same value is not extrapolation
1.4	Receipt of data	The data received are consistent with the previous year's data, and they have been properly described.	Any marked discrepancies with the previous year's data have been duly documented and justified.

1.4	Receipt of data	The order of magnitude of the received data is in line with that of comparable data from other sources (such as ETS data, IEA, EPER, etc.). The result of the review has been duly documented.	The reasons for any discrepancies have been clearly and logically explained and duly documented.
1.4	Receipt of data	The methods/assumptions on which the uncertainties determinations are based have been clearly and logically documented.	Where it was not possible to derive assumptions, expert assessment was carried out, and the relevant expert's quantification was clearly and logically documented.
1.4	Receipt of data	The uncertainties determinations are complete and plausible.	
	Main process: 2. Data preparation / emissions calculation		
2.1	Data entry (preferably into the CSE)	All of the EF have been entered into the CSE.	
2.1	Data entry (preferably into the CSE)	The documentation for the EF data source(s) is complete and conforms to the requirements of the QSE manual (Annexes 3, 4 and 5).	
2.1	Data entry (preferably into the CSE)	Development of the EF within the time series has been plausibly explained and, in the case of unusual effects (such as changes in order of magnitude), has been clearly and logically explained and documented.	Implausible EF have been corrected.
2.1	Data entry (preferably into the CSE)	All of the AD have been entered into the CSE.	
2.1	Data entry (preferably into the CSE)	The documentation for the AD data source(s) is complete and conforms to the requirements of the QSE manual (Annexes 3, 4 and 5).	

Process No.	Sub-process name	Individual goal	Optional goal
2.1	Data entry (preferably into the CSE)	Development of the AD within the time series has been plausibly explained and, in the case of unusual effects (such as changes in order of magnitude), has been clearly and logically explained and documented.	Implausible discrepancies have been corrected.
2.1	Data entry (preferably into the CSE)	Following entry of all data into the CSE, all entered figures, units and conversion factors have been checked for correctness and confirmed.	
2.1	Data entry (preferably into the CSE)	All of the uncertainties have been entered into the CSE and have been documented in keeping with the requirements of the QSE manual (Annexes 3, 4 and 5).	
2.2	Data preparation (model formation, disaggregation, aggregation)	The inventory description includes an adequate description of pertinent models, with regard to organisation, structure, calculation procedures, assumptions, etc..	
2.3	Emissions calculation	The current inventory calculations have been checked against calculations from previous reports.	Where any significant changes or obvious deviations from an expected trend have occurred, the pertinent calculation, and the data used in calculation, have been reviewed, and any persisting discrepancies have been properly, clearly and logically

			explained and duly documented.
2.3	Emissions calculation	The results of emissions calculation for current / previous reports have been checked against other data sources for Germany, especially ETS data, and found to be comparable. The result has been duly documented.	Where comparability has not been found, or no comparison was carried out, the pertinent reasons have been properly, clearly and logically explained.
2.3	Emissions calculation	The national Implied EF (cf. S&A Report I) from the previous report is comparable with the Implied EF of other countries (same order of magnitude).	Extreme Implied EF have been properly, clearly and logically explained, and duly documented, in the NIR, or reference to an existing explanation has been made.
2.4	Preparation of report sections (texts)	The source category has been completely and logically described, for the NIR, in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	
2.5	Approval by the relevant experts	The values of AD, EF and ED, of their uncertainties, are up to date in the NIR and congruent with the pertinent values in the CSE.	
2.5	Approval by the relevant experts	Documentation of the origins for AD, EF and ED data, and for their uncertainties, are up to date in the NIR and congruent with the pertinent values in the CSE.	Lacking or incomplete documentation of data origin has been properly, clearly and logically explained and duly documented.

22.1.3 The database system for emissions – Central System of Emissions

Since 1998, the Federal Environment Agency has maintained and managed an IT tool for inventory preparation: the *Central System of Emissions (CSE)*, an integrated national database. The CSE implements the diverse requirements pertaining to emissions calculation and reporting, and it automates key steps in such work. It supports the processes of inventory planning and reporting (for example, by carrying out emissions calculations and recalculations, and relevant error analysis); inventory management (for example, by carrying out archiving and annual data evaluation); and quality management at the data level (cf. UBA 2003a, Projekthandbuch Decor (Decor project handbook)). The CSE makes it possible to fulfill the key requirements of transparency, consistency, completeness, comparability and accuracy at the data level.

Data documentation plays a central role in the CSE. The CSE stores such information as who is responsible for handling specific tasks; data sources and calculation procedures; and uncertainties in time-series values. The times at which changes are made, and the persons by whom they are made, are also recorded. The system has a history-management function that archives deleted items and can restore them as necessary. This makes it possible to trace back and reconstruct data, and it enables third parties to carry out independent reviews. The system also provides mechanisms that support quality assurance at the data level (e.g. components for detecting uncertainties and checking plausibility). Above all, transparency is accommodated by ensuring that data are recorded within the same structure in which they are provided, and that all processing and transformations into a reporting format take place first in the CSE itself, and thus remain open to examination. In addition, the CSE manages detailed technology-specific activity data and emission factors that can be processed, via calculation rules (calculation methods), into aggregated, source-category-specific values for the various reporting formats. Aggregation of individual CSE time series for the CRF report lines, for example, is described in Annex 3 and Chapter 3ff – in each case, with regard to individual source categories. In addition to aggregation and model formation for calculations, the CSE also supports scenario and forecast calculations and use of the reference approach.

Data exchange within the framework of the National System – i.e. within the Federal Environment Agency and with third parties – is also organised via the Central System of Emissions. Such processes involve both direct data entry and imports of aggregated values, from existing databases and via a standard interface (for example, TREMOD, for transport data; and GAS-EM, for agricultural data). Ideally, inventory data should be entered into the CSE directly by the relevant responsible experts or should be imported, by the CSE administrator, via the import interface. This applies to in-house UBA employees as well as to external parties involved in the National System. To this end, a range of measures have been implemented:

- Provision of a *standardised import format for the CSE* in 2002 has facilitated the direct import of data from other emissions-relevant databases.
- In September 2002, participating technical experts from the Federal Environment Agency were given direct access to the CSE via the Federal Environment Agency intranet.
- Since November 2002, training courses on CSE procedures have been held on an annual basis for involved Federal Environment Agency staff.
- Since 2005, qualitative and quantitative information about data uncertainties has also been included in the CSE.
- Since 2006, reporting obligations under the Geneva Convention on Long-Range Transboundary Air Pollution and EU legislation (such as the NEC directive) have been fulfilled via the CSE.
- Since 2008, data providers and experts outside of the Federal Environment Agency, and project partners, can work interactively with the CSE via remote access.

22.2 Supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

22.2.1 KP-LULUCF

The CRF tables are reported separately.

22.2.2 Standard Electronic Format (SEF) Tables

22.2.2.1 Standard Electronic Format for the reported year 2011

UNFCCC SEF application

Version 1.2

Workflow

Unlock file

Completeness Check

Consistency Check

Lock file

Functions

Mandatory data

Import XML

Reset SEF

Export XML

Settings

Party:	Germany
ISO:	DE
Submission year:	2013
Reported year:	2012
Commitment period:	1
Completeness check:	YES
Consistency check:	YES
File locked:	YES
Lock timestamp:	10.05.2013 12:19
Submission version number:	4
Submission type:	Official

Party	Germany
Submission year	2013
Reported year	2012
Commitment period	1

Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	3112267083	4931830	NO	1941653	NO	NO
Entity holding accounts	547477254	24058140	NO	48262629	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	2828	13158	NO	757604	NO	NO
Retirement account	1273092585	4865496	NO	83095436	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	4932839750	33868624	NO	134057322	NO	NO

Party	Germany
Submission year	2013
Reported year	2012
Commitment period	1

Table 2 (a). Annual internal transactions

Transaction type	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Article 6 issuance and conversion												
Party-verified projects		7039160					7039160		NO			
Independently verifed projects		NO					NO		NO			
Article 3.3 and 3.4 issuance or cancellation												
3.3 Afforestation and reforestation			NO				NO	NO	NO	NO		
3.3 Deforestation			NO				NO	NO	NO	NO		
3.4 Forest management			NO				NO	NO	NO	NO		
3.4 Cropland management			NO				NO	NO	NO	NO		
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
Article 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired lCERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Other cancellation							597	1842	NO	134595	NO	NO
Sub-total		7039160	NO				7039757	1842	NO	134595	NO	NO

Transaction type	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Retirement	907807291	33231950	NO	41123292	NO	NO

Party	Germany
Submission year	2013
Reported year	2012
Commitment period	1

Add registry Delete registry No external transactions

Table 2 (b). Annual external transactions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Transfers and acquisitions												
AT	461889	NO	NO	211859	NO	NO	4733719	100000	NO	1095061	NO	NO
IE	365574	NO	NO	551700	NO	NO	585200	335770	NO	NO	NO	NO
SI	4310824	5000	NO	24100	NO	NO	30000	NO	NO	58200	NO	NO
CH	NO	417332	NO	892687	NO	NO	NO	925032	NO	1120413	NO	NO
LU	NO	NO	NO	NO	NO	NO	NO	NO	NO	14106	NO	NO
NL	10729366	2027704	NO	5418618	NO	NO	12464378	1915511	NO	6107872	NO	NO
SK	66000	NO	NO	5656	NO	NO	2271862	9355	NO	76626	NO	NO
BE	340151	NO	NO	176647	NO	NO	1874909	1215987	NO	556256	NO	NO
SE	47418	6034	NO	NO	NO	NO	98258	NO	NO	106283	NO	NO
PL	1286208	135441	NO	176000	NO	NO	248809	54714	NO	1277483	NO	NO
FI	60097	NO	NO	114580	NO	NO	129580	NO	NO	264341	NO	NO
CZ	559198	NO	NO	151356	NO	NO	593500	NO	NO	61358	NO	NO
BG	1789	NO	NO	NO	NO	NO	NO	18670	NO	3500	NO	NO
GB	20629861	13443339	NO	32626143	NO	NO	22282793	5044474	NO	11186317	NO	NO
DK	61651	NO	NO	4000	NO	NO	4000	590	NO	62242	NO	NO
PT	3000	NO	NO	NO	NO	NO	30000	NO	NO	NO	NO	NO
EU	NO	25468669	NO	6198252	NO	NO	NO	21137172	NO	45288186	NO	NO
NZ	NO	NO	NO	139435	NO	NO	NO	NO	NO	355000	NO	NO
FR	9961362	1284801	NO	9999988	NO	NO	17279111	364912	NO	466206	NO	NO
NO	653314	NO	NO	114200	NO	NO	481499	NO	NO	289130	NO	NO
EE	698000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
GR	766100	NO	NO	NO	NO	NO	NO	100000	NO	97265	NO	NO
IT	1928367	13000	NO	425695	NO	NO	847551	31627	NO	990003	NO	NO
ES	85446	31537	NO	142058	NO	NO	58282	147192	NO	67159	NO	NO
JP	NO	1956899	NO	2289096	NO	NO	NO	87158	NO	4494	NO	NO
HU	48000	NO	NO	NO	NO	NO	733571	NO	NO	137000	NO	NO
LV	NO	NO	NO	NO	NO	NO	NO	NO	NO	3337	NO	NO
CDM	NO	NO	NO	11917102	NO	NO	NO	NO	NO	NO	NO	NO
LT	NO	120588	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
RU	NO	6755451	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
UA	NO	127546	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	53063615	51793341	NO	71579172	NO	NO	64747022	31488164	NO	69687838	NO	NO

Additional information

Independently verified ERUs								NO				

Table 2 (c). Total annual transactions

Total (Sum of tables 2a and 2b)	53063615	58832501	NO	71579172	NO	NO	71786779	31490006	NO	69822433	NO	NO

Party	Germany
Submission year	2013
Reported year	2012
Commitment period	1

Table 3. Expiry, cancellation and replacement

Transaction or event type	Expiry, cancellation and requirement to replace		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Temporary CERs (tCERS)								
Expired in retirement and replacement accounts	NO							
Replacement of expired tCERs			NO	NO	NO	NO	NO	
Expired in holding accounts	NO							
Cancellation of tCERs expired in holding accounts	NO							
Long-term CERs (lCERs)								
Expired in retirement and replacement accounts		NO						
Replacement of expired lCERs			NO	NO	NO	NO		
Expired in holding accounts		NO						
Cancellation of lCERs expired in holding accounts		NO						
Subject to replacement for reversal of storage		NO						
Replacement for reversal of storage			NO	NO	NO	NO		NO
Subject to replacement for non-submission of certification report		NO						
Replacement for non-submission of certification report			NO	NO	NO	NO		NO
Total			NO	NO	NO	NO	NO	NO

Party	Germany
Submission year	2013
Reported year	2012
Commitment period	1

Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	2733213882	21356847	NO	1151721	NO	NO
Entity holding accounts	NO	1743668	NO	9686008	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	3425	15000	NO	892199	NO	NO
Retirement account	2180899876	38097446	NO	124218728	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	4914117183	61212961	NO	135948656	NO	NO

Party	Germany
Submission year	2013
Reported year	2012
Commitment period	1

Table 5 (a). Summary information on additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
Starting values	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Issuance pursuant to Article 3.7 and 3.8	4868096694											
Non-compliance cancellation							NO	NO	NO	NO		
Carry-over	NO	NO		NO								
Sub-total	4868096694	NO		NO			NO	NO	NO	NO		
Annual transactions												
Year 0 (2007)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 1 (2008)	111031173	NO	NO	48712902	NO	NO	103572319	NO	NO	8671720	NO	NO
Year 2 (2009)	372071597	863729	NO	52171623	NO	NO	352967489	541351	NO	26795677	NO	NO
Year 3 (2010)	297102669	8289950	NO	64167793	NO	NO	266517290	4605787	NO	43794853	NO	NO
Year 4 (2011)	207943064	38212452	NO	109134582	NO	NO	200351177	8363527	NO	61624932	NO	NO
Year 5 (2012)	53063615	58832501	NO	71579172	NO	NO	71786779	31490006	NO	69822433	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	1041212118	106198632	NO	345766072	NO	NO	995195054	45000671	NO	210709615	NO	NO
Total	5909308812	106198632	NO	345766072	NO	NO	995195054	45000671	NO	210709615	NO	NO

Table 5 (b). Summary information on replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Previous CPs			NO	NO	NO	NO	NO	NO
Year 1 (2008)		NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)		NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)		NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)		NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO

Table 5 (c). Summary information on retirement

	Retirement					
	Unit type					
Year	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO
Year 3 (2010)	854569558	670990	NO	49721049	NO	NO
Year 4 (2011)	418523027	4194506	NO	33374387	NO	NO
Year 5 (2012)	907807291	33231950	NO	41123292	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO
Total	2180899876	38097446	NO	124218728	NO	NO

Party	Germany
Submission year	2013
Reported year	2012
Commitment period	1

Add transaction Delete transaction No corrective transaction

Table 6 (a). Memo item: Corrective transactions relating to additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Add transaction Delete transaction No corrective transaction

Table 6 (b). Memo item: Corrective transactions relating to replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Add transaction Delete transaction No corrective transaction

Table 6 (c). Memo item: Corrective transactions relating to retirement

	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

No problems found!

22.2.2.2 Discrepant transactions

DES Response Code	Average number of occurences per transaction (X 100.000)		Transaction Number	Proposal Date Time	Transaction Type	Final State	Explanation	Units involved abbreviated		
	Reported Year	Prior to the Reported Year						Serial Number	Unit Type	Quantity
4003	0,01	0								
			DE121058	12-DEC-12 11.07.06.376000 AM	ExternalTransferKyotoUnits	TERMINATED		BG-6930410-6934173	ERU from AAU	3,764

22.2.3 More-detailed information about the National System, and about changes within the National System

All of this information has been provided in the preceding chapters.

22.2.4 Further detailed information about the National Registries and accounting of Kyoto units

All of this information has been provided in the preceding chapters.

22.3 Additional information about greenhouse-gas trends

Here, we provide the detailed tables relative to the trend discussion presented in Chapters 0.2 and 2.

Table 381: Emissions trends in Germany, by greenhouse gas and source category

GG emissions / sinks, in CO_2 equivalents (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Net CO_2 emissions / removals	1,005,890	968,485	921,476	912,499	896,650	895,151	916,031	887,270	879,696	852,522	856,337	866,438	897,213	899,439	888,002
CO_2 emissions (not including LULUCF)	1,041,914	1,004,595	957,437	948,543	932,360	930,781	951,757	922,957	915,050	887,781	891,400	907,443	890,751	892,932	881,034
CH_4	109,950	104,415	100,714	100,235	96,190	92,635	89,718	85,092	79,764	78,258	75,104	72,274	69,198	66,625	62,406
N_2O	86,804	83,036	83,325	80,743	80,607	79,600	81,154	78,302	65,004	61,555	61,669	62,729	61,394	60,357	63,676
HFCs	4,592	4,214	4,377	6,361	6,853	7,012	6,699	7,460	8,167	8,453	7,623	8,578	9,056	8,412	8,507
PFCs	2,627	2,277	2,062	1,931	1,640	1,780	1,738	1,398	1,506	1,249	792	724	789	847	814
SF_6	4,642	4,975	5,491	6,262	6,551	6,779	6,460	6,404	6,173	4,497	4,269	3,933	3,236	3,181	3,400
Total emissions / removals, including LULUCF	**1,214,506**	**1,167,401**	**1,117,445**	**1,108,031**	**1,088,491**	**1,082,957**	**1,101,800**	**1,065,925**	**1,040,311**	**1,006,533**	**1,005,794**	**1,014,676**	**1,040,886**	**1,038,860**	**1,026,806**
Total emissions, not including CO_2 from LULUCF	**1,250,529**	**1,203,512**	**1,153,405**	**1,144,075**	**1,124,201**	**1,118,588**	**1,137,527**	**1,101,613**	**1,075,665**	**1,041,792**	**1,040,857**	**1,055,681**	**1,034,424**	**1,032,353**	**1,019,838**

GHG emissions / sinks, in CO_2 equivalents (Gg)	2005	2006	2007	2008	2009	2010	2011
Net CO_2 emissions / removals	871,823	877,524	854,680	853,256	791,974	834,511	807,118
CO_2 emissions (not including LULUCF)	864,716	870,739	847,397	845,761	783,734	826,063	798,058
CH_4	59,484	56,896	54,226	53,609	51,510	50,388	48,845
N_2O	61,179	60,362	62,026	63,457	63,489	54,897	57,144
HFCs	8,640	8,708	8,742	8,843	9,443	8,963	9,177
PFCs	695	550	484	472	338	285	230
SF_6	3,480	3,398	3,334	3,115	3,065	3,194	3,316
Total emissions / removals, including LULUCF	**1,005,301**	**1,007,438**	**983,492**	**982,752**	**919,818**	**952,239**	**925,830**
Total emissions, not including CO_2 from LULUCF	**998,194**	**1,000,653**	**976,209**	**975,257**	**911,578**	**943,791**	**916,769**

GHG emissions / sinks, by source and sink categories, in CO_2 equivalents (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1. Energy	**1,020,323**	**985,042**	**936,023**	**928,020**	**906,489**	**902,094**	**923,854**	**892,336**	**882,853**	**858,127**	**856,189**	**876,375**	**860,877**	**856,869**	**839,863**
2. Industrial processes	**94,271**	**90,361**	**92,346**	**92,519**	**98,764**	**96,884**	**95,910**	**95,836**	**81,891**	**74,789**	**77,514**	**74,470**	**72,573**	**77,527**	**82,167**
3. Solvent and other product use	**4,477**	**4,337**	**4,157**	**4,074**	**3,547**	**3,553**	**3,471**	**3,446**	**3,420**	**3,165**	**2,909**	**2,687**	**2,484**	**2,267**	**2,195**
4. Agriculture	**87,963**	**79,769**	**77,019**	**76,439**	**73,736**	**75,866**	**76,088**	**75,220**	**75,243**	**76,170**	**76,021**	**75,303**	**72,783**	**71,275**	**72,414**
5. Land use, land-use changes & forestry	**-35,758**	**-35,849**	**-35,671**	**-35,778**	**-35,447**	**-35,370**	**-35,461**	**-35,427**	**-35,094**	**-34,999**	**-34,802**	**-40,746**	**6,723**	**6,778**	**7,232**
CO_2	*-36,024*	*-36,110*	*-35,961*	*-36,044*	*-35,710*	*-35,630*	*-35,727*	*-35,688*	*-35,354*	*-35,259*	*-35,063*	*-41,005*	*6,462*	*6,507*	*6,968*
N_2O & CH_4	*266*	*261*	*289*	*266*	*263*	*260*	*266*	*260*	*259*	*260*	*261*	*259*	*260*	*270*	*264*
6. Waste	**43,230**	**43,742**	**43,572**	**42,758**	**41,402**	**39,931**	**37,938**	**34,514**	**31,998**	**29,282**	**27,963**	**26,588**	**25,446**	**24,144**	**22,934**

GHG emissions / sinks, by source and sink categories, in CO_2 equivalents (Gg)	2005	2006	2007	2008	2009	2010	2011
1. Energy	**824,214**	**828,818**	**804,887**	**805,221**	**751,531**	**789,179**	**760,572**
2. Industrial processes	**78,841**	**79,616**	**81,737**	**78,920**	**72,175**	**68,738**	**69,388**
3. Solvent and other product use	**2,052**	**2,074**	**1,949**	**1,812**	**1,626**	**1,882**	**1,794**
4. Agriculture	**71,423**	**69,896**	**68,752**	**71,624**	**69,618**	**68,365**	**70,360**
5. Land use, land-use changes & forestry	**7,372**	**7,051**	**7,546**	**7,759**	**8,510**	**8,721**	**9,335**
CO_2	*7,107*	*6,785*	*7,283*	*7,495*	*8,240*	*8,448*	*9,060*
N_2O & CH_4	*264*	*266*	*263*	*264*	*270*	*272*	*274*
6. Waste	**21,399**	**19,983**	**18,621**	**17,416**	**16,359**	**15,354**	**14,381**

Table 382: Contributions to emissions trends in Germany, by greenhouse gas and source category

GHG emissions / sinks; shares for various GHG, not including CO_2 from LULUCF (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CO_2 emissions (not including LULUCF)	83.3	83.5	83.0	82.9	82.9	83.2	83.7	83.8	85.1	85.2	85.6	86.0	86.1	86.5	86.4	86.6	87.0	86.8	86.7	86.0	87.5	87.1
CH_4	8.8	8.7	8.7	8.8	8.6	8.3	7.9	7.7	7.4	7.5	7.2	6.8	6.7	6.5	6.1	6.0	5.7	5.6	5.5	5.7	5.3	5.3
N_2O	6.9	6.9	7.2	7.1	7.2	7.1	7.1	7.1	6.0	5.9	5.9	5.9	5.9	5.8	6.2	6.1	6.0	6.4	6.5	7.0	5.8	6.2
HFCs	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.7	0.8	0.8	0.7	0.8	0.9	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.9	1.0
PFCs	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
SF_6	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

GHG emissions / sinks; shares for emission & sink categories, not including CO_2 from LULUCF (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1. Energy	81.6	81.8	81.2	81.1	80.6	80.6	81.2	81.0	82.1	82.4	82.3	83.0	83.2	83.0	82.4	82.6	82.8	82.5	82.6	82.4	83.6	83.0
2. Industrial processes	7.5	7.5	8.0	8.1	8.8	8.7	8.4	8.7	7.6	7.2	7.4	7.1	7.0	7.5	8.1	7.9	8.0	8.4	8.1	7.9	7.3	7.6
3. Solvent and other product use	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4. Agriculture	7.0	6.6	6.7	6.7	6.6	6.8	6.7	6.8	7.0	7.3	7.3	7.1	7.0	6.9	7.1	7.2	7.0	7.0	7.3	7.6	7.2	7.7
5. Land use, land-use changes & forestry (N_2O)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6. Waste	3.5	3.6	3.8	3.7	3.7	3.6	3.3	3.1	3.0	2.8	2.7	2.5	2.5	2.3	2.2	2.1	2.0	1.9	1.8	1.8	1.6	1.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 383: Emissions of direct and indirect greenhouse gases and SO_2 in Germany since 1990

Emissions (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Net CO_2 emissions / removals	1,005,890	968,485	921,476	912,499	896,650	895,151	916,031	887,270	879,696	852,522	856,337	866,438	897,213	899,439	888,002
CO_2 emissions (not including LULUCF)	1,041,914	1,004,595	957,437	948,543	932,360	930,781	951,757	922,957	915,050	887,781	891,400	907,443	890,751	892,932	881,034
CH_4	5,236	4,972	4,796	4,773	4,580	4,411	4,272	4,052	3,798	3,727	3,576	3,442	3,295	3,173	2,972
N_2O	280	268	269	260	260	257	262	253	210	199	199	202	198	195	205
HFCs (CO_2-eq.)	4,592	4,214	4,377	6,361	6,853	7,012	6,699	7,460	8,167	8,453	7,623	8,578	9,056	8,412	8,507
PFCs (CO_2-eq.)	2,627	2,277	2,062	1,931	1,640	1,780	1,738	1,398	1,506	1,249	792	724	789	847	814
SF_6 (CO_2-eq.)	4,642	4,975	5,491	6,262	6,551	6,779	6,460	6,404	6,173	4,497	4,269	3,933	3,236	3,181	3,400
CO	12,402	10,152	8,768	7,977	7,051	6,599	6,126	5,970	5,508	5,137	4,854	4,646	4,356	4,158	3,919
NMVOC	3,131	2,681	2,463	2,315	1,895	1,808	1,739	1,716	1,678	1,537	1,394	1,293	1,232	1,166	1,177
NO_X	2,877	2,634	2,491	2,386	2,227	2,175	2,104	2,036	2,008	1,983	1,925	1,847	1,767	1,712	1,645
SO_2	5,292	3,915	3,193	2,847	2,383	1,718	1,455	1,218	981	803	653	632	567	538	501

Emissions (Gg)	2005	2006	2007	2008	2009	2010	2011
Net CO_2 emissions / removals	871,823	877,524	854,680	853,256	791,974	834,511	807,118
CO_2 emissions (not including LULUCF)	864,716	870,739	847,397	845,761	783,734	826,063	798,058
CH_4	2,833	2,709	2,582	2,553	2,453	2,399	2,326
N_2O	197	195	200	205	205	177	184
HFCs (CO_2-eq.)	8,640	8,708	8,742	8,843	9,443	8,963	9,177
PFCs (CO_2-eq.)	695	550	484	472	338	285	230
SF_6 (CO_2-eq.)	3,480	3,398	3,334	3,115	3,065	3,194	3,316
CO	3,695	3,616	3,516	3,433	3,051	3,495	3,304
NMVOC	1,146	1,134	1,071	1,016	929	1,055	1,006
NO_X	1,574	1,559	1,481	1,404	1,305	1,329	1,288
SO_2	477	487	469	469	419	444	445

Table 384: Changes in emissions of direct and indirect greenhouse gases and SO_2 in Germany, since 1990

Emissions change with respect to the base year / 1990 (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Net CO_2 emissions / removals	0.0	-3.7	-8.4	-9.3	-10.9	-11.0	-8.9	-11.8	-12.5	-15.2	-14.9	-13.9	-10.8	-10.6	-11.7	-13.3	-12.8	-15.0	-15.2	-21.3	-17.0	-19.8
CO_2 emissions (not including LULUCF)	0.0	-3.6	-8.1	-9.0	-10.5	-10.7	-8.7	-11.4	-12.2	-14.8	-14.4	-12.9	-14.5	-14.3	-15.4	-17.0	-16.4	-18.7	-18.8	-24.8	-20.7	-23.4
CH_4	0.0	-5.0	-8.4	-8.8	-12.5	-15.7	-18.4	-22.6	-27.5	-28.8	-31.7	-34.3	-37.1	-39.4	-43.2	-45.9	-48.3	-50.7	-51.2	-53.2	-54.2	-55.6
N_2O	0.0	-4.3	-4.0	-7.0	-7.1	-8.3	-6.5	-9.8	-25.1	-29.1	-29.0	-27.7	-29.3	-30.5	-26.6	-29.5	-30.5	-28.5	-26.9	-26.9	-36.8	-34.2
HFCs (CO_2-eq.)						0.0	-4.5	+6.4	+16.5	+20.5	+8.7	+22.3	+29.1	+20.0	+21.3	+23.2	+24.2	+24.7	+26.1	+34.7	+27.8	+30.9
PFCs (CO_2-eq.)						0.0	-2.4	-21.5	-15.4	-29.8	-55.5	-59.3	-55.7	-52.4	-54.3	-61.0	-69.1	-72.8	-73.5	-81.0	-84.0	-87.1
SF_6 (CO_2-eq.)						0.0	-4.7	-5.5	-8.9	-33.7	-37.0	-42.0	-52.3	-53.1	-49.8	-48.7	-49.9	-50.8	-54.1	-54.8	-52.9	-51.1
Change in total GHG																						
Total emissions with respect to EU burden-sharing[132]	+1.5	-2.3	-6.4	-7.2	-8.8	-9.2	-7.7	-10.6	-12.7	-15.5	-15.5	-14.3	-16.1	-16.2	-17.2	-19.0	-18.8	-20.8	-20.9	-26.0	-23.4	-25.6
CO	0.0	-18.1	-29.3	-35.7	-43.1	-46.8	-50.6	-51.9	-55.6	-58.6	-60.9	-62.5	-64.9	-66.5	-68.4	-70.2	-70.8	-71.6	-72.3	-75.4	-71.8	-73.4
NMVOC	0.0	-14.4	-21.3	-26.0	-39.5	-42.2	-44.4	-45.2	-46.4	-50.9	-55.5	-58.7	-60.6	-62.8	-62.4	-63.4	-63.8	-65.8	-67.5	-70.3	-66.3	-67.9
NO_X	0.0	-8.5	-13.4	-17.1	-22.6	-24.4	-26.9	-29.2	-30.2	-31.1	-33.1	-35.8	-38.6	-40.5	-42.8	-45.3	-45.8	-48.5	-51.2	-54.6	-53.8	-55.2
SO_2	0.0	-26.0	-39.7	-46.2	-55.0	-67.5	-72.5	-77.0	-81.5	-84.8	-87.7	-88.1	-89.3	-89.8	-90.5	-91.0	-90.8	-91.1	-91.1	-92.1	-91.6	-91.6

[132] Defined base-year emissions of 1,232,430 Gg CO_2 equivalent; cf. Chapter 0.2

Table 385: Changes in emissions of direct and indirect greenhouse gases and SO_2 in Germany, since the relevant previous year

Emissions change, in each case with respect to the previous year (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Net CO_2 emissions / removals	**0.0**	-3.7	-4.9	-1.0	-1.7	-0.2	+2.3	-3.1	-0.9	-3.1	+0.4	+1.2	+3.6	+0.2	-1.3	-1.8	+0.7	-2.6	-0.2	-7.2	+5.4	-3.3
CO_2 emissions (not including LULUCF)	**0.0**	-3.6	-4.7	-0.9	-1.7	-0.2	+2.3	-3.0	-0.9	-3.0	+0.4	+1.8	-1.8	+0.2	-1.3	-1.9	+0.7	-2.7	-0.2	-7.3	+5.4	-3.4
CH_4	**0.0**	-5.0	-3.5	-0.5	-4.0	-3.7	-3.1	-5.2	-6.3	-1.9	-4.0	-3.8	-4.3	-3.7	-6.3	-4.7	-4.4	-4.7	-1.1	-3.9	-2.2	-3.1
N_2O	**0.0**	-4.3	+0.3	-3.1	-0.2	-1.2	+2.0	-3.5	-17.0	-5.3	+0.2	+1.7	-2.1	-1.7	+5.5	-3.9	-1.3	+2.8	+2.3	+0.1	-13.5	+4.1
HFCs (CO_2-eq.)	**0.0**	-8.2	+3.9	+45.3	+7.7	+2.3	-4.5	+11.3	+9.5	+3.5	-9.8	+12.5	+5.6	-7.1	+1.1	+1.6	+0.8	+0.4	+1.2	+6.8	-5.1	+2.4
PFCs (CO_2-eq.)	**0.0**	-13.3	-9.4	-6.4	-15.1	+8.5	-2.4	-19.6	+7.8	-17.1	-36.6	-8.5	+9.0	+7.2	-3.8	-14.7	-20.7	-12.1	-2.4	-28.5	-15.5	-19.5
SF_6 (CO_2-eq.)	**0.0**	+7.2	+10.4	+14.0	+4.6	+3.5	-4.7	-0.9	-3.6	-27.2	-5.1	-7.9	-17.7	-1.7	+6.9	+2.4	-2.4	-1.9	-6.6	-1.6	+4.2	+3.8
Development of total GHG emissions and removals																						
Total emissions / removals, including LULUCF	**0.0**	-3.9	-4.3	-0.8	-1.8	-0.5	+1.7	-3.3	-2.4	-3.2	-0.1	+0.9	+2.6	-0.2	-1.2	-2.1	+0.2	-2.4	-0.1	-6.4	+3.5	-2.8
Total emissions, not including CO_2 from LULUCF	**0.0**	-3.8	-4.2	-0.8	-1.7	-0.5	+1.7	-3.2	-2.4	-3.1	-0.1	+1.4	-2.0	-0.2	-1.2	-2.1	+0.2	-2.4	-0.1	-6.5	+3.5	-2.9
CO	**0.0**	-18.1	-13.6	-9.0	-11.6	-6.4	-7.2	-2.5	-7.7	-6.7	-5.5	-4.3	-6.2	-4.6	-5.7	-5.7	-2.1	-2.8	-2.3	-11.1	+14.5	-5.5
NMVOC	**0.0**	-14.4	-8.2	-6.0	-18.2	-4.6	-3.8	-1.3	-2.2	-8.4	-9.3	-7.3	-4.7	-5.4	+1.0	-2.7	-1.1	-5.6	-5.1	-8.6	+13.5	-4.6
NO_X	**0.0**	-8.5	-5.4	-4.2	-6.6	-2.4	-3.2	-3.3	-1.4	-1.3	-2.9	-4.0	-4.3	-3.1	-3.9	-4.3	-0.9	-5.0	-5.2	-7.0	+1.8	-3.0
SO_2	**0.0**	-26.0	-18.4	-10.8	-16.3	-27.9	-15.3	-16.2	-19.5	-18.2	-18.7	-3.3	-10.3	-5.0	-6.9	-4.8	+2.0	-3.6	-0.0	-10.7	+6.0	+0.1

Table 386: Changes in greenhouse-gas emissions in Germany, by source categories, since 1990 / since the relevant previous year

Emissions change with respect to 1990 (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1. Energy	**0.0**	**-3.5**	**-8.3**	**-9.0**	**-11.2**	**-11.6**	**-9.5**	**-12.5**	**-13.5**	**-15.9**	**-16.1**	**-14.1**	**-15.6**	**-16.0**	**-17.7**	**-19.2**	**-18.8**	**-21.1**	**-21.1**	**-26.3**	**-22.7**	**-25.5**
2. Industrial processes	**0.0**	**-4.1**	**-2.0**	**-1.9**	**4.8**	**2.8**	**1.7**	**1.7**	**-13.1**	**-20.7**	**-17.8**	**-21.0**	**-23.0**	**-17.8**	**-12.8**	**-16.4**	**-15.5**	**-13.3**	**-16.3**	**-23.4**	**-27.1**	**-26.4**
3. Solvent and other product use	**0.0**	**-3.1**	**-7.1**	**-9.0**	**-20.8**	**-20.6**	**-22.5**	**-23.0**	**-23.6**	**-29.3**	**-35.0**	**-40.0**	**-44.5**	**-49.4**	**-51.0**	**-54.2**	**-53.7**	**-56.5**	**-59.5**	**-63.7**	**-57.9**	**-59.9**
4. Agriculture	**0.0**	**-9.3**	**-12.4**	**-13.1**	**-16.2**	**-13.8**	**-13.5**	**-14.5**	**-14.5**	**-13.4**	**-13.6**	**-14.4**	**-17.3**	**-19.0**	**-17.7**	**-18.8**	**-20.5**	**-21.8**	**-18.6**	**-20.9**	**-22.3**	**-20.0**
5. Land use, land-use changes & forestry	**0.0**	**0.3**	**-0.2**	**0.1**	**-0.9**	**-1.1**	**-0.8**	**-0.9**	**-1.9**	**-2.1**	**-2.7**	**13.9**	**-118.8**	**-119.0**	**-120.2**	**-120.6**	**-119.7**	**-121.1**	**-121.7**	**-123.8**	**-124.4**	**-126.1**
CO_2 (net sink)	*0.0*	*0.2*	*-0.2*	*0.1*	*-0.9*	*-1.1*	*-0.8*	*-0.9*	*-1.9*	*-2.1*	*-2.7*	*13.8*	*-117.9*	*-118.1*	*-119.3*	*-119.7*	*-118.8*	*-120.2*	*-120.8*	*-122.9*	*-123.5*	*-125.2*
N_2O & CH_4	*0.0*	*-1.7*	*8.9*	*0.0*	*-0.8*	*-2.1*	*0.1*	*-1.9*	*-2.3*	*-2.2*	*-1.6*	*-2.4*	*-2.0*	*1.8*	*-0.6*	*-0.4*	*0.1*	*-0.9*	*-0.5*	*1.7*	*2.6*	*3.3*
6. Waste	**0.0**	**1.2**	**0.8**	**-1.1**	**-4.2**	**-7.6**	**-12.2**	**-20.2**	**-26.0**	**-32.3**	**-35.3**	**-38.5**	**-41.1**	**-44.2**	**-46.9**	**-50.5**	**-53.8**	**-56.9**	**-59.7**	**-62.2**	**-64.5**	**-66.7**
Emissions change, in each case with respect to the previous year; change in %	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	
1. Energy	**0.0**	**-3.5**	**-5.0**	**-0.9**	**-2.3**	**-0.5**	**2.4**	**-3.4**	**-1.1**	**-2.8**	**-0.2**	**2.4**	**-1.8**	**-0.5**	**-2.0**	**-1.9**	**0.6**	**-2.9**	**0.0**	**-6.7**	**5.0**	**-3.6**
2. Industrial processes	**0.0**	**-4.1**	**2.2**	**0.2**	**6.8**	**-1.9**	**-1.0**	**-0.1**	**-14.6**	**-8.7**	**3.6**	**-3.9**	**-2.5**	**6.8**	**6.0**	**-4.0**	**1.0**	**2.7**	**-3.4**	**-8.5**	**-4.8**	**0.9**
3. Solvent and other product use	**0.0**	**-3.1**	**-4.1**	**-2.0**	**-12.9**	**0.2**	**-2.3**	**-0.7**	**-0.7**	**-7.5**	**-8.1**	**-7.7**	**-7.5**	**-8.7**	**-3.2**	**-6.5**	**1.1**	**-6.0**	**-7.0**	**-10.3**	**15.8**	**-4.7**
4. Agriculture	**0.0**	**-9.3**	**-3.4**	**-0.8**	**-3.5**	**2.9**	**0.3**	**-1.1**	**0.0**	**1.2**	**-0.2**	**-0.9**	**-3.3**	**-2.1**	**1.6**	**-1.4**	**-2.1**	**-1.6**	**4.2**	**-2.8**	**-1.8**	**2.9**
5. Land use, land-use changes & forestry	**0.0**	**0.3**	**-0.5**	**0.3**	**-0.9**	**-0.2**	**0.3**	**-0.1**	**-0.9**	**-0.3**	**-0.6**	**17.1**	**-116.5**	**0.8**	**6.7**	**1.9**	**-4.4**	**7.0**	**2.8**	**9.7**	**2.5**	**7.0**
CO_2 (net sink)	*0.0*	*0.2*	*-0.4*	*0.2*	*-0.9*	*-0.2*	*0.3*	*-0.1*	*-0.9*	*-0.3*	*-0.6*	*16.9*	*-115.8*	*0.7*	*7.1*	*2.0*	*-4.5*	*7.3*	*2.9*	*9.9*	*2.5*	*7.2*
N_2O & CH_4	*0.0*	*-1.7*	*10.8*	*-8.2*	*-0.9*	*-1.3*	*2.3*	*-2.0*	*-0.5*	*0.2*	*0.6*	*-0.8*	*0.5*	*3.8*	*-2.4*	*0.2*	*0.5*	*-1.0*	*0.4*	*2.2*	*0.9*	*0.7*
6. Waste	**0.0**	**1.2**	**-0.4**	**-1.9**	**-3.2**	**-3.6**	**-5.0**	**-9.0**	**-7.3**	**-8.5**	**-4.5**	**-4.9**	**-4.3**	**-5.1**	**-5.0**	**-6.7**	**-6.6**	**-6.8**	**-6.5**	**-6.1**	**-6.1**	**-6.3**

23 ANNEX 7: TABLE 6.1 OF THE IPCC GOOD PRACTICE GUIDANCE

The uncertainties for the German greenhouse-gas inventories have been determined completely, for all source categories.

Efforts in this area, which began with determination of uncertainties pursuant to Tier 1, are being carried out by data-supplying experts of Federal Environment Agency departments and by external institutions.

Since then, the basis for Tier 2 uncertainties analysis has been created, and the "Crystal Ball" programme for Monte Carlo simulation has been implemented. Tier 2 uncertainties analysis is carried out every three years (it was last carried out for the 2010 report); when it is carried out, it is carried out in addition to Tier 1 uncertainties determination.

At the same time, additional uncertainties have been determined via experts' assessments and added to the CSE database. An uncertainties data set is now available in which most of the uncertainties have been determined via expert estimation. In cases in which experts' assessments are not yet available, a complete data set is obtained by adopting uncertainties from data reported in the relevant technical literature. The expert assessment process is being continued, systematically and completely.

The results of this year's Tier 1 uncertainties analysis are shown, in keeping with the specifications given in Table 6.1 of IPCC Good Practice Guidance, in Table 387.

Table 387: Table 6.1 of the IPCC Good Practice Guidance – details

CRF	Category	Gas	Base-year emissions [t CO_2-eq.]	Emissions, 2011 [Gg CO_2-eq.]	Combined uncertainty of activity data [%]	Combined uncertainty of emission factors [%]	Combined uncertainty of emissions [%]	Combined uncertainty percentage [%]	Trend uncertainty for emission factors [%]	Trend uncertainty for activity data [%]	Trend uncertainty for emissions [%]
1.A.1.a	All fuels	Methane	185,769.03	1,864,178.41	0.012131919	0.060659595	87.10073623	0.175379269	0.000131729	2.63458E-05	0.000134338
1.A.1.a	All fuels	Carbon dioxide	339,017,879.12	314,159,587.70	3.928904521	1.703578826	4.282381623	1.453130577	0.623458416	1.437860433	1.567208672
1.A.1.a	All fuels	Nitrous oxide	3,568,851.01	2,631,945.42	0.177040093	0.885200466	19.79507777	0.056273386	0.002714023	0.000542805	0.002767771
1.A.1.b	All fuels	Carbon dioxide	20,005,878.03	18,380,045.01	2.972073443	4.676777419	5.57614491	0.110700499	0.100135533	0.063635733	0.11864498
1.A.1.b	All fuels	Methane	13,286.21	6,515.86	0	0	25.71859126	0.000181004	0	0	0
1.A.1.b	All fuels	Nitrous oxide	121,661.73	59,432.72	0	0	30.64281529	0.001967086	0	0	0
1.A.1.c	All fuels	Methane	85,304.42	13,434.78	0	0	82.52203736	0.001197483	0	0	0
1.A.1.c	All fuels	Nitrous oxide	680,537.79	187,142.46	0	0	17.19880661	0.003476479	0	0	0
1.A.1.c	All fuels	Carbon dioxide	64,393,840.73	17,006,584.82	5.01562007	2.883543151	5.788380301	0.106326893	0.057126617	0.099365742	0.114616757
1.A.2.a	All fuels	Methane	52,462.15	61,720.54	0	0	25.12162768	0.001674736	0	0	0
1.A.2.a	All fuels	Nitrous oxide	161,350.51	132,724.85	0	0	34.42226531	0.004934699	0	0	0
1.A.2.a	All fuels	Carbon dioxide	34,741,967.20	34,323,028.07	3.769612306	2.521717529	4.535310064	0.168136319	0.10082703	0.150722199	0.181337451
1.A.2.b	All fuels	Carbon dioxide	1,601,180.10	1,607,977.73	10.82411929	0.903825192	10.86318635	0.018867146	0.00169301	0.020275312	0.020345873
1.A.2.b	All fuels	Methane	1,164.38	1,498.40	0	0	68.92288069	0.000111548	0	0	0
1.A.2.b	All fuels	Nitrous oxide	17,833.99	8,621.44	0	0	64.21691177	0.000597996	0	0	0
1.A.2.d	All fuels	Carbon dioxide	3,646.96	14,649.05	5.217553369	2.236094301	5.676528947	8.98176E-05	3.81588E-05	8.90372E-05	9.68695E-05
1.A.2.d	All fuels	Methane	549.27	2,495.01	0	0	42.53453773	0.000114626	0	0	0
1.A.2.d	All fuels	Nitrous oxide	2,918.98	13,259.20	0	0	50.97405819	0.000730021	0	0	0
1.A.2.e	All fuels	Carbon dioxide	1,989,239.00	190,670.27	5.337089066	1.932683681	5.697464106	0.001173366	0.000429278	0.001185448	0.00126078
1.A.2.e	All fuels	Methane	3,765.41	118.21	0	0	38.11096401	4.86583E-06	0	0	0
1.A.2.e	All fuels	Nitrous oxide	25,637.78	2,121.05	0	0	56.71077771	0.000129923	0	0	0
1.A.2.f	All fuels	Carbon dioxide	137,298,795.28	78,190,543.38	3.240299171	0.423808356	3.271000145	0.276250931	0.038602789	0.295144219	0.297658
1.A.2.f	All fuels	Methane	178,687.13	94,351.72	0.457612129	2.993692657	39.0975306	0.003984447	0.000329042	5.0297E-05	0.000332864
1.A.2.f	All fuels	Nitrous oxide	1,180,185.74	647,553.77	0.60547733	5.246635675	10.92712345	0.007642767	0.00395778	0.00045674	0.003984048
1.A.3.a	Aviation gasoline	Carbon dioxide	2,309,638.04	1,836,860.48	7.057018526	3.529934684	7.890624143	0.015655123	0.007553318	0.015100536	0.016884277
1.A.3.a	Aviation gasoline	Methane	1,998.96	1,776.20	9.40887757	94.23016838	94.69874133	0.000181679	0.000194974	1.94681E-05	0.000195943
1.A.3.a	Aviation gasoline	Nitrous oxide	23,988.04	19,333.70	6.96809564	104.5637418	104.7956604	0.002188402	0.002355	0.000156937	0.002360224
1.A.3.b	All fuels	Carbon dioxide	150,358,325.64	147,867,391.22	9.002619833	0.718728722	9.031264299	1.442413968	0.123803337	1.550730261	1.555664362
1.A.3.b	All fuels	Methane	1,106,097.33	148,108.74	19.82248777	34.58283368	39.86105125	0.006376735	0.005966727	0.00342006	0.006877401
1.A.3.b	All fuels	Nitrous oxide	1,158,401.63	1,338,290.83	9.091634516	27.42312709	28.89092794	0.041761967	0.042752589	0.014173836	0.045040887
1.A.3.c	All fuels	Carbon dioxide	2,880,820.12	1,064,214.82	9.994243258	2.998278009	10.43429774	0.011993929	0.003717031	0.012390081	0.012935626
1.A.3.c	All fuels	Methane	2,309.52	454.76	9.401944622	31.99316003	33.34604702	1.63793E-05	1.69486E-05	4.98074E-06	1.76653E-05
1.A.3.c	All fuels	Nitrous oxide	12,636.22	4,749.34	9.401944622	70.51458466	71.1386197	0.000364928	0.000390128	5.2017E-05	0.00039358
1.A.3.d	Diesel oil	Carbon dioxide	2,065,668.20	768,622.00	46.96477912	2.997761188	47.0603554	0.039069421	0.002684138	0.042051359	0.042136936
1.A.3.d	Diesel oil	Methane	1,674.21	551.61	44.09779616	31.9666207	54.46540613	3.24507E-05	2.05412E-05	2.83365E-05	3.49986E-05
1.A.3.d	Diesel oil	Nitrous oxide	8,590.10	3,429.58	44.09779616	70.51460449	83.1680532	0.000308082	0.000281718	0.000176178	0.000332271
1.A.3.e	All fuels	Carbon dioxide	4,751,743.58	4,098,100.85	41.58284293	2.029698426	41.63234922	0.18428183	0.009689672	0.198514283	0.198750623
1.A.3.e	All fuels	Methane	7,083.45	2,769.09	24.66495283	13.52594187	36.64664635	0.000109607	4.36314E-05	7.95631E-05	9.07413E-05

CRF	Category	Gas	Base-year emissions [t CO_2-eq.]	Emissions, 2011 [Gg CO_2-eq.]	Combined uncertainty of activity data [%]	Combined uncertainty of emission factors [%]	Combined uncertainty of emissions [%]	Combined uncertainty percentage [%]	Trend uncertainty for emission factors [%]	Trend uncertainty for activity data [%]	Trend uncertainty for emissions [%]
1.A.3.e	All fuels	Nitrous oxide	32,743.34	24,423.04	29.25852491	35.87305294	50.96489044	0.001344435	0.001020618	0.000832429	0.001317041
1.A.4.a	All fuels	Carbon dioxide	63,949,629.39	33,429,867.32	7.423588937	1.180018672	7.516788994	0.271416327	0.045953487	0.289096949	0.292726441
1.A.4.a	All fuels	Methane	1,216,099.17	56,284.61	0.114891634	0.409904973	115.2673634	0.00700753	2.68762E-05	7.53309E-06	2.7912E-05
1.A.4.a	All fuels	Nitrous oxide	144,213.47	101,506.17	0.209534357	0.55348698	92.91649736	0.010187185	6.54478E-05	2.47767E-05	6.99807E-05
1.A.4.b	All fuels	Carbon dioxide	129,473,971.12	81,918,768.60	7.853131127	1.377547671	7.973036189	0.705466032	0.131457386	0.749412969	0.760855336
1.A.4.b	All fuels	Methane	1,200,405.63	702,627.59	0.204725822	0.148891507	137.9359167	0.104681881	0.000121868	0.000167569	0.000207198
1.A.4.b	All fuels	Nitrous oxide	801,899.28	400,539.48	0.530145262	0.722925357	72.78525737	0.031488916	0.000337314	0.000247363	0.000418293
1.A.4.c	All fuels	Carbon dioxide	11,059,780.98	5,970,917.48	12.92618532	1.979614266	13.10189	0.084497522	0.01376945	0.089909667	0.090957935
1.A.4.c	All fuels	Methane	178,493.92	103,589.22	0.880623978	1.765474868	63.597066	0.007115749	0.000213045	0.000106267	0.000238077
1.A.4.c	All fuels	Nitrous oxide	41,727.27	41,919.11	7.585334726	28.50748193	53.74721419	0.002433531	0.001392085	0.000370409	0.001440522
1.A.5	All fuels	Carbon dioxide	11,811,085.44	1,202,078.88	4.320680718	1.574182717	4.598514226	0.00597062	0.002204363	0.006050344	0.006439401
1.A.5	All fuels	Methane	235,607.83	4,256.93	4.462212231	35.70981116	36.278058	0.000166805	0.000177084	2.2128E-05	0.000178461
1.A.5	All fuels	Nitrous oxide	70,377.15	9,327.77	3.303499304	60.96977208	61.92091772	0.000623856	0.000662502	3.58961E-05	0.000663474
1.B.1	Solid fuels	Carbon dioxide	10,676.00	2,926.00	0	0	2.141922022	6.76935E-06	0	0	0
1.B.1.a	Solid fuels	Methane	18,415,177.65	2,612,320.34	0.046822711	0.613377509	37.21242407	0.104998562	0.001866591	0.000142488	0.001872022
1.B.1.b	Solid fuels	Methane	18,089.82	8,221.71	0	0	10.44030651	9.27138E-05	0	0	0
1.B.1.c	Solid fuels	Methane	1,806,840.00	15,057.00	0	0	50	0.000813163	0	0	0
1.B.2.a	Liquid fuels	Carbon dioxide	1,129.30	768.24	0	0	10.49976437	8.71256E-06	0	0	0
1.B.2.a	Liquid fuels	Methane	716,687.61	267,822.27	0	0	13.77842762	0.003985798	0	0	0
1.B.2.b	Gaseous fuels	Carbon dioxide	1,404,105.53	1,095,100.49	0	0	22.3599757	0.026448087	0	0	0
1.B.2.b	Gaseous fuels	Methane	6,966,101.98	5,372,507.31	0.011842959	0.011842959	11.16485917	0.064788693	7.41194E-05	7.41194E-05	0.000104821
1.B.2.c		Carbon dioxide	336,721.95	296,899.37	0	0	24.48670165	0.00785251	0	0	0
1.B.2.c		Methane	409,295.41	179,462.74	0	0	14.90522081	0.002889227	0	0	0
1.B.2.c		Nitrous oxide	1,102.34	204.61	0	0	15.21618971	3.36277E-06	0	0	0
2.A.1		Carbon dioxide	15,145,810.00	13,130,750.00	0	0	3.201562119	0.04540675	0	0	0
2.A.2		Carbon dioxide	5,867,646.69	4,926,561.81	2.35362763	4.69908509	10.75343313	0.057221605	0.026968214	0.013507551	0.030161872
2.A.4		Carbon dioxide	426,720.85	361,559.62	50	2	50.03998401	0.019541866	0.000842374	0.021059345	0.021076186
2.A.7 ceramics		Carbon dioxide	531,112.90	338,251.95	0	0	29.90903135	0.010927268	0	0	0
2.A.7 glass		Carbon dioxide	695,617.07	741,344.47	3.087645144	5.524688239	6.328959842	0.005067822	0.004771147	0.002666505	0.005465719
2.B.1		Carbon dioxide	5,745,000.00	7,450,000.00	0	0	0.71568549	0.005759005	0	0	0
2.B.2		Nitrous oxide	3,384,400.15	2,935,614.68	1	5	5.099019514	0.01616794	0.017098736	0.003419747	0.017437357
2.B.3		Nitrous oxide	18,804,600.00	521,563.45	20	7	21.1896201	0.011937112	0.004253046	0.012151561	0.012874348
2.B.4		Carbon dioxide	443,160.00	18,630.00	10	10	14.14213562	0.000284575	0.000217024	0.000217024	0.000306918
2.B.5		Carbon dioxide	6,888,160.70	9,211,820.18	3.264467276	3.672296505	21.25562912	0.211489286	0.039407432	0.035031014	0.052726821
2.B.5		Methane	252.86	571.89	15	2	15.13274595	9.34755E-06	1.3324E-06	9.99303E-06	1.00815E-05
2.B.5		Nitrous oxide	C	C	20	75	77.62087348	0.005198035	0.005416864	0.001444497	0.005606156
2.C.1		Methane	3,918.60	4,653.99	0	0	67.06114799	0.000337106	0	0	0

CRF	Category	Gas	Base-year emissions [t CO_2-eq.]	Emissions, 2011 [Gg CO_2-eq.]	Combined uncertainty of activity data [%]	Combined uncertainty of emission factors [%]	Combined uncertainty of emissions [%]	Combined uncertainty percentage [%]	Trend uncertainty for emission factors [%]	Trend uncertainty for activity data [%]	Trend uncertainty for emissions [%]
2.C.1		Carbon dioxide	22,711,891.28	16,350,035.36	6.762963538	5.254244702	8.643027569	0.152634796	0.100074616	0.128810327	0.163116612
2.C.1		Nitrous oxide	27,613.10	15,559.02	0	0	64.4686151	0.001083427	0	0	0
2.C.2		Carbon dioxide	429,000.00	6,050.00	0	0	50.48762225	0.00032992	0	0	0
2.C.3		Carbon dioxide	1,011,923.12	591,227.50	0	0	15.03329638	0.009600145	0	0	0
2.C.3		CF_4	1,358,500.00	69,582.50	0	0	15	0.001127354	0	0	0
2.C.3		C_2F_6	193,200.00	11,932.40	0	0	15.03	0.000193712	0	0	0
2.C.4		Sulphur hexafluoride	197,103.30	57,558.37	0	0	25.84987816	0.001607074	0	0	0
2.C.5		HFC-134a	C	C	0	0	30.03747659	0.001126379	0	0	0
2.E		HFC-134a	C	C	0	0	10	0.000124688	0	0	0
2.E		Sulphur hexafluoride	167,300.00	101,814.00	0	0	10	0.001099706	0	0	0
2.E		HFC-227ea	C	C	0	0	10	0.00032263	0	0	0
2.F		HFC-125	115,063.46	1,534,878.87	0	0	11.28277341	0.018705052	0	0	0
2.F		C_2F_6	122,529.42	48,449.84	0	0	11.71204708	0.000612906	0	0	0
2.F		C_3F_8	15,784.63	35,823.20	0	0	12.33730337	0.000477368	0	0	0
2.F		c-C_4F_8	0.00	2,880.29	0	0	12.2	3.79547E-05	0	0	0
2.F		CF_4	90,256.77	60,933.16	0	0	10.09236491	0.000664226	0	0	0
2.F		Sulphur hexafluoride	6,856,907.82	3,284,984.69	0	0	7.25352313	0.025736608	0	0	0
2.F		HFC-134a	2,051,802.76	5,664,120.07	0	0	5.702847808	0.034889375	0	0	0
2.F		HFC-143a	56,062.66	1,463,048.15	0	0	13.95020697	0.022044905	0	0	0
2.F		HFC-152a	101,352.52	43,703.84	0	0	2.959840998	0.000139719	0	0	0
2.F		HFC-227ea	582.37	63,213.13	0	0	6.413764055	0.000437914	0	0	0
2.F		HFC-23	26,377.14	85,668.12	0	0	12.31377037	0.001139408	0	0	0
2.F		HFC-236fa	0.00	13,931.11	0	0	9.286100202	0.00013973	0	0	0
2.F		HFC-32	296.01	101,231.01	0	0	7.983607261	0.000872935	0	0	0
2.F		HFC-43-10mee	C	C	0	0	2	4.21244E-06	0	0	0
3		Carbon dioxide	2,552,000.00	1,506,045.20	0	0	7.867769957	0.012798487	0	0	0
3.D		Nitrous oxide	C	C	0.433446157	0.02889641	47.54390535	0.01478227	9.68983E-06	0.000145347	0.00014567
4.A.1.a	Dairy cattle	Methane	16,002,658.22	11,677,385.18	4	40	40.19950248	0.507031849	0.544127326	0.054412733	0.546841195
4.A.1.b	Cattle or dairy cattle	Methane	12,228,994.20	7,996,294.20	2.453061346	24.53061346	24.65296141	0.212925079	0.228503109	0.022850311	0.229642782
4.A.2	Other animals	Methane	1,329,708.96	1,019,022.30	3.570708853	24.96804532	25.22207859	0.027760899	0.029638974	0.004238704	0.029940531
4.B.1.a	Dairy cattle	Methane	2,230,082.46	1,771,939.08	4	40	40.19950248	0.076937562	0.08256647	0.008256647	0.082978275
4.B.1.a	Dairy cattle	Nitrous oxide	1,621,327.96	967,944.94	2.831752598	70.79381494	70.85042736	0.074073367	0.079825365	0.003193015	0.079889199
4.B.1.b	Cattle or dairy cattle	Methane	2,285,461.82	1,452,321.58	2.411028786	24.11028786	24.23053942	0.038009734	0.040790603	0.00407906	0.040994049
4.B.1.b	Cattle or dairy cattle	Nitrous oxide	1,455,129.45	1,099,715.81	1.864856102	46.62140255	46.65868476	0.055421965	0.05972563	0.002389025	0.059773392
4.B.2	Other animals	Methane	119,108.69	135,730.94	4.576535514	18.56510453	19.12087298	0.002803209	0.002935426	0.00072362	0.003023302
4.B.2	Other animals	Nitrous oxide	234,270.05	192,321.62	7.562345275	224.4461458	224.57351	0.046650424	0.050284624	0.001694258	0.050313158
4.B.8	Swine	Methane	2,063,405.06	1,622,875.48	2.894492518	28.94184665	29.08622654	0.050984896	0.054714997	0.005472082	0.054987949
4.B.8	Swine	Nitrous oxide	570,372.58	502,608.87	2.277124085	56.91537653	56.96091098	0.030922602	0.033323814	0.001333251	0.033350475

CRF	Category	Gas	Base-year emissions [t CO_2-eq.]	Emissions, 2011 [Gg CO_2-eq.]	Combined uncertainty of activity data [%]	Combined uncertainty of emission factors [%]	Combined uncertainty of emissions [%]	Combined uncertainty percentage [%]	Trend uncertainty for emission factors [%]	Trend uncertainty for activity data [%]	Trend uncertainty for emissions [%]
4.B.9	Poultry	Nitrous oxide	37,565.90	49,750.52	5.708311921	57.08311921	57.36782481	0.003082726	0.003308264	0.000330826	0.003324765
4.D.1		Nitrous oxide	29,140,629.55	26,360,901.71	15.44547515	53.19679934	55.39370147	1.577210299	1.633581118	0.474303659	1.701044159
4.D.2		Nitrous oxide	2,104,157.56	1,315,386.66	20	200	200.9975124	0.285570323	0.306463227	0.030646323	0.307991731
4.D.3		Nitrous oxide	16,539,747.67	14,195,706.36	142.819168	319.1414022	349.6406002	5.361024856	5.277583291	2.361774591	5.781942978
5.A		Carbon dioxide	-80,640,850.87	-32,789,088.21	0	0	19.87396592	0.703854412	0	0	0
5.A		Methane	9,084.07	1,315.29	0	0	38.07886553	5.4097E-05	0	0	0
5.A		Nitrous oxide	60,374.25	66,289.39	1.332301907	298.6386385	298.6416603	0.021382742	0.023061363	0.000102883	0.023061593
5.B		Carbon dioxide	28,632,121.89	28,632,508.12	0.307024394	0.180875586	40.67364277	1.257886392	0.006033013	0.010240643	0.011885622
5.B		Nitrous oxide	196,076.30	206,715.25	0	0	98.2513384	0.021937137	0	0	0
5.C		Carbon dioxide	11,327,524.73	8,768,426.74	0	0	39.55723008	0.374642038	0	0	0
5.D		Carbon dioxide	2,233,153.03	2,128,101.19	0	0	36.33203908	0.083512408	0	0	0
5.E		Carbon dioxide	2,307,729.04	2,256,015.86	0	0	24.80501092	0.060443628	0	0	0
5.G		Carbon dioxide	116,784.72	64,317.22	0	0	5.30346073	0.000368431	0	0	0
6.A		Methane	38,598,000.00	11,046,000.00	0	0	50	0.596546085	0	0	0
6.B		Methane	2,226,211.52	60,936.75	0	0	75	0.004936391	0	0	0
6.B		Nitrous oxide	2,342,219.21	2,414,592.77	2.267736686	13.60642012	13.79410374	0.035975459	0.038272137	0.006378689	0.038800053
6.D		Methane	49,777.90	536,234.20	1.408471747	42.25415242	42.27762043	0.024486911	0.026394829	0.000879828	0.026409488
6.D		Nitrous oxide	13,982.61	323,111.33	1.179053321	49.58688591	49.60090141	0.017310544	0.018664397	0.000443793	0.018669672
Total		**(in Gg)**	**1,214,003.8**	**925,829.6**				**6.269** %			**6.525 %**

Uncertainties for source categories have been determined successively, within the framework of UBA sections' data deliveries for current emissions reporting. On the other hand, external experts have carried out additional uncertainties determination, in research projects, for source categories for which no uncertainties information, or incomplete information, has been available to date. The results of such uncertainties analysis have been integrated within the current report.

The uncertainties in the source category Agriculture (CRF 4) were estimated by experts of the Johann Heinrich von Thünen Institute (TI).

Current work planning calls for Tier 2 uncertainties analysis to be carried out every three years. Uncertainties are determined pursuant to Tier 1, and reported, every year.

24 REFERENZEN

AGEB, 2003: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanzen der Bundesrepublik Deutschland - Jahre 1990-1999, Verlags- und Wirtschaftsgesellschaft der Elektrizitätswerke, Frankfurt a. M.AGEB, 2002: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Sonderauswertung für das UBA zur Darstellung von ausgewählten Energieverbräuchen in der Struktur der Energiebilanz vor 1995 für Zeitreihen von 1995 bis 1999 (unveröffentlicht)

AGEB, 2010: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanz für die Bundesrepublik Deutschland URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 , (Aufruf: 25.08.2010 & 10.11.2010), Köln, Berlin.

AGEB, 2012: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanz für die Bundesrepublik Deutschland URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 , (Aufruf: 02.08.2012), Köln, Berlin.

AGEB, 2011a: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Heizwerte der Energieträger und Faktoren für die Umrechnung von spezifischen Mengeneinheiten in Wärmeinheiten (2000-2009) (veröffentlicht am 21. März.2011); URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=65 (Aufruf: 10.10.2011), Köln, Berlin.

AMD, 2002/2003**:** Amd Saxony LLC&Co. KG, Dresden, Umweltbericht. S. 16

AMTSBLATT DER EUROPÄISCHEN GEMEINSCHAFT: Richtlinie des Rates vom 21.Mai 1991 über die Behandlung von kommunalem Abwasser; Nr. L 135/40 , 30 S. 91, Artikel 2 Nr. 6

ARBEITSGRUPPE BODEN (1994): Bodenkundliche Kartieranleitung, 4. Auflage, Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, 392 S.

ARBEITSGRUPPE BODEN (2005): Bodenkundliche Kartieranleitung. 5. verbesserte und erweiterte Auflage, Hannover

ATV, 2004: ATV-DVWK-M 374: Produktionsspezifische Abwässer und Abfälle aus der Glas- und Mineralfaserindustrie, ATV-DVWK Deutsche Vereinigung der Wasserwirtschaft, Abwasser und Abfall e.V., 08/2004

AUGUSTIN, J. (2001): Emission, Aufnahme und Klimarelevanz von Spurengasen. - In: Succow, M. & H. Joosten [Hrsg.]: Landschaftsökologische Moorkunde. 2., völlig neubearb. Aufl.: 28-38; Stuttgart (Schweizerbart`sche Verlagsbuchhandlung).

BACHMAIER, H., und GRONAUER, A. (2007) Klimabilanz von Biogasstrom. Bayerische Landesanstalt für Landwirtschaft (LfL). Freising.

BAFA, 2012: Bundesamt für Wirtschaft und Ausfuhrkontrolle, Amtliche Mineralöldaten für die Bundesrepublik Deutschland, URL: http://www.bafa.de/bafa/de/energie/mineraloel_rohoel/amtliche_mineraloeldaten/index.html , (Aufruf: 01.10.2012), Eschborn.

BAKER, J.M., OCHSNER, T.E., VENTEREA, R.T., GRIFFIS, T.J., 2007: Tillage and soil carbon sequestration - What do we really know? Agriculture, Ecosystems and Environment, 118, 1 – 5

BARITZ, R.; SEUFERT, G.; MONTANARELLA, L.; VAN RANST, E. 2010: Carbon concentrations and stocks in forest soils of Europe. Forest Ecology and Management, 260, 262–277

BASt, 2007: Bundesanstalt für Straßenwesen: Unterreihe Verkehrstechnik; V 164: "Straßenverkehrszählung 2005: Ergebnisse", Thorsten Kathmann, Hartmut Ziegler, Bernd Thomas; 62 Seiten; Bergisch Gladbach, 2007

BASt, 2008: Bundesanstalt für Straßenwesen: Unterreihe Verkehrstechnik; V 166: Verkehrsentwicklung auf Bundesfernstraßen 2006, Arnd Fitschen, Ingo Koßmann, 239 Seiten; Bergisch Gladbach, 2008

BATZ, 1995: Kokereien und Produktemissionen. Mündliche Mitteilung. Umweltbundesamt.

BAYERISCHE LANDESANSTALT FÜR LANDWIRTSCHAFT (LfL) (2007): 20 Jahre Boden-Dauerbeobachtung in Bayern, Teil 3: Entwicklung der Humusgehalte zwischen 1986 und 2007; Schriftenreihe, 10, Freising-Weihenstephan.

BDZ 1995: Sonderauswertung des Bundesverbandes der deutschen Zementindustrie, erstellt für das UBA für die Jahre 1990-1994

BFI 2012: VDEh-Betriebsforschungsinstitut GmbH: Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichtserstattung. Forschungsbericht, Düsseldorf 2010. – gemeinsame Sonderpublikationvon BFI und Umweltbundesamt, Dessau-Roßlau 2012 (in Veröffentlichung)

BGR 1995, 1997: Digitale Bodenübersichtskarte der BRD (BUEK 1000); Maßstab: 1:1.000.000; Hannover

BGR (Bundesanstalt für Geowissenschaften und Rohstoffe), 2011: Schätzprofile der BÜK 1000 n 2.3; FISBo BGR

BGS BGSs-Bogen– „Brennstoff-, Gas- und Stromwirtschaft der Hochofen-Stahl-und Walzwerke sowie Schmiede-,Preß- und Hammerwerke einschließlich örtlich verbundener sonstiger Betriebe (ohne eigene Kokereien“ ab 2010 vom VDEh, davor Eisen/stahlstatistik des Statistischen Bundesamtes

BEYER et al., 2004: Beyer, M.; Chudy, A.; Hoffmann, L.; Jentsch, W.; Laube, W.; Nehring, K.; Schiemann, R.: Rostocker Futterbewertungssystem. Kennzahlen des Futterwertes und Futterbedarfs auf der Basis von Nettoenergie. Dummerstorf: Forschungsinstitut für die Biologie landwirtschaftlicher Nutztiere. 392 pp.

BLASING, T.J. (2012): Recent Greenhouse Gas Concentrations; http://cdiac.ornl.gov/pns/current_ghg.html; access date 01.11.2012

BLE (Bundesanstalt für Landwirtschaft und Ernährung) (Hrsg.), 2011: Waldbrandstatistik der Bundesrepublik Deutschland für das Jahr 2010, Bonn, 18 S.

BLUM, W., HEINBACH, R. 2006: Endbericht zum BZE Ringversuch Humus 2006. Bayerische Landesanstalt für Wald und Forstwirtschaft (LWF), Freising, 216 S.

BLUM, W.; HEINBACH, R. 2007: Endbericht zum BZE Ringversuch Mineralboden 2007. Teil 1. Bayerische Landesanstalt für Wald und Forstwirtschaft (LWF), Freising, 218 S.

BMBF, 1997: Verbundvorhaben des Umweltbundesamtes mit dem BMBF: Deponiekörper, Förderkennzeichen 1460799A bis G (Teilvorhaben), Projektträger Abfallwirtschaft und Altlasten im Umweltbundesamt Berlin, Koordinierung Fachgebiet Abfall- und Siedlungswasserwirtschaft, Bergische Universität - Gesamthochschule Wuppertal

BMELF (Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft), 1990: Bundeswaldinventur 1986 – 1990. Inventurbericht und Übersichtstabellen für das Bundesgebiet nach dem Gebietsstand bis zum 3. 10. 1990 einschließlich Berlin (West)

BMELF (Bundesministerium für Ernährung, Landwirtschaft und Forsten), 1994: Der Wald in den neuen Bundesländern - Eine Auswertung vorhandener Daten nach dem Muster der Bundeswaldinventur, Bonn, 38 S.

BMVEL (Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft) (Hrsg.), 2001. Aufnahmeanweisung für die Bundeswaldinventur II (2001 - 2002), 2. korrigierte, überarbeitete Ausgabe, Mai 2001, Bonn, 108 S.

BMELV (Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft) (Hrsg.), 2005. Die zweite Bundeswaldinventur – BWI²: Der Inventurbericht. Bonn, 231 S.

BMELV (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz) (Hrsg.), 2009: Waldbericht der Bundesregierung 2009. Berlin, 117 S.BMELV (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz) (Hrsg.), 2010: Aufnahmeanweisung für die Inventurstudie 2008 im Rahmen der Treibhausgasberichterstattung. 2. korrigierte, überarbeitete Aufl., Bonn, 60 S.

BMELV (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz), 2012: Konzept zur Erstellung von THG-Emissions- und Kohlenstoffinventaren der Quell- und Senkengruppen 4 und 5 im Zuständigkeitsbereich des BMELV, AZ: 521-65408/0002, unveröffentlicht.

BMLFUW, 2005: Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft Österreich (2005): Abschätzung der Auswirkungen des Tanktourismus auf den Treibstoffverbrauch und die Entwicklung der CO_2-Emissionen in Österreich. Wien.

BMU, 1990: Bundesminister für Umwelt, Naturschutz und Reaktorsicherheit, Karl Eugen Huthmacher: Eckwerte der ökologischen Sanierung und Entwicklung in den neuen Ländern, Bonn

BMVg, 2011: Bundesministerium der Verteidigung: Energieeinsatz zur Wärmeversorgung der Bundeswehr (unveröffentlicht).

BÖRJESSON, P., und BERGLUND, M. (2008): Environmental systems analysis of biogas systems—Part II: The environmental impact of replacing various reference systems. Biomass and Bioenergy 31 (2007) 326–344.

BPB, 2002: Bundeszentrale für politische Bildung. Projektgruppe Zukunft der Wirtschaft, Die Zukunft der Wirtschaft, Landwirtschaft und Ernährung, herausgegeben von Margarete Wohlan

BOSSHARD, H.H. 1984: Holzkunde. Band 2: Zur Biologie, Physik und Chemie des Holzes. Birkhäuser, Basel. 312 S.

BURSCHEL, P.; KÜRSTEN, E.; LARSON, B.C. (1993): Die Rolle von Wald und Forstwirtschaft im Kohlenstoffhaushalt - eine Betrachtung für die Bundesrepublik Deutschland. Forstliche Forschungsberichte München, Forstwissenschaftliche Fakultät d. Universität München u. Bayrische Landesanstalt f. Wald u. Forstwirtschaft, Freising, 135 S.

BV Glas, 2012: Jahresbericht des Bundesverband Glasindustrie e.V., mit statistischem Anhang

BV Kalk, 2011 (Bundesverband der deutschen Kalkindustrie e.V.): Kalk Daten nationaler Inventarbericht; per E-Mail an das UBA übermittelt.

BVE, 2012: Bundesvereinigung der Deutschen Ernährungsindustrie e.V., Broschüre Ernährungsindustrie 2012, URL: www.bve-online.de

BYRNE, K.A., B. Chojnicki, T.R. Christensen, M. Drösler, A. Freibauer, T. Friborg, S. Frolking, A. Lindroth, J. Mailhammer, N. Malmer, P. Selin, J. Turunen, R. Valenti & L. Zetterberg, 2004: EU Peatlands: Current Carbon Stocks and Trace Gas Fluxes. CarboEurope-GHG Report 4/2004. Specific Study, Tipo-Lito Recchioni, Viterbo, October 2004, S.58.

CAIRNS, M.A.; BROWN, S.; HELMER, E.H.; BAUMGARDNER, G.A., 1997: Root biomass allocation in the world's upland forests. Oecologia, Vol. 111 (1), pp. 1-11

COOLS, N.; VERSCHELDE, P.; QUATAERT, P.; MIKKELSEN, J.; DE VOS, B. 2006: Quality Assurance and Quality Control in Forest Soil Analysis: 4th Forest Soil Co-ordinating Centre (FSCC) Interlaboratory Comparison, Research Institute for Nature and Forest, Geraardsbergen, 66p + annex, http://www.icp-forests.org/DocsSoil/4thSoilRingtest.pdf [zitiert am 20.08.2010]

CORINAIR, 2006 - EMEP/CORINAIR Emission Inventory Guidebook - 2006, EEA technical report No. 11/2006; Dezember 2006, Kopenhagen 2006
URL: http://www.eea.europa.eu/publications/EMEPCORINAIR4

CLODIC., D & BEN YAHIA, M. 1997: Centre d'Energétique, Ecole des Mines de Paris: New Test Bench for Measuring Leak Flow Rate of Mobile Air Conditioning Hoses and Fittings. Earth Technology Conference, Baltimore.

CLODIC D., BARRAULT S., SABA S. 2012: Global inventories of the worldwide fleets of refrigerating and airconditioning equipment in order to determine refrigerant emissions, The 1990 to 2006 updating. Extracts from the Final Report, April 2012.

CLODIC D., BARRAULT S. 2011: 1990 to 2010 Refrigerant inventories for Europe. Previsions on banks and emissions from 2006 to 2030 for the European Union. Final report. Part A 1990 to 2010 refrigerant inventories for Europe. 18.10.2011.

DÄMMGEN et al. (2011a): Dämmgen, U.; Amon, B.; Gyldenkærne, S.; Hutchings, N.J.; Kleine Klausing, H.; Haenel, H.-D.; Rösemann, C.: Reassessment of the calculation procedure for the volatile solids excretion rates of cattle and pigs in the Austrian, Danish and German agricultural emission inventories. Landbauforschung, 61: 115 - 126

DÄMMGEN et al. (2011b): Dämmgen, U.; Brade, W.; Schulz, J.; Kleine Klausing, H.; Hutchings, N.J.; Haenel, H.-D.; Rösemann, C.: The effect of feed composition and feeding strategies on excretion rates in German pig production. Landbauforschung, 61: 327-342

DÄMMGEN, U.; HUTCHINGS N.J., 2005: The assessment of emissions of nitrogen species from agriculture using the methodology of the atmospheric emission inventory guidebook. In: Kuczyński T, Dämmgen U, Webb J, Myczko A (eds) Emissions from European agriculture. Wageningen Academic Publishers, Wageningen. pp 51-62

DÄMMGEN et al, 2002: Dämmgen, U., Lüttich, M., Döhler, H., Eurich-Menden, B., Osterburg, B.: GAS-EM – A Procedure to Calculate Gaseous Emissions from Agriculture. Landbauforschung Völkenrode 52, S. 19-42.

DÄMMGEN et al, 2012a: Dämmgen, U., Amon, B., Hutchings, N.J., Haenel, H.-D., Rösemann, C.: Data sets to assess methane emissions from untreated cattle and pig slurry and manure storage systems in the German and Austrian emission inventories. Landbauforschung 62, 1 – 20.

DÄMMGEN et al, 2012b: Dämmgen, U., Rösemann, C., Haenel H.-D., Hutchings N.J.: Enteric methane emissions from German dairy cows. Landbauforschung, 62: 21 – 32.

DAV, 2011: Deutscher Asphaltverband e.V., Schieffelingsweg 6, 53123 Bonn, Veröffentlichung zur Asphaltproduktion in Deutschland, http://www.asphalt.de/site/startseite/aktuelles/asphaltproduktion/ (Dokument asphaltp10.pdf), Stand April 2011

DBU, 2002: Vogt, R., Knappe, F., Giegrich, J., Detzel, A., IFEU-Institut für Energie und Umweltforschung Heidelberg (Hrsg.): Ökobilanz Bioabfallverwertung. Untersuchung zur Umweltverträglichkeit von Systemen zur Verwertung von biologisch-organischen Abfällen. Initiativen zum Umweltschutz, Band 52. Erich Schmidt Verlag, Berlin 2002

DEBRIV, 2004: Deutscher Braunkohlen-Industrie-Verein e.V., Mitteilung vom 15. September 2004 an das IKP Stuttgart.

DEHSt, 2012: Fackelverluste des JI-Projektes im Saarland: https://www.jicdm.dehst.de/promechg/pages/project2.aspx?PID=3184&ctit=&ccat=&cscop=&cpac=&cstat=&chost=&cred1=&cred2=

DE VRIES, W.; REINDS, G.J.; GUNDERSON, P; STERBA, H. 2006: The impact of nitrogen deposition on carbon sequestration in European Forests and forest soils. Global Change Biology, 12, 1151-1173

DGE, 2008: Deutsche Gesellschaft für Ernährung e.V.: Ernährungsbericht 2008, ISBN 978-3-88749-214-4

DGMK, 1992: Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V.: Forschungsbericht 448-2 - Ansatzpunkte und Potentiale zur Minderung des Treibhauseffektes aus Sicht der fossilen Energieträger, Hamburg, Seite II-89

DIE VERBRAUCHER INITIATIVE e.V., 2005: Distickstoffmonoxid, (Online Dokument) http://www.zusatzstoffe-online.de/html/zusatz.php3?nr=942 , Zugriff Mai 2005

DIETER, M., ELSASSER, P., 2002: Carbon Stocks and Carbon Stock Changes in the Tree Biomass of Germany's Forests. In: Forstwissenschaftliches Centralblatt (121. Jahrgang), S. 195-210. Berlin: Blackwell Wissenschafts-Verlag

DIETER, M.; ENGLERT, H. 2005: Gegenüberstellung und forstpolitische Diskussion unterschiedlicher Holzeinschlagsschätzungen für die Bundesrepublik Deutschland. Arbeitsbericht des Instituts für Ökonomie 2005/2, Bundesforschungsanstalt für Forst- und Holzwirtschaft, Institut für Ökonomie

DIN, 2003: DIN EN 1279-3: Glas im Bauwesen - Mehrscheiben-Isolierglas - Teil 3: Langzeitprüfverfahren und Anforderungen bezüglich Gasverlustrate und Grenzabweichungen für die Gaskonzentration; Deutsche Fassung EN 1279-3:2002

DIN, 2004: Deutsches Institut für Normung e. V. (DIN). DIN 1343. Referenzzustand, Normzustand, Normvolumen; Begriffe und Werte. Internetseite mit Recherchefunktionen. URL: http://www2.din.de. Berlin.

DIW, 1991: Deutsches Institut für Wirtschaftsforschung, Entwicklung des Energieverbrauchs und seiner Determinanten in der ehemaligen DDR. Von Hans-Joachim Ziesing. Untersuchung im Auftrag des Bundesministers für Wirtschaft. Im Unterauftrag: Institut für Energetik (IfE), Leipzig; Institut für Wirtschaftswissenschaften der Akademie der Wissenschaften, Berlin; Staatliche Vorratskommission für nutzbare Ressourcen der Erdkruste, Berlin. Berlin, April 1991

DIW, 2002: Rieke, H. (DIW): Fahrleistungen und Kraftstoffverbrauch im Straßenverkehr; in: DIW Wochenbericht Nr. 51-52/2002; Berlin, Dezember 2002; Ergebnisse auch kontinuierlichveröffentlicht in „Verkehr in Zahlen“

DLG, 2005: Deutsche Landwirtschafts-Gesellschaft (ed.) Bilanzierung der Nährstoff-ausscheidungen landwirtschaftlicher Nutztiere. Arbeiten der DLG/Band 199. DLG-Verlag, Frankfurt/Main. 69 pp

DMT 2005: Freundliche persönliche Mitteilung von Herrn Meiners, Deutsche Montan Technologie. 28.09.2005. Gelsenkirchen.

DMT 2011: Meiners et al: „Diffuse Emissionen fester Brennstoffe (Kohlen) – Emissionen von Grubengas aus stillgelegten Bergwerken; Potential zur Freisetzung und Verwertung von Grubengas“, FKZ 360 16 028 im Auftrag des Umweltbundesamtes 2011

DÖPELHEUER, 2002: Anwendungsorientierte Verfahren zur Bestimmung von CO, HC und Ruß aus Luftfahrttriebwerken, Dissertationsschrift des DLR, Institut für Antriebstechnik, Köln, 2002

DRÖSLER, M., ADELMANN, W., AUGUSTIN, J., BERGMAN, L., BEYER, C., CHOJNICKI, B., FÖRSTER, C., FREIBAUER, A., GIEBELS, M., GÖRLITZ, S., HÖPER, H., KANTELHARDT, J., LIEBERSBACH, H., HAHN-SCHÖFL, M., MINKE, M., PETSCHOW, U., PFADENHAUER, J., SCHALLER, L., SCHÄGNER, P., SOMMER, M., THUILLE, A., WEHRHAN, M., 2011: Klimaschutz durch Moorschutz. Schlussbericht des Vorhabens „Klimaschutz - Moornutzungsstrategien“ 2006-2010; 174 S.

DüV - Düngeverordnung (2007) Verordnung über die Anwendung von Düngemitteln, Bodenhilfsstoffen, Kultursubstraten und Pflanzenhilfsmitteln nach den Grundsätzen der guten fachlichen Praxis beim Düngen (Düngeverordnung – DüV). In der Fassung der Bekanntmachung vom 27. Februar 2007 (BGBl. I S.221).

DÜWEL, O., SIEBNER, C.S., UTERMANN, J., KRONE, F., 2007: Gehalte an organischer Substanz in Oberböden Deutschlands – Bericht über länderübergreifende Auswertung von Punktinformationen im FISBo BGR-“; BGR, Hannover

DUNGER, K.; OEHMICHEN, K.; STÜMER, W.; IOST, A.; RIEDEL, T. 2010c: Annex 3, Chapter 19.5.1: Other detailed methodological descriptions for the source/sink category “Land-use change and forestry” – Forest land (5.A), 575-585. In: Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2010. National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2008. Dessau: Federal Environment Agency, ISSN 1862-4359, 672 p.

EC, 2006a: European Commission, Joint Research Centre, Institute for Prospective Technological Studies: Integrated Pollution Prevention and Control – Reference Document on Best Available Techniques in the Production of Polymers. October 2006. Sevilla, Spain.

EC, 2007: European Commission, Joint Research Centre, Institute for Prospective Technological Studies: Integrated Pollution Prevention and Control – Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Solids and Others industry. October 2006. Sevilla, Spain.

EC, 2012: Fleet Register der Europäischen Kommission; URL:http://ec.europa.eu/fisheries/fleet/index.cfm?method=Search.SearchAdvanced&country=DEU, (Aufruf 22.10.2012)

EINIG, K., A. JONAS & B. ZASPEL, 2009: Eignung von CORINE-Geodaten und Daten der Flächenerhebung zur Analyse der Siedlungs- und Verkehrsflächenentwicklung in Deutschland. Statistisches Bundesamt - Wirtschaft und Statistik 4/2009, S.355 - 364

EMEP, 2003: Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook, 3rd Edition September 2003 UPDATE, EEA, Copenhagen, 2003

EMEP, 2005: European Environment Agency: EMEP/CORINAIR Emission Inventory Guidebook - 2005. Technical report No 30., Stand: 31.12.2005 URL: http://reports.eea.europa.eu/EMEPCORINAIR4/en/

EMEP (2006) -EMEP/CORINAIR Emission Inventory Guidebook – 2006, Technical Report No 11/2006. http://www.eea.europa.eu/publications/EMEPCORINAIR4

EMEP, 2009: EMEP (2009) -EMEP/EEA air pollutant emission inventory guidebook – 2009, Technical Report No 6/2009. http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009

EMEP/EEA, 2010: EMEP/EEA Guidebook 2009, Kapitel 1.A.3.a, 1.A.5.b Aviation, URL: http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation.pdf (Update Dezember 2010) und http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation_annex.zip.

EUROCONTROL, 2004 – The Advanced Emission Model (AEM3) - Validation Report, Jelinek, F., Carlier, S., Smith, J., EEC Report EEC/SEE/2004/004, Brüssel 2004. URL: http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2004_016.html

EUROCONTROL, 2006 – The Advanced Emission Model (AEM3) - Validation Report, Jelinek, F., Carlier, S., Smith, J., EEC Report EEC/SEE/2004/004, Brüssel 2004 URL: http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2004_016.html http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2006_030.html

FAO (Food and Agriculture Organization of the United Nations) 1990: Soil Map of the World. Revised Legend. Reprinted with corrections. FAO, Rome, World Soil Resources Report 60

FAO Statistical Yearbook 2004; Table D1 - Dietary energy protein and fat consumption 2004; www.fao.org/docrep/008/y5473m/y5473m00.HTM#Contents_en

FAO: Statistical Yearbook 2007-2008 (2010) ; Table D1: Dietary energy protein and fat consumption www.fao.org/economic/ess/ess-publications/ess-yearbook/fao-statistical-yearbook-2007-2008/d-consumption/en/;

FAO Statistical Yearbook 2010; Table D1 - Dietary energy protein and fat consumption ; www.fao.org/economic/ess/ess-publications/ess-yearbook/ess-yearbook2010/yearbook2010-consumption/en/

FAUSTZAHLEN (1993): Faustzahlen für Landwirtschaft und Gartenbau. 12th ed., Landwirtschaftsverlag, Münster, 1993

FHG ISI, 1993: Fraunhofer-Institut für Systemtechnik und Innovationsforschung: Emissionen der Treibhausgase Distickstoffoxid und Methan in Deutschland: Emissionsbilanz, Identifikation von Forschungs- und Handlungsbedarf sowie Erarbeitung von Handlungsempfehlungen ; Phase 1, UBA-Berichte 93/09, FKZ 10402682, E. Schmidt-Verlag Berlin, 1993

FICHTNER et al. 2011: Fichtner, W; Karl, U; Hartel, R; Balussou, D: Fortschreibung der Emissionsfaktoren für Feuerungs- und Gasturbinenanlagen nach 13./17. BImSchV und TA Luft; Bericht zum Forschungsvorhaben des Umweltbundesamtes unter FKZ 3708 42 301, durchgeführt vom Deutsch-Französischen Institut für Umweltforschung (DFIU) und dem Europäischen Institut für Energieforschung (EIFER)

FISCHER, 1997: Klimawirksame Emissionen durch PKW-Klimaanlagen. Diplomarbeit an der TU Berlin, FB 10, ISS-Fahrzeugtechnik.

FOEN (Federal Office for the Environment) 2010: Switzerland´s Greenhouse Gas Inventory 1990 - 2008, Bern,Switzerland

FORTMANN, H., P. RADEMACHER, H. GROH & H. HÖPER (in Veröffentlichung): Stoffgehalte und –vorräte im Boden und deren Veränderungen; GeoBerichte des LBEG;

FRAVER et. al 2002, Fraver, S.; Wagner, R.G.; Day, M.; 2002. Dynamics of coarse woody debris following gap harvesting in the Acadian forest of central Main, U.S.A. Can. J. For. Res. 32, 2094-2105.

FRAUENHOFER ISI 2000: Reichert und Schön: "Methanemissionen durch den Einsatz von Gas in Deutschland von 1990 bis 1997 mit einem Ausblick auf 2010"; Auftragsnummer AG GI5-46043-3/31 im Auftrag des Deutschenvereins des Gas- und Wasserfaches e.V., Karlsruhe 2000

FREIBAUER, A. (2003): Regionalised inventory of biogenic greenhouse gas emissions from European agriculture. European Journal of Agronomy 19(2): 135-160

FREIBAUER, A.; GENSIOR, A. 2011: Annex 3, Chapter 19.5.2: Other detailed methodological descriptions for the source/sink category “Land-use change and forestry” (5) – Cropland, grassland, wetlands, settlements and other areas (5.B/5.C/5.D/5.E/5.F), 650-671. In: Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2011. National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2009. Dessau: Federal Environment Agency, ISSN 1862-4359, 755 p.

FULLER, R., SMITH, G. und DEVEREUX, B. (2003): The characterisation and measurement of land cover change through remote sensing: problems in operational applications. International Journal of Applied Earth Observation and Geoinormation 4: 234-253.

GÄRTNER, S.; MÜNCH, J.; REINHARDT, G. und VOGT, R. (2008): Materialband: E. Ökobilanzen. In: BMU-Bericht „Optimierungen für einen nachhaltigen Ausbau der Biogaserzeugung und -nutzung in Deutschland“, FKZ: 0327544.

GDA, 2011: Gesamtverband der Aluminiumindustrie e.V. (GDA) – GDA Startseite – Produktion, URL: : http://www.aluinfo.de/index.php/produktion.html

GENSIOR, A. & J. ZEITZ (1999): Einfluss einer Wiedervernässungsmaßnahme auf die Dynamik chemischer und physikalischer Bodeneigenschaften eines degradierten Niedermoores. Archiv für Naturschutz und Landschaftsforschung, 38, S. 267 – 302

GfE – Gesellschaft für Ernährungsphysiologie, Ausschuss für Bedarfsnormen (2006): Energie- und Nährstoffbedarf landwirtschaftlicher Nutztiere. Nr. 10. Empfehlungen zur Energie- und Nährstoffversorgung von Schweinen. Frankfurt/M., DLG, 247 S.

GICON, 2008: Implementierung der Bilanz der Emissionsursachen auf Basis der MESAP-Datenbank Bachmann, Thomas; Kalies, Heiko GICON, Großmann Ingenieur Consult GmbH Niederlassung Leipzig 2008

GLOBAL CARBON PROJECT: The Carbon Budget 2010; http://www.globalcarbonproject.org/carbonbudget/10/hl-full.htm#AtmosphericEmissions; access date: 01.11.2012

GRUNDNER, F.; SCHWAPPACH, A. 1952: Massentafeln zur Bestimmung des Holzgehaltes stehender Waldbäume und Waldbestände. 10. Aufl. Verlag Paul Parey, Berlin, Hamburg, 216 S.

GSE 2003: Service 'Forest Monitoring Inputs for Greenhouse Gas (GHG) Reporting'. Service Results 2003, Reporting Area: Main parts of the Federal State "Saxony", Issue 1.0, 50 p.

GSE 2006: S6 Service Operations Report. Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting. Service to BMELV. GSEFM-T2-S6-Ph1. Issue 1.0, 125 p.

GSE 2007: S6 Service Operations Report. Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting. Service to BMELV. GSEFM-T3-S6-Ph2. Issue 2.1, 93 p.

GSE 2009: S6 Service Operations Report. Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting. Service to BMELV. GSEFM-T3-S6-Ph3. Issue1.0, 211 p.

HAENEL et al. (2011): Haenel, H.-D.; Dämmgen, U.; Rösemann, C.: Estimating numbers of piglets, weaners and fattening pigs for the German agricultural emission inventory. Landbauforschung, 61: 229 – 236.

HAENEL et al. (2011a): Haenel, H.-D.; Dämmgen, U.; Laubach, P.; Rösemann, C.: Update of the calculation of metabolizable energy requirements for pigs in the German agricultural emission inventory. Landbauforschung, 61: 217 – 228.

HAENEL et al. (2012): Haenel, H.-D.; Rösemann, C.; Dämmgen, U.; Poddey, E.; Freibauer , A.; Döhler, H.; Eurich-Menden, B.; Wulf, S.; Dieterle, M.; Osterburg, B.: Calculation of gaseous and particulate emissions from German agriculture 1990 – 2010. Report on methods and data. Landbauforschung, Special Issue 356: http://www.ti.bund.de/fileadmin/dam_uploads/Institute/AK/PDFs/SH_356.zip

HAENEL et al. (2012a): Haenel D.; Rösemann C.; Dämmgen U.: Antwort auf die Anfrage zur Berechnung der Methanemissionen der Rinder; 14.01.2013 (unveröffentlicht; hinterlegt in der Inventarbeschreibung Landwirtschaft: Inventarüberprüfung 2012)

HÄUSSLER, T., SIEGMUND, R., RIEDEL, T. und KENTER, B. (2006): S6 Service Operations Report. Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting. Service to BMELV. Stage 2 of the Earthwatch GMES Service Element. Technischer Bericht, GAF AG, München

HAKKILA, P. 1972: Utilisation of residual forest biomass. Springer-Verlag, Berlin, Heidelberg, New York, 568 S.

HENRICHSMEYER et al, 1996: Henrichsmeyer, W.; Cypris, Ch.; Löhe, W.; Meuth, M.; Isermeyer F; Heinrich, I.; Schefski, A.; Neander, E.; Fasterding, F.;, Neumann, M.; Nieberg, H.: Entwicklung des gesamtdeutschen Agrarsektormodells RAUMIS96. Endbericht zum Kooperationsprojekt. Forschungsbericht für das BMELF (94 HS 021), Bonn, Braunschweig

HOBBS et al., 2004: Hobbs P.J.; Webb J.; Mottram T.T.; Grant B.; Misselbrook T.M.: Emissions of volatile organic compounds originating from UK livestock agriculture. J Science of Food and Agriculture 84, 1414-1420

HÖPER, H. (2002): Carbon and nitrogen mineralization rates in German agriculturally used fenlands. In: Broll, G. Merbach, W. und E.-M. Pfeiffer (Hrsg.): Wetlands in Central Europe. Soil organisms, soil ecological processes, and trace gas emissions. Springer, Berlin, 149-164.

HVG, 2008: Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung. Teilvorhaben 02: Bereitstellung aktueller Emissionsdaten für die Glas- und Mineralfaserindustrie., Forschungsbericht in Veröffentlichung

IER, 2008: Institut für Energiewirtschaft und Rationelle Energieanwendung Stuttgart (Herausgeber),: Theloke, Jochen; Wagner, Susanne; Jepsen Dirk: Emissionen aus der Nahrungsmittelindustrie, Forschungsbericht UBA-FB 001480, FKZ 206 42 101/01.

IFE, 1991: IfE Leipzig GmbH, Energiebilanz 1990 für die neuen Bundesländer. Von Jochen Hesselbach und Mitarbeit von Bernd Lemmnitz, Elke Lindner, Hans-Albert Müller und Ursula Zehrfeld. Untersuchung im Auftrag des Bundesministers für Wirtschaft, Leipzig 1991

IFEU, 2002, Knörr, W. et al, IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Aktualisierung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen aus dem motorisierten Verkehr in Deutschland 1980 bis 2020; sowie TREMOD 3.0 ; im Auftrag des Umweltbundesamtes, FKZ 201 45 112; Berlin 2002

IFEU, 2003a: Detzel, A., Vogt, R., Fehrenbach, H., Knappe, F., Gromke, U., IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationale Richtlinien. Teil Abfall/Abwasser, Februar 2003

IFEU, 2009: Helms, H., Lambrecht, U., Knörr, W. , IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Aktualisierung des Modells TREMOD-Mobile Machinery , im Auftrag des Umweltbundesamtes, FKZ 360 16 018, Heidelberg, Korrigendum 11.02.2010.

IFEU, 2012: Knörr, W. et al, IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2030, sowie TREMOD 5.3, im Auftrag des Umweltbundesamtes, FKZ 3707 45 101, Berlin.

IFEU & INFRAS, 2009: IFEU – Institut für Energie- und Umweltforschung Heidelberg gGmbH und INFRAS Zürich: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland, FKZ 360 16 023, Heidelberg & Zürich.

IFEU & ÖKO-INSTITUT, 2010: Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV), Endbericht zum F+E-Vorhaben 360 16 029; URL: http://www.uba.de/uba-info-medien/4357.html, Berlin & Heidelberg, November 2010

IGZ (2007): IGZ – Institut für Gemüse- und Zierpflanzenbau, Großbeeren/Erfurt. Düngung im Freilandgemüsebau – Datenbasis für eine erfolgreiche Düngung im Freilandgemüsebau (2. Auflage). Berlin/Bonn. http://www.igzev.de/files/Dueng_im_FGB.pdf

IKP, 1996: Institut für Kunststoffprüfung und Kunststoffkunde (IKP), Universität Stuttgart: Ganzheitliche Bilanzierung von Dachbahnen aus Bitumen. In elektronischer Form über die UBA-Fachbibliothek zu beziehen (Signatur UM 381318)

INFRAS, 2010: Handbuch der Emissionsfaktoren 3.1 -, Bern, Januar 2010: URL: http://www.hbefa.net

IPCC, 1996a: Intergovernmental Panel on Climate Change: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Workbook, 1996

IPCC, 1996b: Intergovernmental Panel on Climate Change: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Reference Manual, 1996

IPCC, 1996c: Intergovernmental Panel on the Climate Change, Emission Inventory Guidebook, 1996: B 465, B466, B 644

IPCC, 1999: Intergovernmental Panel on Climate Change: Aviation and the Global Atmosphere, Kapitel 9, Aircraft Emissions: Current Inventories and Future Scenarios, Cambridge University Press, 1999

IPCC, 2000: Intergovernmental Panel on Climate Change, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC Secretariat, 16th Session, Montreal, 1-8 May 2000 http://www.ipcc-nggip.iges.or.jp/public/gp/english/

IPCC, 2003: Intergovernmental Panel on Climate Change: Good Practice Guidance for Land Use, Land-Use Change and Forestry. vi + 307 S.

IPCC, 2004: Intergovernmental Panel on Climate Change: Synthesis and Assessment Report on the Greenhouse Gas Inventories submitted in 2004, Part I. FCCC/WEB/SAI/2004. Bonn.

IPCC, 2006: Intergovernmental Panel on Climate Change: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual, Volume 4, 2006

IPCC 2006a – Intergovernmental Panel on Climate Change: Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 3_ Mobile Combustion, S. 3.61;
URL: http://www.ipccnggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

IPCC, 2006b – Intergovernmental Panel on Climate Change: Datenbank für Emissionsfaktoren des IPCC; URL: http://www.ipcc-nggip.iges.or.jp/EFDB/main.php

IPCC 2006c: IPCC Guidelines for National Greenhouse Gas Inventories, Volume 6 Wastewater Treatment and Discharge, 2006

IPCC, 2007: Intergovernmental Panel on Climate Change: IPCC Fourth Assessment Report: Climate Change 2007 URL: http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html

IPCC, et al, 1997: IPCC/UNEP/OECD/IEA: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Greenhouse Gas Inventory. Volume 3. Reference Manual. URL: http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm

IVT, 2004: Institut für angewandte Verkehrs- und Tourismusforschung e.V.: Fahrleistungserhebung 2002, Teil: Begleitung und Auswertung. Untersuchung im Auftrag der Bundesanstalt für Straßenwesen, Projektnummer FE 82.201/2001. Heilbronn/Mannheim.

JARVIS & PAIN, 1994: Jarvis, S.C.; Pain, B.F.: Greenhouse gas emissions from intensive livestock systems: their estimation and technologies for reduction. Climatic Change 27, 27-38.

KIRCHGESSNER et al. (1994): Kirchgessner M, Windisch W, Müller HL : Methane release from dairy cows and pigs. In: Aguilera JF (ed) Proc XIII Symp on energy metabolism of farm animals. EAAP Publ 76:399-402

KIRCHGESSNER, M.; ROTH, F.X.; SCHWARZ, F.J.; STANGL, G.I. (2008): Tierernährung. 12. Auflage. DLG-Verlag, Frankfurt a.M., 635 S.

KNIGGE, W.; SCHULZ, H. (1966): Grundriss der Forstbenutzung. Paul Parey Verlag, Hamburg und Berlin, 584 S.

KÖNIG, H.-C., 2007. Waldbrandschutz - Kompendium für Forst und Feuerwehr, 1. Fachverlag Matthias Grimm, Berlin, 197 pp.

KÖNIG, N.; BLUM, U.; SYMOSSEK, F.; BUSSIAN, B.; ELLINGHAUS, R.; FURTMANN, K.; GÄRTNER, A.; GUTWASSER, F.; HAUENSTEIN, M.; KIESLING, G.; KLINGENBERG, U.; KLINGER, T; MÖLLER, A.; NACK, T.; REICHELT, L.; SCHIMMING, C.; STAHN, M.; TREFZ-MALCHER, G.; UTERMANN, J. 2005: Handbuch Forstliche Analytik. Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Bonn, 510 S. http://www.bmelv.de/SharedDocs/Standardartikel/Landwirtschaft/Wald-Jagd/WaldBodenZustand/Handbuch-Forstliche-Analytik.html

KOLLMANN, F. 1982: Technologie des Holzes und der Holzwerkstoffe. Springer-Verlag, Berlin, Heidelberg, New York

KONOPATZKY, A. 2009: Die Veränderungen von Corg- und Nt-Zuständen der Waldböden im Norddeutschen Tiefland am Beispiel Brandenburgs. Tagungsbeitrag zu Kommission III, Böden eine endliche Ressource. DBG, Bonn, 4 S., http://eprints.dbges.de/373/

KORRESPONDENZ ABWASSER, ABFALL 2009: Organ der DWA und des Güteschutz Kanalbau, 56. Jahrgang, Nr. 11, November 2009

KTBL, 2005: Methodenaktualisierung für die Emissionsberechung 2003. F+E Vorhaben 203 412 53 des UFOPLAN 2003. Teilvorhaben 04: EF Landwirtschaft: Landwirtschaft – Ermittlung und Anpassung von Emissionsfaktoren (CRF 4). Abschlussbericht. KTBL, Darmstadt, 90 S.

KTBL, 2012: Dokumentation zur Datenaufbereitung der Aktivitätsdaten Biogas für den Nationalen Inventarbericht, Submission 2013 für 2011 (Stand: August 2012). Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL), Darmstadt, 8 S.

KURZ, W.A.; BEUKEMA, S.J.; APPS, M.J. (1996): Estimation of root biomass and dynamics for the carbon budget model of the Canadian forest sector, Can. J. For. Res., Nr. 26 (11), pp.1973-1979

LABER, H. (2005): Biologische N_2-Fixierung von Gemüseerbsen und –buschbohnen. In: Infodienst 02/2005 für Beratung und Schule der Sächsischen Agrarverwaltung. Sächsische Landesanstalt für Landwirtschaft (Hrsg.), 81-89

LALE, Andreas 2000: Langzeitemissionsverhalten von Deponien für Siedlungsabfälle in den neuen Bundesländern. TU Dresden, Dissertation; Fakultät Forst-, Geo- und Hydrowissenschaften.

LANGE, Hans-Jürgen, 1988: Kokereien. VOC aus Produktemissionen. Umweltbundesamt. Vermerk. Blatt 2.2.88 vorbehaltlich weiterer Recherchen. Angaben für 1990 – 1995, Angenommener VOC Anteil von 50%. Unveröffentlicht.

LECHTENBÖHMER et al, 2005: Lechtenböhmer, S.; Harthan, R.; Dämmgen, U.; Strogies, M: Umsetzung des Inventarplanes und nationale unabhängige Überprüfung der Emissionsinventare für Treibhausgase. Teilvorhaben 01. Pilotstudie unabhängige bilaterale Inventarüberprüfung. Endbericht im Auftrag des Umweltbundesamts FKZ: 202 42 203. unveröffentlicht.

LENK et al., 2005: Auswirkungen des Tanktourismus auf das deutsche Steueraufkommen – eine finanzwissenschaftliche Bestandsaufnahme; Leipzig, 2005

LINDE GAS GMBH, 2005: Aufschäumen von Molkereiprodukten; URL: http://www.lindegas.at/international/web/lg/at/likelgatn.nsf/PrintView/63ED15ADE8FCF595C1256B7B004C6250 , Zugriff Mai 2005

LISKI, J. 1995: Variation in soil organic carbon and thickness of soil horizons within a boreal forest stand - effect of trees and implications for sampling. Silva Fennica, 29, 255–266

LISKI J.; PERRUCHOUD, D.; KARJALAINEN, T. 2002: Increasing carbon stocks in the forest soils of Western Europe. Forest Ecology and Management, 169, 159-175

LUO, Z., WANG, E., SUN, O.J., 2010: Can no-tillage stimulate carbon sequestration in agricultural soils? A meta-analysis of paired experiments. Agriculture, Ecosystems and Environment, 139, 224 – 231

MEYER, K., 1999: Die Flüsse der klimarelevanten Gase CO_2, CH_4, N_2O eines nordwestdeutschen Niedermoores unter dem Einfluss der Wiedervernässung. Göttinger Bodenkundliche Berichte, 111, 134 S.

MELLERT, K.; WEIS, W.; RÜCKER, G. 2007: Ermittlung der (potentiell) zu erwartenden Signalstärke von Bodenveränderungen – Grundlage für die Bewertung und Interpretation von Ergebnissen der BZE II. BFH, Eberswalde, 92 S., http://bfh-web.fh-eberswalde.de/bze/front_content.php?idcat=120&idart=224

MNUW, 1990:·Ministerium für Naturschutz, Umweltschutz und Wasserwirtschaft 1990): Umweltbericht der DDR – Informationen zur Analyse der Umweltbedingungen in der DDR und zu weiteren Maßnahmen, März 1990, statistische Angaben für das Aufkommen an Siedlungsabfall für das Gebiet der ehemaligen DDR Tabelle 12, S. 56

MOKANY, K., R.J. RAISON & A.S. PROKUSHKIN, 2006: Critical analysis of root:shoot ratios in terrestrial biomes. Global Change Biology, 12, 84 - 96

MÜLLER-BBM (2009a): Bender et al „Inventarverbesserung 2008, Verbesserung und Ergänzung der aktuellen Inventardaten, IPCC-Kategorie (1996) 1.B.2 Diffuse Emissionen aus Erdöl und Erdgas“, Müller-BBM; Bericht Nr. M 76 595/4, UBA FKZ 360 16 012, 136 S.

MÜLLER-BBM (2009b): Bender et al „Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV aus dem Jahre 2004 für die Verwendung bei der UNFCC- und UNECE-Berichterstattung - Bereich Lageranlagen“, Müller-BBM Bericht Nr. M74 244/7, UBA FKZ 3707 42 103/01, 31 S.

MÜLLER-BBM (2012): Bender und Langer „Ermittlung von Emissionsfaktoren und Aktivitätsraten im Bereich IPCC (1996) 1.B.2.b.iii“, Müller-BBM Bericht Nr. M96023/01, UBA FKZ 360 16 035, 41 S.

MÜLLER-USING, S.; BARTSCH, N.; 2009. Decay dynamic of coarse and fine woody debris of a beech (Fagus sylvatica L.) forest in Central Germany. Eur J Forest Res, 128, 287-296

MUNDEL, G. (1976): Untersuchungen zur Torfmineralisation in Niedermooren.- Archiv Acker-, Pflanzenbau und Bodenkunde. H. 10, 20: 669-679

MWV, 2006: Mineralölwirtschaftsverband, „Mineralölzahlen 2005“.

MWV, 2011: Mineralölwirtschaftsverband: MWV Jahresbericht Mineralölzahlen 2010 URL: http://www.mwv.de/upload/Publikationen/dateien/JB_2010_dNrnbxXn6f7j2mf.pdf, (Aufruf: 27.09.2011), Berlin.

MWV, 2012: Mineralölwirtschaftsverband: MWV Jahresbericht Mineralöl-Zahlen 2011 URL: http://www.mwv.de/upload/Publikationen/dateien/2011_JB_Endfassung_Internet_cp2dg2sNbpnYyDX.pdf, (Aufruf: 22.10.2012), Berlin.

NABUURS G.J.; SCHELHAAS M.J. 2002: Carbon profiles of typical forest types across Europe assessed with CO2FIX. Ecological Indicators, 1, 3, 213-223

OECD/IEA, 2011: CO_2-Emissions from fuel combustion 2011 Edition - Highlights, OECD & IEA, Paris, URL: http://www.iea.org/co2highlights/co2highlights.pdf

OEHMICHEN, K., DEMANT, B., DUNGER, K., GRÜNEBERG, E., HENNIG, P., KROIHER, K., NEUBAUER, M., POLLEY, H., RIEDEL, T., ROCK, J., SCHWITZGEBEL, F., STÜMER, W., WELLBROCK, N., ZICHE, D. und BOLTE, A. (2011): Inventurstudie 2008 und Treibhausgasinventar Wald, Band 343. Landbauforschung — vTI Agriculture and Forestry Research. ISBN 978-3-86576-069-2

OEHMICHEN, K.; DUNGER, K.; Steuk, J.; STÜMER, W.; RIEDEL, T. 2011b: Annex 3, Chapter 19.5.1: Other detailed methodological descriptions for the source/sink category “Land-use change and forestry” (5) – Forest land (5.A), 637-649. In: Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2011. National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2009. Dessau: Federal Environment Agency, ISSN 1862-4359, 755 p.

ÖKO-INSTITUT, 2004a: Arbeitsergebnisse aus dem F+E-Vorhaben 201 42 258 Unterstützung beim Aufbau eines Nationalen Systems für eine transparente Erhebung der Grundlagendaten und für die Emissionsberichterstattung entsprechend Artikel 5(1) des Kyoto-Protokolls, Auftragnehmer Öko-Institut, noch bis 15.10.2005 laufend (unveröffentlicht)

ÖKO-INSTITUT, 2004b: Emissionen in Abwasser- und Schlammbehandlung. Arbeitspapier im Rahmen des dem F+E-Vorhaben 201 42 258 Unterstützung beim Aufbau eines Nationalen Systems für eine transparente Erhebung der Grundlagendaten und für die Emissionsberichterstattung entsprechend Artikel 5(1) des Kyoto-Protokolls (unveröffentlicht)

ÖKO-INSTITUT, 2004c: CO_2 Emisssionsfaktoren für die Erstellung der nationalen CO_2-Inventare. Teilbericht für den nationalen Inventarbericht 2004.

ÖKO-INSTITUT, 2005 Analyse, Dokumentation und Überarbeitung der Bilanz der Emissionsursachen(BEU) / Verena Graichen, Ralph O. Harthan, Julia Repenning Weitere Titel Zeitnahe Erfassung und Bewertung des Energieumsatzes von stationären Quellen als Grundlage für strategische Entscheidungen, Bewertungen von Maßnahmen und die Erfüllung internationaler Berichtspflichten im Bereich Klimaschutz und Luftreinhaltung

ÖKO-INSTITUT, 2006a: Kurzstudie - Stand und Entwicklung von Treibhausgasemissionen in den Vorketten für Erdöl und Erdgas für das Institut für wirtschaftliche Oelheizung e.V. (IWO), Endbericht erstellt von Uwe R. Fritsche. Darmstadt, Juli 2006.

ÖKO-INSTITUT, 2006b: Datenaustausch zwischen Emissionshandel und Nationaler Klimaschutzberichterstattung, Abschlussbericht zum F+E-Vorhaben FKZ 205 41 521, Berlin, Dezember 2006. Unveröffentlicht.

ÖKO-INSTITUT, 2009: Überarbeitung des Emissionsinventars des Flugverkehrs, vorläufiger Endbericht zum F+E-Vorhaben FKZ 360 16 019, Berlin, August 2009.

ÖKO-INSTITUT, 2012: Inventartool zum deutschen Flugverkehrsinventar 1990-2011, im Rahmen der Aktualisierung des Moduls TREMOD-AV im Transportemissionsmodell TREMOD, Berlin, 2012

ÖKO-INSTITUT / DIW 2007 (Öko-Institut – Institut für angewandte Ökologie e.V.) / DIW (Deutsches Institut für Wirtschaftsforschung) 2007: Dokumentation der Datenqualität von Aktivitätsdatenfür die Berichte über Emissionen aus stationären Feuerungen im Rahmendes Nationalen Inventarberichtes und des Monitoring Mechanismus nach RLEG 99/296; Endbericht zum F&E-Vorhaben FKZ 204 41 132 i.A. des UBA; Berlin

ÖKO-RECHERCHE, 1996, Büro für Umweltforschung und –beratung GmbH: Aktuelle und künftige Emissionen treibhauswirksamer fluorierter Verbindungen in Deutschland, im Auftrag des UBA, FKZ 106 01 074/01, Frankfurt am Main, 1996

ÖKO-RECHERCHE, 2001: Emissionen des Kältemittels R-134a aus mobilen Klimaanlagen. Jährliche Emissionsraten von bis zu sieben Jahre alten PKW-Klimaanlagen, Gutachten für das Umweltbundesamt Berlin, Frankfurt.

ÖKO-RECHERCHE, 2005: Emissionen und Emissionsprognose von H-FKW, FKW und SF6 in Deutschland - Aktueller Stand und Entwicklung eines Systems zur jährlichen Ermittlung (Emissionsdaten bis 2003 und Emissionsprognosen für die Jahre 2010 und 2020), Gutachten im Auftrag des Umweltbundesamtes, Dessau, FKZ 202 41 356. URL: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennummer&Suchwort=3000

ÖKO-RECHERCHE, 2007: Daten von H-FKW, FKW und SF6 für die nationale Emissionsberichterstattung gemäß Klimarahmenkonvention für die Berichtsjahre 2004 und 2005 (F-Gas-Emissionen 2004/2005 und Unsicherheitsbestimmung im ZSE), Gutachten im Auftrag des Umweltbundesamtes, Dessau, FKZ 205 41 217/01. URL: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennummer&Suchwort=3439

ÖKO-RECHERCHE, 2009: Öko-Recherche - Büro für Umweltforschung und –beratung GmbH, Dr. Winfried Schwarz: SF_6 und NF_3 in der deutschen Photovoltaik-Industrie - Inventarverbesserung 2008 – Verbesserung und Ergänzung der Daten für die nationale Emissionsberichterstattung gemäß Klimarahmenkonvention in der Quellgruppe Photovoltaik (2.F.9.h), Endbericht, FuE-Vorhaben FKZ 360 16 027, Frankfurt a.M., Dezember 2009.

ÖKO-RECHERCHE, Ecofys, 2003: Establishing the Leakage Rates of Mobile Air Conditioners. Report on the EU Commission (DG Environment). B4-3040/2002/337136/MAR/C1. Frankfurt/Nürnberg.

ORELLAS, D.L.,1982: Heat and Products of Detonation for Explosives, Lawrence Livermore National Laboratory, University of California, USA, April 5th

OSOWSKI, S., J. NEUMANN & H. FAHLENKAMP (2004): Nutzung biogener Festbrennstoffe in Vergasungsanlagen. Chemie Ingenieur Technik, 76, No. 7

PAUL, C.; WEBER, M.; MOSANDL, R. 2009: Kohlenstoffbindung junger Aufforstungsflächen. München: Karl Gayer Institut & Technische Universität München, Lehrstuhl für Waldbau, 70 S (unveröffentlicht)

PENNSTATE COLLEGE OF AGRICULTURAL SCIENCES (2011): Calf Rumen Images. http://www.das.psu.edu/research-extension/dairy/nutrition/calves/rumen [2011-02-15]

PIATKOWSKI B.; JENTSCH W. 2012: Anfrage zur Berechnung der Methanemissionen der Rinder; 18.12.2012 (unveröffentlicht; hinterlegt in der Inventarbeschreibung Landwirtschaft: Inventarüberprüfung 2012)

PISTORIUS, T.; ZELL, J.; HARTEBRODT, C. 2006: Untersuchungen zur Rolle des Waldes und der Forstwirtschaft im Kohlenstoffhaushalt des Landes Baden-Württemberg; Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg, Institut für Forstökonomie, Technischer Bericht; 224 S.

PÖPKEN, S., 2011: Obstanbau, Weinanbau und Weihnachtsbaumkulturen in Deutschland. Zwischenbericht des Forschungsprojekts „Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen“; Johann Heinrich von Thünen-Institut, Institut für Weltforstwirtschaft

PREISEGGER, 1999: Solvay Fluor und Derivate GmbH: Automotive Air Conditioning Impact of Refrigerant on Global Warming, in: Joint IPCC/TEAP Expert Meeting on Options for the Limitation of Emissions of HFCs and PFCs, Petten, 26-28 May 1999.

PRIETZEL, J.; STETTER, U.; KLEMMT, H.-J.; REHFUESS, K.E. 2006: Recent carbon and nitrogen accumulation and acidification in soils of two Scots pine ecosystems in Southern Germany. Plant and Soil, 289, 153-170

PROGNOS, 2000: Anwendung des IPCC-Referenzverfahrens zur Ermittlung der verbrennungsbedingten CO_2-Emissionen in Deutschland, Forschungsprojekt des UBA, FKZ 29744850, 2000

RENTZ et al, 2002: Rentz, Otto; Karl, Ute; Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010, Bericht zum Forschungsprojekt des Umweltbundesamtes unter FKZ 299 43 142, durchgeführt vom DFIU (Universität Karlsruhe, Deutsch-Französisches Institut für Umweltforschung)

RENTZ et al. 2002b: O. Rentz, K. Gütling und U. Karl 2002: Erarbeitung der Grundlagen für das BVT-Merkblatt Großfeuerungsanlagen im Rahmen des Informationsaustausches nach Art. 16(2) IVU-Richtlinie, Forschungsbericht 200 46 317, Gutachten im Auftrag des Umweltbundesamtes.

RETTENBERGER et al, 1997: RETTENBERGER, STEGMANN: Neue Aspekte der Deponiegasnutzung. Trierer Berichte zur Abfallwirtschaft Band 11. Economia-Verlag Bonn 1997. u.a. S. 268, 319

RICHTLINIE DES RATES vom 21. Mai 1991 über die Behandlung von kommunalem Abwasser (91/271/EWG) (ABl. L 135 vom 30.5.1991, S. 40

RÖSEMANN et al. 2011: Rösemann C, Haenel H-D, Poddey E, Dämmgen U, Döhler H, Eurich-Menden B, Laubach P, Dieterle M, Osterburg B: Calculation of gaseous and particulate emissions from German agriculture 1990 – 2009. Methods and data. Landbauforschung - vTI Agriculture and Forestry Research, Sonderheft 342.

RÖSEMANN et al. 2013: Rösemann, C.; Haenel H.-D.; Dämmgen, U.; Poddey, E.; Freibauer , A.; Wulf, S.; Eurich-Menden, B.; Döhler, H.; Schreiner, C.; Bauer, B.; Osterburg, B.: Calculation of gaseous and particulate emissions from German agriculture 1990 – 2011. Report on methods and data (RMD). Submission 2013. Thünen Rep 1. URL: http://www.ti.bund.de/fileadmin/dam_uploads/Institute/AK/PDFs/Th%C3%BCnen_Report_1.zip

ROTH, U.; DÖHLER, H.; HARTMANN, S.; WULF, S. (2011): Treibhausgasbilanzen und CO2eq-Vermeindungskosten landwirtschaftlicher Biogasanlagen. In: Biogas in der Landwirtschaft – Stand und Perspektiven. KTBL-Schrift 488, Darmstadt, S. 196-208

SACHS, L. 1984: Angewandte Statistik. Bd. 6. Aufl., Springer-Verlag, Berlin, Heidelberg, New York, Tokyo.

SCHÖN, WALZ, et al. 1993: Emissionen der Treibhausgase Distickstoffoxid und Methan in Deutschland : Emissionsbilanz, Identifikation von Forschungs- und Handlungsbedarf sowie Erarbeitung von Handlungsempfehlungen, ISBN 3-503-03495-1

SCHÖNING, I.; TOTSCHE, K.U.; KOGEL-KNABNER, I. 2006: Small scale spatial variability of organic carbon stocks in litter and solum of a forested Luvisol. Geoderma, 136, 631-642

SCHULZE, E-D.; HÖGBERG, P.; VAN OENE, H.; PERSSSON, T.; HARRISON, A. F.; READ, D. J.; KJÖLLER, A.; MATTEUCCI, G. 2000: Interactions between the carbon and nitrogen cycle and the role of biodiversity. Ecological Studies, 142, 468–492

SCHWARZ, KIMMEL, GSCHREY; LEISEWITZ, SAUER o.J.: Modelle für die Inventarerhebung von F-Gasen, Studie im Auftrag des Umweltbundesamtes, FKZ 363 01 351, 2012. Unveröffentlicht.

SCHWITZGEBEL , F.; DUNGER, K.; POLLEY, H. 2009: Die Inventurstudie 2008. Ergebnisse einer Kohlenstoffinventur auf Bundeswaldinventur-Basis. Hintergrund, Methodik und Durchführung der Studie. Allg Forst Z Waldwirtsch Umweltvorsorge 64: 1070-1071

SENSER et al, 1991: SENSER F, SCHERZ H.: Der Kleine "Souci-Fachmann-Kraut", Lebensmitteltabelle für die Praxis, 2. Auflage Wissenschaftliche Verlagsgesellschaft mbH, Stuttgart

SIEGL et al., 2002: R-134a Emissions from Vehicles, ENVIRON. SCI & TECHNOL., VOL. 36, 561-566.

SIX, J.; CONTANT, R.T.; PAPUL, E.A.& PAUSTIAN, K. 2002: Stabilization Mechanisms Of Soil Organic Matter: Implications For C-Saturation Of Soils. Plant And Soil, 241, 155-176

SNEATH, R.W., CHADWICK, D.R., PHILLIPS, V.R., PAIN, B.F. 1997. A UK inventory of nitrous oxide emissions from farmed livestock. Commissions WA 0604 and WA 0605, SRI/IGER, May 1997.

SOMMER S.G. 2001: Effect of composting on nutrient loss and nitrogen availability of cattle deep litter. European Journal of Agronomy 14, 123-133

STATISTIK DER KOHLENWIRTSCHAFT e.V o.J.: Statistik der Kohlenwirtschaft, „Herstellung von Braunkohlenbriketts, Braunkohlenkoks, Staub-, Trocken- und Wirbelschichtkohle nach Revieren“, www.kohlenstatistik.de (Aufruf: 10.10.2011)

STATISTISCHES BUNDESAMT, 1992: Statistisches Bundesamt, Statistisches Jahrbuch 1992 für die Bundesrepublik Deutschland, Tab. 26.2.1 An Abfallbeseitigungsanlagen angelieferte Abfallmengen nach Art der Anlagen, Tab. 26.2.2 An Abfallbeseitigungsanlagen angelieferte Abfallmengen nach Abfallarten

STATISTISCHES BUNDESAMT, 2002c: Statistisches Bundesamt, Klassifikation der Wirtschaftszweige, Ausgabe 1993 (WZ93), Wiesbaden 2002.

STATISTISCHES BUNDESAMT, 2008, Klassifikation der Wirtschaftszweige mit Erläuterungen 2008, Wiesbaden.
URL:
http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Klassifikationen/GueterWirtschaftklassifikationen/Content75/KlassifikationWZ08,templateId=renderPrint.psml

STATISTISCHES BUNDESAMT 2012a: Statistisches Bundesamt, Statistik 066 „Monatsberichte über die Elektrizitätsversorgung / Dezember 2012“ Tab. 3.2 und Tab. 5b.

STATISTISCHES BUNDESAMT, 2011b: Statistisches Bundesamt, Statistik 060: Auswertungen des Statistischen Bundesamtes der Bundesrepublik Deutschland „Energieverwendung der Betriebe des Verarbeitenden Gewerbes sowie Bergbaus und Gewinnung von Steinen und Erden“

STATISTISCHES BUNDESAMT, 2011c: Statistisches Bundesamt, Statistik 067: Auswertungen des Statistischen Bundesamtes der Bundesrepublik Deutschland „Stromerzeugungsanlagen der Betriebe des Verarbeitenden Gewerbes sowie Bergbaus und Gewinnung von Steinen und Erden“

STATISTISCHES BUNDESAMT, 2010e Umweltnutzung und Wirtschaft, Bericht zu den Umweltökonomischen Gesamtrechnungen (2010)

[STATISTISCHES BUNDESAMT, 2010f Umweltnutzung und Wirtschaft, Tabellen zu den umweltökonomischen Gesamtrechnungen, Teil 4: Wassereinsatz, Abwasser, Abfall, Flächennutzung, Umweltschutzmaßnahmen (2010)

STATISTISCHES BUNDESAMT, 2011: Statistisches Jahrbuch 2011, erschienen im September 2011 unter http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Navigation/Publikationen/Querschnittsveroeffentlichungen/Jahrbuch,templateId=renderPrint.psml__nnn=true

STATISTISCHES BUNDESAMT, 2011: Außenhandelsstatistik, Online-Abfrage (GENESIS) für die WA-Nr. 28362000 durch das UBA (Stand: 30.06.2011/ 14:49:01), Ausfuhr und Einfuhr nach Gewicht, Datei gesichert in der Inventarbeschreibung des UBA, Dessau-Roßlau 2011.

STATISTISCHES BUNDESAMT, Fachserie 3, Reihe 3, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung und pflanzliche Erzeugung (div. Jgg.)

STATISTISCHES BUNDESAMT, Fachserie 3, Reihe 3.1.2, Land- und Forstwirtschaft, Fischerei,– Bodennutzung der Betriebe (Landwirtschaftlich genutzte Flächen); (div. Jgg.)

STATISTISCHES BUNDESAMT, Fachserie 3, Reihe 3.1.4, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung - Baumobstflächen - 2007

STATISTISCHES BUNDESAMT, Fachserie 3, Reihe 3.2.1, Land- und Forstwirtschaft, Fischerei, Wachstum und Ernte – Feldfrüchte; (div. Jgg.)

STATISTISCHES BUNDESAMT, FACHSERIE 3, Reihe 3.2.2, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 3.2.2: Erhebung der Weinerzeugung - Wein- und Mostmengen nach Qualitätsstufen und Weinmostart (Weißmost/Rotmost)

STATISTISCHES BUNDESAMT, Fachserie 3 Reihe 4, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 4: Viehbestand und tierische Erzeugung.

STATISTISCHES BUNDESAMT, Fachserie 3 Reihe 4.1, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 4.1: Viehbestand.

STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 3.1, Jg. ab 1991: Statistisches Bundesamt, Fachserie 4, Reihe 3.1: Produzierendes Gewerbe - Produktion im produzierenden Gewerbe, Wiesbaden

STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 4.1.1, Jg. ab 1991-2003: Statistisches Bundesamt, Fachserie 4, Reihe 4.1.1: Erhebung über die Energieverwendung der Betriebe des verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden, Wiesbaden

STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 6.4, Jg. ab 1991: Statistisches Bundesamt, Fachserie 4, Reihe 6.4: Stromerzeugungsanlagen der Betriebe im Bergbau und im verarbeitenden Gewerbe, Wiesbaden.

STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 8.1, versch. Jahrgänge bis 2009: Statistisches Bundesamt; Fachserie 4, Reihe 8.1; Eisen und Stahl, Poeschel-Verlag

STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 8.2, Jg. ab 1990: Statistisches Bundesamt, Fachserie 4, Reihe 8.2: Produzierendes Gewerbe, Düngemittelversorgung, Wiesbaden.

STATISTISCHES BUNDESAMT, Fachserie 8 Reihe 4, Jg. ab 1991: Statistisches Bundesamt, Fachserie 8, Reihe 4: Binnenschifffahrt (für die Jahre 1990-2003), Wiesbaden.

STATISTISCHES BUNDESAMT, Fachserie 19 Reihe 1, Jg ab 1990: Statisisches Bundesamt, Fachserie 19, Reihe 1: Umwelt, Abfallentsorgung.

STATISTISCHES BUNDESAMT, Fachserie 19, Reihe 2.1, 2011: Statistisches Bundesamt, Fachserie 19, Reihe 2.1: Öffentliche Wasserversorgung und Abwasserbeseitigung, Klärschlamm (für die Jahre 1991, 1995, 1998, 2001, 2004, 2007), Wiesbaden

STATISTISCHES BUNDESAMT, Fachserie 19 Reihe 2.2: Umwelt, Nichtöffentliche Wasserversorgung und Abwasserbeseitigung 2007 (2009)

STATISTISCHES BUNDESAMT, BGS-Bögen unveröffentlicht (Brennstoff-, Gas- und Stromwirtschaft der Hochofen-, Stahl- und Walzwerke sowie Schmiede-, Press- und Hammerwerke einschließlich der oertlich verbundenen sonstigen Betriebe (ohne eigene Kokerei))- Zusammenfassung der Erfassungsbögen der Eisen- und Stahl-Statistik (FS 4 Reihe 8.1)

STATISTIK DER KOHLEWIRTSCHAFT e.V. Übersichten Download: URL:http://www.kohlenstatistik.de/home.htm (Aufruf 12.10.2012)

STEHFEST E; BOUWMAN L, 2006: N_2O und NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modelling of global emissions. Nutr. Cyl. Agroecosyst. 74, 207-228

STEUK, J. 2010: Vorgaben zur Bewirtschaftung von Wald in Deutschland im Kontext internationaler Vorgaben nach IPCC. vTI-WOI Eberswalde (unveröffentlicht).

STRAUSS, Karl 1998: Kraftwerkstechnik zur Nutzung fossiler, regenerativer und nuklearer Energiequellen. 4. Auflage. Springer-Verlag.

STRUSCHKA, 2008: Struschka, Dr. M., Kilgus, D., Springmann, M.; Baumbach, Prof.Dr. Günter: Effiziente Bereitstellung aktueller Emissonsdaten für die Luftreinhaltung; UBA-Forschungsbericht 205 42 322; Dessau, 2008.

TA LUFT, 1986: Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz, TA Luft - Technische Anleitung zur Reinhaltung der Luft, vom 27. Februar 1986, Gemeinsames Ministerialblatt S. 95, ber. S. 202)

TA LUFT, 2002: Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz, TA Luft - Technische Anleitung zur Reinhaltung der Luft, vom 24. Juli 2002, Gemeinsames Ministerialblatt (GMBl). Nr. 25 - 29 vom 30.7. 2002 S. 511ff.

TOMTER, S.M., HYLEN, G. & NILSEN, J.-E. 2010: Development of Norway's National Forest Inventory. In: Tomppo, E., Gschwantner, T., Lawrence, M. & McRoberts, R.E. (eds.): National Forest Inventories. Pathways for common reporting, pp. 411-424. Springer, Heidelberg. ISBN 978-90-481-3232-4.

UBA, 1983: Greiner, B., Barghoorn, M. Dobberstein, J., Eder, G., Fuchs, J., Gössele, P.: Chemisch-physikalische Analyse von Hausmüll. Forschungsbericht 83-033 im Auftrag des Umweltbundesamted, Berlin.

UBA, 1986: Barghoorn, M., Gössele, P., Kaworski, W.: Bundesweite Hausmüllanalyse 1983-85, Forschungsbericht 10303508 im Auftrag des Umweltbundesamtes, Berlin.

UBA, 1989b: Luftreinhaltung '88. Tendenzen - Probleme - Lösungen. Materialien zum Vierten Immissionsschutzbericht der Bundesregierung an den Deutschen Bundestag (Drucksache 11/2714) nach Paragraph 61 Bundes-Immissionsschutzgesetz Körperschaft, erschienen Berlin Schmidt, E.

UBA, 1993: Umweltbundesamt: UBA-Text 9/93, Emissionen der Treibhausgase Distickstoffoxid und Methan in Deutschland. Auftragnehmer: Schön, M. et al. Fhg-ISI

UBA, 2000a: UBA-Text 14/00: Pfeiffer, Frank / Struschka, Michael / Baumbach, Günter: Ermittlung der mittleren Emissionsfaktoren zur Darstellung der Emissionsentwicklung aus Feuerungsanlagen im Bereich der Haushalte und Kleinverbraucher, Institut für Verfahrenstechnik und Dampfkesselwesen, Universität Stuttgart, Herausgeber: Umweltbundesamt, FKZ 299 42 245 / 02, Berlin

UBA, 2001: German Notes on BAT for the production of Large Volume Solid Inorganic Chemicals – Soda. URL: www.bvt.umweltbundesamt.de/archiv/sodad.pdf english: www.bvt.umweltbundesamt.de/archiv-e/sodae.pdf)

UBA, 2003a: Projekthandbuch Decor, Umweltbundesamt, Förderkennzeichen IT 20, in Bearbeitung

UBA, 2004: IZT, KPMG, DFIU: Arbeitsergebnisse aus dem F+E-Vorhaben 202 42 266 „Bestimmung und Einführung von Methoden zur Qualitätssicherung und Qualitätskontrolle für die deutschen Inventare der Treibhausgasemissionen entsprechend den Vorgaben der Klimarahmenkonvention (KRK) und der Anforderung der ECE-Luftreinhaltekonvention“ (unveröffentlicht)

UBA, 2004b: Dr. R. Joas; A. Potrykus; R. Schott; S. Wenzel: VOC-Minderungspotenzial beim Transport und Umschlag von Mineralölprodukten mittels Kesselwagen, FKZ 202 44 372, UBA-Texte 12/2004, Dessau.
URL: http://www.umweltdaten.de/publikationen/fpdf-l/2637.pdf

UBA 2005b, FKZ 20442203/02: Endbericht zum Forschungsprojekt „Einsatz von Sekundärbrennstoffen“

UBA 2005c, FKZ 20541115: unveröffentlichter Zwischenbericht zum Forschungsprojekt „Bereitstellung der Energiedaten für stationäre Feuerungsanlagen zur Erfüllung der Berichtspflichten im Rahmen des Nationalen Treibhausgasinventars (NIR 2006) und des Berichtes zur Festlegung der zugewiesenen Mengen nach Kyoto-Protokoll“

UBA 2005d: Umweltbundesamt: Qualitätssystem Emissionsinventare. Handbuch zur Qualitätskontrolle und –sicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU-Entscheidung 280/2004/EG, Dessau. Stand 24.08.2005.

UBA, 2006: Umweltbundesamt: UBA-Text 29/06,: Lechtenböhmer, Nanning, Buttermann, Hillebrand: Bilanzierung der Gewinnung und Verwendung von Kalkstein und Ausweisung der CO_2-Emissionen, Forschungsbericht FKZ 20541217/02, Dessau 2006

UBA, 2007: Dr. Matthias Kühle-Weidemeier, Wasteconsult International: Endbericht des UFOPlan-Projekts „Anlagen zur mechanisch-biologischen Restabfallbehandlung, FKZ 206 33 301. Juni 2007

UBA 2007b: Umweltbundesamt: Qualitätssystem Emissionsinventare. Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU-Entscheidung 280/2004/EG, Dessau. Stand 05.06.2007, unveröffentlicht.

UBA, 2010: Ableitung der Kalksteinbilanz aus den statistischen Daten der BGR für Zwecke der Emissionsberichterstattung nach Klimarahmenkonvention und Kyoto Protokoll (Kategorie CRF 2.A.3), Publikationsnummer 4033, direkt unter http://www.uba.de/uba-info-medien/4033.html

UBA, 2011, FKZ 3707 33 303: Endbericht zum Forschungsprojekt „Nutzung der Potenziale des biogenen Anteils im Abfall zur Energieerzeugung“ URL: http:///www.uba.de/uba-info-medien/4116.html

UBA 2011b, FKZ 360 16 031: Endbericht zum Forschungsprojekt: „Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarungen für ausgewählte Industriebranchen – hier: N2O Emissionsfaktoren aus der Abwasserreinigung der vier relevantesten Industriebereiche. Ute Austermann-Haun Hochschule Ostwestfalen Lippe), Alvaro Carozzi (Dr. Steinle Indgenieurgesellschaft für Abwassertechnik mbH), Dessau, Oktober 2011.

UBA/BMU 2011: Altfahrzeug-Verwertungsquoten in Deutschland im Jahr 2009 gemäß Art. 7 Abs. 2 der Altfahrzeug-Richtlinie 2000/293/EG – Quality Report: Beschreibung der verwendeten Daten nach Artikel 1 der KOM-Entscheidung 2005/293/EG über Altfahrzeuge, Dessau-Roßlau, Bonn, 29. Juni 2011.

UMEG 2004: Umweltmessungen, Umwelterhebungen und Gerätesicherheit 2004: Emissionsfaktoren-Handbuch, Emissionserklärung 2004 Baden-Württemberg

UMWELTBUNDESAMT GmbH 2012: Final report of the 2012 technical review of the greenhouse gas emission inventory of Germany to support the determination of annual emission allocations under Decision 406/2009/EC, Reference: DG CLIMA.C.1/SER/2011/0019, 17.08.2012, archiviertes Dokument "ESD-2012-FINAL_Review_Report-Germany.doc", Wien 2012

UNECE (United Nations Economic Commission for Europe) 2006: Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests, part IIIa: sampling and analysis of soil. Project Coordinating Center (PCC9, Hamburg, 117 p, http://www.icp-forests.org/Manual.htm

UNFCCC, 1998: Kyoto Protocol to the United Nations Framework Convention on Climate Change, United Nations 1998

UNFCCC, 2005: Germany. Report of the individual review of the greenhouse gas inventory submitted in the year 2004. FCCC/WEB/IRI/2994/DEU, dd. January 17, 2005. http://unfccc.int/files/national_reports/annex_i_ghg_inventories/inventory_review_reports/application/pdf/2004_irr_in-country_review_germany.pdf

UNFCCC (United Nations Framework Convention on Climate Change) 2007: Germany. Report of the review of the initial report of Germany, United Nations 2007

UNFCCC 2010: National Inventory Submissions. http://unfccc.int/national_reports/annex_i_ghg_inventories/inventory_review_reports/items/4715.php, United Nations 2010

UNFCCC, 2011: Report of the individual review of the annual submission of Germany submitted in 2010. FCCC/ARR/2010/DEU, dd. May 18, 2011.

UU STS, 2007: Utrecht University (UU), Copernicus Institute Department of Science, Technology, and Society (STS): Estimating CO2 Emissions from the Non- Energy Use of Fossil Fuels in Germany - Methodenaktualisierung für die Emissionsberechnung 2003, FKZ 203 41 253/02.

VANDRÉ, R., Wulf S., Häußermann, U., and Horlacher, D. (2012) N_2O emissions from solid manure storage. Calculation of a national emission factor. Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL), Darmstadt, Germany, pp. 15.

VDD 2012: Datenübermittlung des Verbandes, Dokument in der Inventarbeschreibung in „Bitumen_AREF_Zeitreihen_und_Unsicherheiten_Archiv.zip“, Dessau-Roßlau 2012

VDEh Wirtschaftsvereinigung Stahl - Stahlinstitut VDEh – Lieferung BGS-Bögen jährlich ab 2010

VDI, 1999: Verein Deutscher Ingenieure e.V: VDI-Richtlinie 2578 - Emissionsminderung - Glashütten, 11/1999

VDMA 2011: *Energiebedarf für Kältetechnik in Deutschland*, Frankfurt am Main, 04.04.2011.

VDP, versch. JG: Verband Deutscher Papierfabriken e.V.: Ein Leistungsbericht, Bonn, verschiedene Jahrgänge seit 1990

VDP, 2004: Verband Deutscher Papierfabriken e.V.: Ein Leistungsbericht, Bonn

VdZ, 2009: Forschungsinstitut der Zementindustrie: Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarungen für ausgewählte Industriebranchen: Teilvorhaben 03 Zementindustrie (FKZ 370742301/03); Ruppert, Johannes; Scheuer, Wilfried; Schäfer, Stefan; Düsseldorf, 2009.

VDZ, 2011 (Verein Deutscher Zementwerke e.V.): Zement – Produktionsdaten der deutschen Zementindustrie; per E-Mail an das UBA übermittelt.

VOGT, K.A.; VOGT, D.J.; PALMIOTTO, P.A.; OON, P.; OHARA, J.; ASBJORNSEN, H. (1996): Review of root dynamics in forest ecosystems grouped by climate, climatic forest type and species. Plant and Soil, Vol. 187 Nr.2, pp. 159-219

VOLK, F., 1997: Recherches sur les Fumees Produits par la Detonation de divers Explosifs, Explosifs

vTI - Johann Heinrich von Thünen-Institut 2012: Ausführungsbestimmung zur Erstellung von Emissions- und Kohlenstoffinventaren und deren Qualitätsmanagement für den Bereich der Quellgruppen 4 und 5. Anlage zum Konzept Emissions- und Kohlenstoffinventare im nachgeordneten Bereich des BMELV vom 01.03.2012. Version 1.01, Stand vom 31.08.2012

WALG, O., 2006: Humus contra Heizwert - Rebholzverwertung. Der Winzer, 3/2006

WASTECONSULT INTERNATIONAL, 2009: Methanemissionen aus passiv entgasten Deponien und der Ablagerung von mechanisch-biologisch vorbehandelten Abfällen, FKZ: 360 16 015, Dezember 2009

WEG 2008a: Erdgas-Erdöl, Entstehung-Suche-Förderung, Hannover, 34 S. URL: http://www.erdoel-erdgas.de/Erdgas_Erd%F6l___Entstehung___Suche___F%F6rderung-134-1-68b.html WEG, 2008b: WEG Bericht zur Schwefelgewinnung im Inland, URL: http://www.erdoel-erdgas.de/article/articleview/13/1/59/

WEG (2010): Jahresbericht des Wirtschaftsverbandes Erdöl- und Erdgasgewinnung e.V., WEG, 2010. URL: http://www.erdoel-erdgas.de/

WEG (2011): Jahresbericht des Wirtschaftsverbandes Erdöl- und Erdgasgewinnung e.V., WEG, 2011 URL: http://www.erdoel-erdgas.de/

WEILBACHER, 1987: Ausgasung von Zellgasen, interner Laborbericht vom 17.08.87 (überreicht von der BASF AG, Ludwigshafen).

WEINGARTEN, P., 1995: Das „Regionalisierte Agrar- und Umweltinformationssystem für die Bundesrepublik Deutschland“ (RAUMIS). Ber Landwirtschaft 73, 272-302

WEISBERG, S., 2005: Applied Linear Regression. 3. Auflage, Wiley Interscience, Hoboken, 310p.

WEISS, SCHIELER, SCHADAUER, RADUNSKY, ENGLISCH, 2000: Die Kohlenstoffbilanz des Österreichischen Waldes und Betrachtungen zum Kyoto-Protokoll. Umweltbundesamt GmbH, Wien.

WELLBROCK et al. 2006: Wellbrock, N.; Aydin, C. - T.; Block, J.; Bussian, B.; Deckert, M.; Diekmann, O.; Evers, J.; Fetzer, K. D.; Gauer, J.; Gehrmann, J.; Kölling, C.; König, N.; Liesebach, M.; Martin, J.; Meiwes, K. J.; Milbert, G.; Raben, G.; Riek, W.; Schäffer, W.; Schwerhoff, J.; Ullrich, T.; Utermann, J.; Volz, H. - A.; Weigel, A.; Wolff, B. (2006): Bodenzustandserhebung im Wald (BZE II) Arbeitsanleitung für die Außenaufnahmen. Hrsg. BMELV. Berlin. pp. 413.

WINKLER, M. (2004): „Abschätzung von Emissionsfaktoren bei Transport und Lagerung von Mineralölprodukten“ aus Erdöl, Erdgas, Kohle 120. Jg. 2004, Heft 10 S. 312 ff; Urban Verlag Hamburg/Wien GmbH 2004

WIRTH, C.; SCHULZE, E.-D.; SCHWALBE, G.; TOMCZYK, S.; WEBER, G.; WELLER, E. (2004): Dynamik der Kohlenstoffvorräte in den Wäldern Thüringens. Thüringer Landesanstalt für Wald, Jagd und Fischerei, Jena, 308 S.

WOLFF & RIEK 1996: Wolff, B.; Riek, W. (1996): Deutscher Waldbodenbericht 1996 - Ergebnisse der bundesweiten Bodenzustandserhebung in Wald (BZE) 1987 - 1993. Hrsg.: Bundesministerium für Ernährung, Landwirtschaft und Forsten, Bonn, Bd. 1 u. 2.

ZEEMAN G., 1994: Methane production/emission in storages for animal manure. Fertilizer Research 37, 207-211

ZIESING et al, 2003: Ziesing, Hans-Joachim (DIW), Felix Christian Matthes, (Öko-Institut), Franz Wittke (AGEB), Heike Leonhardt (UBA) „Harmonisierung der Energiedaten zur CO_2-Berechnung“, Endbericht zum EUROSTAT-Vorhaben des Umweltbundesamtes, 24.04.2003, aktualisiert um die „Energiebilanz 1999“ vom 20.09.2003