Australian Government

Department of Climate Change, Energy, the Environment and Water

Australian National Greenhouse Accounts Factors

For individuals and organisations estimating greenhouse gas emissions

2024

Cataloguing data

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Acknowledgement of Country

We acknowledge the Traditional Owners of Country throughout Australia and recognise their continuing connection to land, waters and culture. We pay our respects to their Elders past and present.

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1 Introduction

The *2024 National Greenhouse Accounts (NGA) Factors workbook* has been prepared by the Department of Climate Change, Energy, the Environment and Water, and is designed to support individuals and organisations estimating their greenhouse gas emissions. The Department does not make any recommendations for the use of the methods contained within this document for any specific emissions accounting or reporting purposes.

This workbook (2024 NGA Factors Workbook) is not published for the purposes of reporting under the National Greenhouse and Energy Reporting (NGER) Scheme. Although drawing on the *National Greenhouse and Energy Reporting (Measurement) Determination 2008*, the methods described in the 2024 NGA Factors Workbook have a broad general application to the estimation of a range of greenhouse gas emissions inventories. Information and guidance on the NGER Scheme can be found at the Clean Energy Regulator website and a summary of latest amendments to the Measurement Determination can be found in Appendix 7.

The NGA Factors is subject to a system of continuous improvement. The Department welcomes feedback related to any of the content contained within the document. Feedback should be sent to nationalgreenhouseaccounts@dcceew.gov.au.

Links to other programs and initiatives related to greenhouse gas estimation and reporting are available in Appendix 6.

1.1 Greenhouse gas emission sources

Direct emissions

Scope 1

Direct (or scope 1) emissions are produced from sources within the boundary of an organisation and as a result of that organisation's activities. They are calculated at the point of emission release. These emissions include those from the following activities:

- generation of energy, heat, steam and electricity, such as fuel combustion in generators;
- manufacturing processes which produce emissions such as cement, aluminium and ammonia production;
- transportation of materials, products, waste and people; such as the use of vehicles owned and operated by the reporting organisation;
- intentional or unintentional GHG releases (fugitive emissions) such as methane emissions from coal mines, natural gas leaks from joints and seals; and
- solid waste disposal and wastewater treatment including on-site waste management.

The default emission factors listed in this workbook have been estimated by the Department of Climate Change, Energy, the Environment and Water in conjunction with the production of the Australian National Greenhouse Accounts (ANGA). Unless otherwise stated, the methods for calculating emissions listed in this document are based on "Method 1" from the *National Greenhouse and Energy Reporting (Measurement) Determination 2008*.

This ensures consistency between inventories at company level and the emission estimates presented in the National Greenhouse Accounts. The methods used at the national level, and reflected in the factors reported here, are consistent with Intergovernmental Panel on Climate

Change (IPCC) guidelines and are subject to international expert review each year. More information on the estimation methods employed in the National Greenhouse Accounts is available in the latest National Inventory Report.

Indirect emissions

Indirect emissions are emissions generated in the wider economy as a consequence of an organisation's activities but which are physically produced by the activities of another organisation. There are two classes of indirect emissions; electricity and other.

Electricity (scope 2)

Scope 2 emissions are indirect emissions which occur as a result of activities that generate electricity, heating, cooling or steam that is consumed by an organisation but which is generated outside that organisation's boundaries. They are physically produced by the burning of fossil fuels by the generator of the electricity.

Other indirect emissions (scope 3)

Scope 3 emissions are indirect emissions, other than electricity (scope 2), which occur outside of the boundary of an organisation as a result of actions by the organisation. Scope 3 emissions may occur:

- upstream, such as the emissions generated in the extraction and production of fossil fuels;
- downstream, such as the emissions from transport of an organisation's product to customers, or the emissions from outsourced activities.

The majority of a company's value chain greenhouse gas emissions may lie outside their own operations. Emissions from a company's value chain occurring externally to their operations within Australia may be estimated using the scope 3 emission factors published in this workbook. If you need to calculate emissions occurring outside of Australia, please check relevant resources, such as the IPCC Emission Factor database for more appropriate location specific emission factors.

Using emission factors

Emission factors are used to convert a unit of activity into its emissions equivalent. Greenhouse gas emissions are calculated by multiplying the relevant source specific emission factor, by the quantity of the activity, to give the emissions of different greenhouse gases for each source type.

Example: Greenhouse Gas Emissions (t CO_2-e) =

Activity Data (GJ) x Emission Factor (t CO_2-e /GJ)

When an emission factor is given as t CO_2-e /GJ but the activity data is not in GJ, then an energy content factor is also included in the calculation. The energy content factor is the amount of energy contained in fuel, measured in gross calorific value.

Example: Greenhouse Gas Emissions (t CO_2-e) =

Activity Data (kL) x Energy Content Factor (GJ/kL) x Emission Factor (t CO_2-e /GJ)

It is important to note that an emission factor is activity-specific and that the type of activity determines the emission factor used. Emission factors are generally expressed on a carbon dioxide equivalent (CO_2-e) basis using the Global Warming Potential (GWP) factors from the IPCC 5th Assessment report and provided in **Appendix 2 Global Warming Potentials**. As greenhouse gases vary in their radiative forcing and in their atmospheric residence time, converting emissions into a carbon dioxide equivalent over a 100-year horizon allows the integrated effect of emissions of the various gases to be compared on an equivalent basis.

Emission factor timing

This issue of the NGA Factors coincides with the release of the NGER (Measurement) Amendment (2024 Update) Determination 2024, issued for the 2024-25 NGER reporting cycle. Data used for the estimation of the factors within this document are the latest available at the time of estimation - which includes NGER reporting data for the 2022-23 cycle.

1.2 Revisions to previous issue

Updated emission factors

The emission factors reported in this publication replace those listed in the 2023 NGA Factors Workbook.

Scope 2 and 3 electricity

The 2024 update to the scope 2 emission factors are available in Table 1 and further details are provided in *Appendix 4 Methodology for calculating electricity emission factors*.

The Jurisdictional Residual Power Percentage value for the ACT has been updated to include changes in the way it is calculated. It now includes the generation of solar power from small rooftop systems below 100 kW as contributing to the ACT's renewable power consumption.

Waste

Additional information provided in Appendix 5 in relation to the calculation of emission factors for Scope 3 emissions from solid waste disposal.

Updated emission factor for the incineration of municipal solid waste.

2 Energy

Emissions in the Energy sector (IPCC Sector 1) arise from fuel combustion, fugitive emissions, and carbon dioxide transport and storage. Fuel combustion includes:

- Electricity - Emissions from the combustion of fuels to generate electricity.
- Stationary energy - Emissions from the combustion of fuels to generate steam, heat or pressure, other than for electricity generation and transport.
- Transport - Emissions from the combustion of fuels for transportation within Australia.

Fugitive emissions are emissions released during the extraction, processing and delivery of fossil fuels. Carbon dioxide transport and storage emissions are any leakage or venting of carbon dioxide during the transport, injection and geological storage of carbon dioxide associated with carbon capture and storage activities.

2.1 Greenhouse gas emissions from energy

The principal greenhouse gas generated by the combustion of fossil fuels for energy is carbon dioxide (CO_2). The quantity of gas produced depends on the carbon content of the fuel and the degree to which the fuel is fully combusted. Additionally, small quantities of methane (CH_4) and nitrous oxide (N_2O) are also produced, depending on the actual combustion conditions. For example, CH_4 may be generated when fuel is only partially combusted. Similarly, N_2O results from the reaction between nitrogen and oxygen in the combustion air.

2.2 Estimating emissions from stationary energy sources

Electricity

Scope 2 emissions are physically produced by the burning of fuels (coal, natural gas, etc.) at the power station to create electricity. Emissions from upstream (e.g. coal transport) and downstream (e.g. transmission and distribution losses) in the electricity supply chain are captured in scope 3 emissions.

For electricity, the scope 3 emission factor depends on the amount of electricity lost throughout the grid network. These losses depend on:

- the distance of the generator from customers - more power is lost the further it travels;
- the voltage and resistance of the transmission lines - the “quality” of the line;
  how much power is flowing through the line - a more heavily loaded line means more heat and more losses.

There are two methods for estimating electricity emissions – the location-based method and the market-based method. Reporting electricity emissions under both methods provides different perspectives of the emissions associated with a company’s electricity usage.

The **location-based method** shows a company’s electricity emissions in the context of its location. It calculates the emissions from a company’s electricity consumption, reflecting the emissions intensity of electricity generation within the state or territory where it operates.

The location-based scope 2 emission factors are state-based emission factors from on-grid electricity generation, calculated from the physical characteristics of the electricity grid. The emission factors are calculated each financial year based on electricity generation within each state and territory and take into account interstate electricity flows, where they exist, and the emissions attributable to those flows. The state-based emission factor calculates an average emission factor for all electricity consumed from the grid in a given state, territory or electricity grid.

Table 1 Indirect (scope 2 and scope 3) emission factors from consumption of purchased or acquired electricity

State, Territory or grid description	Scope 2 Emission Factors (kg CO_2-e/kWh)	Scope 3 Emission Factors (kg CO_2-e/kWh)
New South Wales and Australian Capital Territory	0.66	0.04
Victoria	0.77	0.09

Queensland	0.71	0.10
South Australia	0.23	0.05
Western Australia - South West Interconnected System (SWIS)	0.51	0.06
Western Australia - North Western Interconnected System (NWIS)	0.61	0.09
Tasmania	0.15	0.03
Northern territory - Darwin Katherine Interconnected System (DKIS)	0.56	0.07
National	0.63	0.07

Sources: Primary data sources comprise National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Schedule 1), Australian Energy Statistics, Clean Energy Regulator, and AEMO data and Department of Climate Change, Energy, the Environment and Water.

Notes:

- Data are for financial years ending in June.
- These factors include methane emissions from hydro dams. This impacts Tasmania, NSW/ACT and Victoria.
- Self-consumption of small-scale rooftop solar is deducted from the estimation of these factors.
- To convert to kg CO_2-e/GJ, multiply by 1000 then divide by 3.6.
- Depending on the intended use, the publication of these revised factors does not necessarily imply any need to revise past estimates of emissions. Historic emission factor estimates are available in previous releases of the NGA Factors.
- For further information on the estimation of scope 2 emissions, see Appendix 4 Methodology for calculating electricity

The **market-based method** shows a company's electricity emissions in the context of its investments in different electricity products and markets. This includes from voluntary purchases of renewable electricity and mandatory schemes like the Large-scale Renewable Energy Target.

The market-based method assigns an emissions factor of zero for a company's investments in renewable electricity and uses a national residual mix factor to calculate emissions from any remaining electricity consumption.

Companies should be aware that when they are consuming electricity from the grid, they are consuming electricity from a range of generating technologies in operation at the time of consumption, which may include non-renewable sources of generation. The market-based method allows companies to match their consumption with investments in renewable electricity, but it does not mean that they are only consuming electricity from renewable generators.

Table 2 Indirect (scope 2 and scope 3) emission factors from consumption of purchased or acquired electricity: market-based factors

Residual Mix Factor for the market-based method	**Scope 2 Emission Factors (kg CO_2-e/kWh)**	**Scope 3 Emission Factors (kg CO_2-e/kWh)**
National	0.81	0.11

Sources: Primary data sources comprise National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Schedule 1), Australian Energy Statistics, Clean Energy Regulator, and AEMO data and Department of Climate Change, Energy, the Environment and Water.

Notes:

- An adjustment has been made to include methane emissions from hydro dams.
- Self-consumption of small-scale rooftop solar is deducted from the estimation of these factors.
- To convert to kg CO_2-e/GJ, multiply by 3.6 then divide by 1000.
- Depending on the intended use, the publication of these revised factors does not necessarily imply any need to revise past estimates of emissions. Historic emission factor estimates are available in previous NGA Factors Workbooks.
- For further information on the estimation of scope 2 emissions, see Appendix 4 Methodology for calculating electricity

Calculating emissions from electricity purchased or acquired using the location-based method

The following method is used for estimating scope 2 and scope 3 emissions released from electricity purchased or acquired and consumed using the location-based method:

$$t\ CO_2\text{-}e = \frac{Q \times (EF2 + EF3)}{1{,}000}$$

Where:
t CO_2-e is the emissions measured in CO_2-e tonnes.
Q is the quantity of electricity purchased or acquired and consumed from the operation of the facility during the year measured in kilowatt hours.
EF2 is the scope 2 emission factor, in kilograms of CO_2-e emissions per kilowatt hour, as per Table 1.
EF3 is the scope 3 emission factor, in kilograms of CO_2-e emissions per kilowatt hour, as per Table 1.
Note: As the emission factors are given in kg CO_2-e, the division by 1,000 is necessary when reporting in t CO_2-e.

Example 1 Calculation of scope 2 and 3 emissions (t CO_2-e) from purchased electricity (kWh) using the location-based method

A company has operations in New South Wales and Victoria. A component of the company's energy use is electricity purchased from the National Electricity Market grid. During the year the NSW operations consumed 11,300,000 kWh of electricity, while the Victoria operations consumed 14,600,000 kWh. Emissions are estimated using the equation below:

$$t\ CO_2\text{-}e = \frac{Q \times (EF2 + EF3)}{1{,}000}$$

Where:
NSW
Q = 11,300,000 kWh
EF2 = 0.66 kg CO_2-e /kWh
EF3 = 0.04 kg CO_2-e /kWh
Victoria
Q = 14,600,000 kWh
EF2 = 0.77 kg CO_2-e /kWh

EF3 = 0.09 kg CO_2-e /kWh	
Calculation of Total Greenhouse Gas Emissions (t CO_2-e)	
For NSW operations	$= \frac{11{,}300{,}000 \times (0.66+0.04)}{1000}$ = 7,910 t CO_2-e
For Victoria operations	$= \frac{14{,}600{,}000 \times (0.77+0.09)}{1000}$ = 12,556 t CO_2-e
Combined total greenhouse gas emissions (t CO_2-e)	= 20,466 t CO_2-e

Calculating emissions from electricity purchased or acquired using the market-based method

The following method may be used for estimating scope 2 and scope 3 emissions released from electricity purchased or acquired and consumed using the market-based method:

$$t\ CO_2\text{-}e = \Big(\big(Q - Q_{exempt}\big) \times \big(1 - (RPP + JRPP)\big) + \big(Q_{exempt} \times (1 - JRPP)\big) - (REC_{surr} - REC_{onsite}) \times 1{,}000\Big) \times \frac{RMF1 + RMF2}{1{,}000}$$

Where:

t CO_2-e is the emissions measured in CO_2-e tonnes.

Q is the quantity of electricity purchased or acquired and consumed from the operation of the facility during the year measured in kilowatt hours.

Qexempt is the quantity of electricity exempt from Renewable Energy Target (RET) liability, measured in kilowatt hours.

RPP is the RET Renewable Power Percentage for the applicable period as published by the Clean Energy Regulator, averaged across the previous and current calendar years. For example, calendar years 2023 and 2024 are used for the calculation of the financial year 2024 RPP.

JRPP is the jurisdictional renewable power percentage for the applicable period and activity state. It is calculated as the number of eligible Renewable Energy Certificates surrendered by or on behalf of the jurisdictional authority divided by total electricity consumption in the jurisdiction.

RECsurr is the number of eligible Renewable Energy Certificates voluntarily surrendered in the reporting year equivalent to megawatt hours.

REConsite is the number of eligible Renewable Energy Certificates that have been or will be issued for electricity produced on-site during the year and consumed from the operation of the facility equivalent to megawatt hours.

RMF1 is the scope 2 residual mix factor, in kilograms of CO_2-e emissions per kilowatt hour, as per Table 2.

RMF2 is the scope 3 residual mix factor, in kilograms of CO_2-e emissions per kilowatt hour, as per Table 2.

Notes:

- As the emission factors are given in kg CO_2-e, it is necessary to divide by 1,000 when reporting in t CO_2-e.
- The ACT is currently the only state with a JRPP. The JRPP for the ACT for the 2024 reporting period is 79.51%.

- The RET Renewable Power Percentage is published by the Clean Energy Regulator.
- An eligible Renewable Energy Certificate is:
    - a Large-scale Generation Certificate (LGC) that is voluntarily surrendered through the Renewable Energy Certificate Registry in the reporting year with a generation date of less than 36 months prior to the end of the reporting year; or
    - a purchase of GreenPower electricity from an accredited GreenPower Provider.

Example 2 Calculation of scope 2 and 3 emissions (t CO_2-e) from purchased or acquired electricity (kWh) using the market-based method

A company has operations in New South Wales. A component of the company's energy use is electricity purchased from the National Electricity Market grid. During the year the NSW operations consumed 11,300,000 kWh of electricity from the grid. The company generated and consumed 500,000 kWh of electricity from onsite renewable electricity sources, for which LGCs were created. 200,000 kWh of these LGCs were surrendered to meet the company's RET liability, while the remaining 300,000 kWh were voluntarily surrendered. The company's activities are not in a jurisdiction whose jurisdictional authority voluntarily surrenders Renewable Energy Certificates. The company purchased and voluntarily surrendered 1,000 LGCs in the same period. Emissions are estimated using the equation below:

$t\ CO_2\text{-}e = \Big(\big(Q - Q_{exempt}\big) \times \big(1 - (RPP + JRPP)\big) + \big(Q_{exempt} \times (1 - JRPP)\big) - (REC_{surr} - REC_{onsite}) \times 1{,}000\Big) \times \frac{RMF1 + RMF2}{1{,}000}$	
Where:	
Q	= 11,300,000 kWh
Qexempt	= 0.0
RPP	= 0.1872 (value for average of published RPP for 2023 and 2024 calendar years)
JRPP	= 0.0
RECsurr	= 1,000 + 300 MWh
REConsite	= 500 MWh of LGC creations
RMF1	= 0.81 kg CO_2-e/kWh
RMF2	= 0.11 kg CO_2-e/kWh
Calculation of Total Greenhouse Gas Emissions (t CO_2-e)	
$= \Big((11{,}300{,}000 - 0.0) \times \big(1 - (0.1872 + 0.0)\big) + \big(0.0 \times (1 - 0.0)\big) - (1{,}300 - 500) \times 1{,}000\Big) \times \frac{0.81 + 0.11}{1{,}000}$	
Combined total greenhouse gas emissions (t CO_2-e)	= 7,254 t CO2-e

Emissions factors for the Carbon Credits (Carbon Farming Initiative) Act 2011

This section contains emissions factors for electricity grids to be used for calculating a carbon dioxide equivalent net abatement amount in accordance with a methodology determination under the Carbon Credits (Carbon Farming Initiative) Act 2011. These emission factors are listed in Table 3.

Table 3: Indirect (scope 2) emission factors for electricity grids

Electricity grid	**Emission factor (kg CO_2-e/kWh)**
National Electricity Market (NEM)	0.64
Western Australia - South West Interconnected System (SWIS)	0.51
Northern territory - Darwin Katherine Interconnected System (DKIS)	0.56
Western Australia - North Western Interconnected System (NWIS)	0.61
Off-grid	0.67

Sources: National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Schedule 1) and Department of Industry, Science, and Resources, Australian Energy Statistics, Clean Energy Regulator, and AEMO data and Department of Climate Change, Energy, the Environment and Water.

Stationary combustion of solid fuels

Table 4 Direct (scope 1) and Indirect (scope 3) emission factors for the combustion of solid fuels - including certain coal based products

Fuel combusted	**Energy Content factor (GJ/t)**	**Scope 1 Emission Factor (kg CO_2-e/GJ) CO_2**	**Scope 1 Emission Factor (kg CO_2-e/GJ) CH_4**	**Scope 1 Emission Factor (kg CO_2-e/GJ) N_2O**	**Scope 1 Emission Factor (kg CO_2-e/GJ) Combined gases**	**Scope 3 Emission Factor (kg CO_2-e /GJ)**
Bituminous coal	27.0	90	0.04	0.2	90.24	3.0
Sub-bituminous coal	21.0	90	0.04	0.2	90.24	2.5
Anthracite	29.0	90	0.04	0.2	90.24	NE
Brown coal (lignite)	10.2	93.5	0.02	0.3	93.82	0.4
Coking coal	30.0	91.8	0.03	0.2	92.03	6.4
Coal briquettes	22.1	95	0.08	0.3	95.38	NE
Coal coke	27.0	107	0.03	0.2	107.23	NE
Coal tar	37.5	81.8	0.03	0.2	82.03	NE
Solid fossil fuels other than those mentioned in the items above	22.1	95	0.08	0.2	95.28	NE
Industrial materials that are derived from fossil fuels, if recycled and combusted to produce heat or electricity	26.3	81.6	0.03	0.2	81.83	NE
Passenger car tyres, if recycled and combusted to produce heat or electricity	32.0	62.8	0.03	0.2	63.03	NE
Truck and off-road tyres, if recycled and combusted to produce heat or electricity	27.1	55.9	0.03	0.2	56.13	NE
Non-biomass municipal materials, if combusted to produce heat or electricity	10.5	87.1	0.8	1.0	88.9	NE
Dry wood	16.2	0	0.1	1.1	1.2	NE
Green and air dried wood	10.4	0	0.1	1.1	1.2	NE
Sulphite lyes	12.4	0	0.08	0.5	0.58	NE
Bagasse	9.6	0	0.3	1.1	1.4	NE

Biomass, municipal and industrial materials, if combusted to produce heat or electricity	12.2	0	0.8	1.0	1.8	NE
Charcoal	31.1	0	5.3	1.0	6.3	NE
Primary solid biomass fuels other than those mentioned in the items above	12.2	0	0.8	1.0	1.8	NE

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Schedule 1) and Department of Climate Change, Energy, the Environment and Water.

Notes:

- All emission factors incorporate relevant oxidation factors (sourced from the National Inventory Report).
- All emission factors expressed in terms of energy measured as gross calorific value (GCV) equivalents.
- Energy content and emission factors for coal products are measured on an as combusted basis. The energy content for black coal types and coking coal (metallurgical coal) is on a washed basis.
- Biofuels CO_2 emission factors assume emissions and removals due to the harvesting and regrowth of biomass are reported in the relevant land use category of the Land sectors where the biomass originates and are in balance.
- NE = not estimated. No data available to support the provision for a scope 3 factor of these fuels.

Calculating emissions from stationary combustion of solid fuels

The following formula can be used to estimate greenhouse gas emissions from the combustion of each type of fuel listed in Table 4.

$$t\,CO_2\text{-}e = \frac{Q \times EC \times (EF1 + EF3)}{1{,}000}$$

Where:

t CO_2-e is the emissions of gas type measured in CO_2-e tonnes.
Q is the quantity of fuel type measured in tonnes or gigajoules.
EC is the energy content factor of the fuel (gigajoules per tonne) according to each fuel in Table 4.
EF1 is the scope 1 emission factor, in kilograms of CO_2-e per gigajoule, for each gas type and for each fuel type as per Table 4. These can also be added together to get a combined emission factor, to ensure CO_2, CH_4 and N_2O emissions are included, as per Example 2.
EF3 is the scope 3 emission factor, in kilograms of CO_2-e per gigajoule, for each gas type and for each fuel type as per Table 4.

Notes:
If **Q** is specified in gigajoules, then EC is 1.

As the emission factors are given in kg CO_2-e, the division by 1,000 is necessary when reporting in t CO_2-e.

Example 3 Calculation of emissions (t CO_2-e) from stationary combustion of solid fuel (t)

A facility consumes 20,000 tonnes of brown coal for a purpose other than for the production of electricity or to produce coke. Scope 1 and scope 3 emissions are estimated as follows:

$$t\,CO_2\text{-}e = \frac{Q \times EC \times (EF1 + EF3)}{1{,}000}$$

Where:

Q = 20,000 t

EC = 10.2 GJ/t

EF1 is the Scope 1 emission factor for each individual gas as per Table 4, which can be combined into a single emission factor.

carbon dioxide CO_2 = 93.50 kg CO_2-e/GJ

methane CH_4 = 0.02 kg CO_2-e/GJ

nitrous oxide N_2O = 0.30 kg CO_2-e/GJ

EF3 from Table 4 = 0.40 kg CO_2-e/GJ

Solution 1: Calculation of Total Greenhouse Gas Emissions (t CO_2-e)

Combined emission factor	$= 93.5 + 0.02 + 0.30 + 0.40$ = 94.22 kg CO_2-e/GJ
Combined scopes 1 and 3 total greenhouse gas emissions (t CO_2-e)	$= \frac{20{,}000 \times 10.2 \times 94.22}{1{,}000}$ = 19,221 t CO_2-e

Solution 2: Calculation of Emissions of Individual Greenhouse Gases (t CO_2-e)

Scope 1 Emissions of carbon dioxide	$= \frac{20{,}000 \times 10.2 \times 93.5}{1{,}000}$ = 19,074 t CO_2-e
Scope 1 Emissions of methane	$= \frac{20{,}000 \times 10.2 \times 0.02}{1{,}000}$ = 4 t CO_2-e
Scope 1 Emissions of nitrous oxide	$= \frac{20{,}000 \times 10.2 \times 0.30}{1{,}000}$ = 61 t CO_2-e
Scope 3 Emissions	$= \frac{20{,}000 \times 10.2 \times 0.40}{1{,}000}$ = 82 t CO_2-e
Combined scopes 1 and 3 total greenhouse gas emissions (t CO_2-e)	= 19,221 t CO_2-e

Stationary combustion of gaseous fuels

Table 5 Direct (Scope 1) emission factors for the consumption of gaseous fuels including liquefied natural gas

Fuel combusted	Energy Content factor (GJ/m3 unless otherwise indicated)	Scope 1 Emission Factor (kg CO_2-e/GJ) CO_2	Scope 1 Emission Factor (kg CO_2-e/GJ) CH_4	Scope 1 Emission Factor (kg CO_2-e/GJ) N_2O	Scope 1 Emission Factor (kg CO_2-e/GJ) Combined gases
Natural gas distributed in a pipeline	0.0393	51.4	0.1	0.03	51.53
Coal seam methane that is captured for combustion	0.0377	51.4	0.2	0.03	51.63
Coal mine waste gas that is captured for combustion	0.0377	51.9	4.6	0.3	56.8
Compressed natural gas (reverting to standard conditions)	0.0393	51.4	0.1	0.03	51.53
Unprocessed natural gas	0.0393	51.4	0.1	0.03	51.53
Ethane	0.0629	56.5	0.03	0.03	56.56
Coke oven gas	0.0181	37.0	0.03	0.05	37.08
Blast furnace gas	0.0040	234.0	0.03	0.02	234.05
Town gas	0.0390	60.2	0.04	0.03	60.27
Liquefied natural gas	25.3 GJ/kL	51.4	0.1	0.03	51.53
Gaseous fossil fuels other than those mentioned in the items above	0.0390	51.4	0.1	0.03	51.53
Landfill biogas that is captured for combustion (methane only)	0.0377	0.0	6.4	0.03	6.43

Sludge biogas that is captured for combustion (methane only)	0.0377	0.0	6.4	0.03	6.43
A biogas that is captured for combustion, other than those mentioned in the items above	0.0370	0.0	6.4	0.03	6.43
Biomethane	0.0393	0.0	0.1	0.03	0.13

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Schedule 1)

Notes:

- All emission factors incorporate relevant oxidation factors (sourced from the National Inventory Report).
- All EFs expressed in terms of energy measured as gross calorific value (GCV) equivalents Biofuels CO_2 emission factors assume emissions and removals due to the harvesting and regrowth of biomass are reported in the relevant land use category of the Land sectors where the biomass originates and are in balance.
- No data available to calculate scope 3 for gaseous fuels other than natural gas (Table 6) and ethane (Table 7).
- Energy content is measured on a dry gas bases under standard conditions:
    - air pressure of 101.325 kilopascals;
    - air temperature of 15.0 degrees Celsius; and
    - air density of 1.225 kilograms per cubic metre.

Table 6 Indirect (Scope 3) emission factors for the consumption of natural gas

State or territory	Scope 3 Emission Factors for Natural Gas (kg CO_2-e/GJ) Metro	Scope 3 Emission Factors for Natural Gas (kg CO_2-e/GJ) Non-Metro
New South Wales and ACT	13.1	14.0
Victoria	4.0	4.0
Queensland	8.8	7.9
South Australia	10.7	10.6
Western Australia	4.1	4.0
Tasmania	C	C
Northern Territory	C	C

Source: Wilkenfeld and Associates (2012), derived from NGER data.

Notes:

- As Scope 3 factors are calculated at the point where natural gas is delivered to end users, it is necessary to calculate consumption at each of the load centres. Gas reaches end users either from the metro distribution networks or direct from the high-pressure distribution pipelines. Households and commercial users tend to be served by the former, and electricity generators and large industrial plants from the latter.
- Metro is defined as located on or east of the dividing range in NSW, including Canberra and Queanbeyan, Melbourne, Brisbane, Adelaide or Perth. Otherwise, the non-metro factor should be used.

- Factors are calculated for all natural gas distributed in a pipeline which may include coal seam methane.
- Table 6 is not applicable to ethane. See Table 7 Indirect (Scope 3) emissions from the consumption of ethane.
- C = Confidential. Scope 3 emission factors for Tasmania and the Northern Territory are not available due to confidentiality constraints that arise from the use of a limited number of NGER data inputs. It is suggested that for Tasmania the use of the Victorian emission factors is appropriate, while for Northern Territory the use of the Western Australian emission factors is appropriate.
- Scope 3 emission factors do not include fugitive emission leakage from low pressure natural gas distribution pipeline networks while those from high pressure gas networks are considered negligible.

Table 7 Indirect (Scope 3) emission factors for the consumption of ethane

Ethane produced in accordance with Division 23 of Part 3 of the Clean Energy Regulations 2011	Scope 3 Emission Factors for Ethane (kg CO_2-e /GJ)
New South Wales	23.7
Victoria	5.7

Source: Wilkenfeld and Associates (2012), derived from NGER data

Calculating emissions from stationary combustion of gaseous fuels

The following formula can be used to estimate greenhouse gas emissions from the combustion of each type of fuel listed in Table 5.

$$t\ CO_2\text{-}e = \frac{Q \times EC \times (EF1 + EF3)}{1{,}000}$$

Where:

t CO_2-e is the emissions of each gas type, from each gaseous fuel type, measured in CO_2-e tonnes.
Q is the quantity of fuel type (e.g. cubic metres, gigajoules or kilolitres)
EC is the energy content factor of fuel type (gigajoules per cubic metre), according to Table 5.
EF1 is the scope 1 emission factor, in kilograms of CO_2-e per gigajoule, for each gas type and for each fuel type as per Table 4. These can also be added together to get a combined emission factor, to ensure CO_2, CH_4 and N_2O emissions are included, as per Example 4.
EF3 is the scope 3 emission factor, in kilograms of CO_2-e per gigajoule, as per Table 6.

Notes:
If **Q** is specified in gigajoules, then EC is 1.
As the emission factors are given in kg CO_2-e, the division by 1,000 is necessary when reporting in t CO_2-e.

Example 4 Calculation of emissions (t CO_2-e) from natural gas consumption (GJ)

A facility, in Sydney NSW, consumes 100,000 gigajoules of natural gas (distributed in a pipeline). Scope 1 and scope 3 emissions are estimated as follows:

$$t\ CO_2\text{-}e = \frac{Q \times EC \times (EF1 + EF3)}{1{,}000}$$
Where: Q = 100,000 GJ EC = 1 GJ/GJ EF1 is the Scope 1 emission factor for each individual gas as per Table 5, which can be combined into a single emission factor. carbon dioxide CO_2 = 51.4 kg CO_2-e/GJ methane CH_4 = 0.1 kg CO_2-e/GJ nitrous oxide N_2O = 0.03 kg CO_2-e/GJ EF3 as per Table 6 = 13.1 kg CO_2-e/GJ
Solution 1: Calculation of Total Greenhouse Gas Emissions (t CO_2-e)
Combined emission factor $= 51.4 + 0.1 + 0.03 + 13.1$ = 64.63
Combined scopes 1 and 3 total greenhouse gas emissions (t CO_2-e) $= \frac{100{,}000 \times 1 \times 64.63}{1{,}000}$ = 6,463 t CO_2-e
Solution 2: Calculation of Emissions of Individual Greenhouse Gases (t CO_2-e)
Scope 1 Emissions of carbon dioxide $= \frac{100{,}000 \times 1 \times 51.4}{1{,}000}$ = 5,140 t CO_2-e
Scope 1 Emissions of methane $= \frac{100{,}000 \times 1 \times 0.1}{1{,}000}$ = 10 t CO_2-e
Scope 1 Emissions of nitrous oxide $= \frac{100{,}000 \times 1 \times 0.03}{1{,}000}$ = 3 t CO_2-e
Scope 3 Emissions $= \frac{100{,}000 \times 1 \times 13.1}{1{,}000}$ = 1,310 t CO_2-e
Combined scopes 1 and 3 total greenhouse gas emissions (t CO_2-e) = 6,463 t CO_2-e

Example 5 Calculation of emissions (t CO_2-e) from liquefied natural gas consumption (kL)

A facility consumes 1150 kilolitres (kL) of liquefied natural gas. As there is no scope 3 emission factor provided for liquefied natural gas, the scope 1 emissions are estimated as follows:

$$t\ CO_2\text{-}e = \frac{Q \times EC \times EF}{1{,}000}$$
Where: Q = 1150 kL EC = 25.3 GJ/kL EF1 is the Scope 1 emission factor for each individual gas as per Table 5, which can be combined into a single emission factor. carbon dioxide CO_2 = 51.4 kg CO_2-e/GJ methane CH_4 = 0.1 kg CO_2-e/GJ nitrous oxide N_2O = 0.03 kg CO_2-e/GJ
Solution 1: Calculation of Total Greenhouse Gas Emissions (t CO_2-e)

Combined emission factor	$= 51.4 + 0.1 + 0.03$	= 51.53 kg CO_2-e/GJ
Combined total greenhouse gas emissions (t CO_2-e) $= \frac{1150 \times 25.3 \times 51.53}{1,000}$		= 1,499 t CO_2-e
Solution 2: Calculation of Emissions of Individual Greenhouse Gases (t CO_2-e)		
Scope 1 Emissions of carbon dioxide	$= \frac{1150 \times 25.3 \times 0.1}{1,000}$	= 3 t CO_2-e
Scope 1 Emissions of methane	$= \frac{1150 \times 25.3 \times 0.03}{1,000}$	= 1 t CO_2-e
Scope 1 Emissions of nitrous oxide	$= \frac{1150 \times 25.3 \times 0.03}{1,000}$	= 1 t CO_2-e
Combined scopes 1 and 3 total greenhouse gas emissions (t CO_2-e)		= 1,499 t CO_2-e

Stationary combustion of liquid fuels

Table 8 Direct (Scope 1) and indirect (scope 3) emission factors for the consumption of liquid fuels, including certain petroleum based products for stationary energy purposes

Fuel combusted	**Energy Content factor (GJ per unit of fuel)**	**Scope 1 Emission Factor (kg CO_2-e/GJ) CO_2**	**Scope 1 Emission Factor (kg CO_2-e/GJ) CH_4**	**Scope 1 Emission Factor (kg CO_2-e/GJ) N_2O**	**Scope 1 Emission Factor (kg CO_2-e/GJ) Combined gases**	**Scope 3 Emission Factor (kg CO_2-e /GJ)**
Petroleum based oils (other than petroleum based oil used as fuel), e.g. lubricants	38.8 GJ/kL	13.9	0.0	0.0	13.9	18.0
Petroleum based greases	38.8 GJ/kL	3.5	0.0	0.0	3.5	18.0
Crude oil including crude oil condensates	45.3 GJ/t	69.6	0.08	0.2	69.88	NE
Other natural gas liquids	46.5 GJ/t	61.0	0.08	0.2	61.28	NE
Automotive gasoline/petrol (other than for use as fuel in an aircraft)	34.2 GJ/kL	67.4	0.2	0.2	67.80	17.2
Aviation gasoline	33.1 GJ/kL	67	0.2	0.2	67.40	18.0
Kerosene (other than for use as fuel in an aircraft)	37.5 GJ/kL	68.9	0.01	0.2	69.11	18.0
Aviation turbine fuel/kerosene	36.8 GJ/kL	69.6	0.02	0.2	69.82	18.0
Heating oil	37.3 GJ/kL	69.5	0.03	0.2	69.73	18.0
Diesel oil	38.6 GJ/kL	69.9	0.1	0.2	70.20	17.3
Fuel oil	39.7 GJ/kL	73.6	0.04	0.2	73.84	18.0

Liquefied aromatic hydrocarbons	34.4 GJ/kL	69.7	0.03	0.2	69.93	18.0
Solvents: mineral turpentine or white spirits	34.4 GJ/kL	69.7	0.03	0.2	69.93	18.0
Liquefied petroleum gas (LPG)	25.7 GJ/kL	60.2	0.2	0.2	60.60	20.2
Naphtha	31.4 GJ/kL	69.8	0.01	0.01	69.82	18.0
Petroleum coke	34.2 GJ/t	92.6	0.08	0.2	92.88	18.0
Refinery gas and liquids	42.9 GJ/t	54.7	0.03	0.03	54.76	18.0
Refinery coke	34.2 GJ/t	92.6	0.08	0.2	92.88	18.0
Petroleum based products other than mentioned in the items above	34.4 GJ/kL	69.8	0.02	0.1	69.92	18.0
Biodiesel	34.6 GJ/kL	0.0	0.08	0.2	0.28	NE
Ethanol for use as a fuel in an internal combustion engine	23.4 GJ/kL	0.0	0.08	0.2	0.28	NE
Biofuels other than those mentioned in the items above and below	23.4 GJ/kL	0.0	0.08	0.2	0.28	NE
Renewable aviation kerosene	36.8 GJ/kL	0.0	0.02	0.2	0.22	NE
Renewable diesel	38.6 GJ/kL	0.0	0.1	0.2	0.30	NE

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Schedule 1).

Notes:

- All emission factors incorporate relevant oxidation factors (sourced from the National Inventory Report).
- All EFs are expressed in terms of energy measured as gross calorific value (GCV) equivalents.
- Biofuels CO_2 emission factors assume emissions and removals due to the harvesting and regrowth of biomass are reported in the relevant land use category of the Land sectors where the biomass originates and are in balance.
- Scope 3 factors for biofuels such as biodiesels and ethanol are highly dependent on individual plant and project characteristics, and therefore have not been estimated.
- NE = not estimated. No or limited data available to support the provision for a scope 3 factor of these fuels.

Calculating emissions from stationary combustion of liquid fuels

The following formula can be used to estimate greenhouse gas emissions from the stationary combustion of each type of liquid fuel listed Table 8.

$$t\ CO_2\text{-}e = \frac{Q\ \times\ EC\ \times (EF1 + EF3)}{1{,}000}$$

Where:

t CO_2-e is the emissions of each gas type, from each fuel type, measured in CO_2-e tonnes.

Q is the quantity of fuel type measured in kilolitres, tonnes or gigajoules.
EC is the energy content factor of the fuel (gigajoules per unit of fuel type) according to each fuel in Table 8.
EF1 is the scope 1 emission factor, in kilograms of CO_2-e per gigajoule, for each gas type and for each fuel type as per Table 6. These can also be added together to get a combined emission factor, to ensure CO_2, CH_4 and N_2O emissions are included, as per Example 6.
EF3 is the scope 3 emission factor, in kilograms of CO_2-e per gigajoule, for each gas type and for each fuel type as per Table 8.

Notes:
If **Q** is specified in gigajoules, then EC is 1.
As the emission factors are given in kg CO_2-e, the division by 1,000 is necessary when reporting in t CO_2-e.

Example 6 Calculation of emissions (t CO_2-e) from stationary diesel oil consumption (kL)

A facility consumes 700 kilolitres (kL) of diesel oil in their on-site generator. Scope 1 and scope 3 emissions are estimated as follows:

$$t\ CO_2\text{-}e = \frac{Q \times EC \times (EF1 + EF3)}{1{,}000}$$

Where:
Q = 700 kL
EC = 38.6 GJ/kL

EF1 is the Scope 1 emission factor for each individual gas as per Table 8 , which can be combined into a single emission factor.

carbon dioxide CO_2 = 69.90 kg CO_2-e/GJ
methane CH_4 = 0.1 kg CO_2-e/GJ
nitrous oxide N_2O = 0.2 kg CO_2-e/GJ

EF3 from Table 8 = 17.3 kg CO_2-e/GJ

Solution 1: Calculation of Total Greenhouse Gas Emissions (t CO_2-e)

Combined emission factor $= 69.9 + 0.1 + 0.2 + 17.3$ = 87.5 kg CO_2-e/GJ

Combined scopes 1 and 3 total greenhouse gas emissions (t CO_2-e)
$= \frac{700 \times 38.6 \times 87.5}{1{,}000}$ = 2,364.3 t CO_2-e

Solution 2: Calculation of Emissions of Individual Greenhouse Gases (t CO_2-e)

Emissions of carbon dioxide $= \frac{700 \times 38.6 \times 69.90}{1{,}000}$ = 1,888.7 t CO_2-e

Emissions of methane $= \frac{700 \times 38.6 \times 0.1}{1{,}000}$ = 2.7 t CO_2-e

Emissions of nitrous oxide $= \frac{700 \times 38.6 \times 0.2}{1{,}000}$ = 5.4 t CO_2-e

Scope 3 Emissions	$= \frac{700 \times 38.6 \times 17.3}{1,000}$	= 467.4 t CO_2-e
Combined scopes 1 and 3 total greenhouse gas emissions (t CO_2-e)		= 2,364.3 t CO_2-e

2.3 Estimating emissions from transport fuels

Transport fuel emissions

Fuels used for transport purposes produce different methane and nitrous oxide emissions than if the same fuels were used for stationary energy purposes. While CO_2 emissions are only dependant on the fuel type, CH_4 and N_2O emissions are dependent on the type of engine technology used as well as the fuel type. Therefore, separate emission factors are provided in Table 9 to apply where fuels are used for general transport purposes as well as specific transport types.

Table 9 Direct (scope 1) and indirect (scope 3) emission factors for the consumption of transport fuels in different transport equipment

Transport type	Fuel combusted	Energy Content factor (GJ per unit of fuel)	Scope 1 Emission Factor (kg CO_2-e/GJ) CO_2	Scope 1 Emission Factor (kg CO_2-e/GJ) CH_4	Scope 1 Emission Factor (kg CO_2-e/GJ) N_2O	Scope 1 Emission Factor (kg CO_2-e/GJ) Combined gases	Scope 3 Emission Factor (kg CO_2-e /GJ)
Cars and light commercial vehicles	Gasoline	34.2	67.4	0.02*	0.2*	67.62	17.2
Cars and light commercial vehicles	Diesel oil	38.6	69.9	0.01*	0.5*	70.41	17.3
Cars and light commercial vehicles	Liquefied petroleum gas (LPG)	26.2	60.2	0.5*	0.3*	61.00	20.2
Cars and light commercial vehicles	Fuel oil	39.7	73.6	0.08	0.5	74.18	18.0
Cars and light commercial vehicles	Ethanol	23.4	0.0	0.2*	0.2*	0.4	NE
Cars and light commercial vehicles	Biodiesel	34.6	0.0	0.8	1.7	2.5	NE
Cars and light commercial vehicles	Renewable diesel	38.6	0.0	0.01*	0.5*	0.51	NE

Cars and light commercial vehicles	Other biofuels	23.4	0.0	0.8	1.7	2.5	NE
Light duty vehicles	Compressed natural gas	0.0393 GJ/m^3	51.4	7.3	0.3	59.0	18.0
Light duty vehicles	Liquefied natural gas	25.3	51.4	7.3	0.3	59.0	18.0
Heavy duty vehicles	Compressed natural gas	0.0393 GJ/m^3	51.4	2.8	0.3	54.5	18.0
Heavy duty vehicles	Liquefied natural gas	25.3	51.4	2.8	0.3	54.5	18.0
Heavy duty vehicles	Diesel oil - Euro iv or higher	38.6	69.9	0.07	0.4	70.37	17.3
Heavy duty vehicles	Diesel oil - Euro iii	38.6	69.9	0.1	0.4	70.4	17.3
Heavy duty vehicles	Diesel oil - Euro i	38.6	69.9	0.2	0.4	70.5	17.3
Heavy duty vehicles	Renewable diesel – Euro iv or higher	38.6	0.0	0.07	0.4	0.47	NE
Heavy duty vehicles	Renewable diesel – Euro iii	38.6	0.0	0.1	0.4	0.5	NE
Heavy duty vehicles	Renewable diesel – Euro i	38.6	0.0	0.2	0.4	0.6	NE
Aviation	Gasoline for use as fuel in an aircraft	33.1	67.0	0.06	0.6	67.66	18.0
Aviation	Kerosene for use as fuel in an aircraft	36.8	69.6	0.01	0.6	70.21	18.0
Aviation	Renewable aviation kerosene	36.8	0.0	0.01	0.6	0.61	NE

Notes:

- * For vehicles manufactured prior to 2004, the following scope 1 emission factors (in kg CO_2-e/GJ) should be used instead of those presented in Table 9: *Gasoline CH_4 =0.6, N_2O = 1.6, Diesel oil CH_4 =0.1, N_2O = 0.4, LPG CH_4 =0.7, N_2O = 0.6, Ethanol CH_4= 0.8, N_2O = 1.7, Renewable diesel CH_4 = 0.1, N_2O = 0.4.*
- NE = not estimated. Scope 3 factors for biofuels such as biodiesels and ethanol are highly dependent on individual plant and project characteristics. No data are available to support the provision for a scope 3 factor of these fuels.
- For compressed natural gas, emission factors are for gas that has converted to standard conditions.

Calculating emissions from transport fuels

The following formula can be used to estimate greenhouse gas emissions from the combustion of each type of fuel listed in Table 9 used for transport energy purposes.

$$t\ CO_2\text{-}e = \frac{Q \times EC \times (EF1 + EF3)}{1,000}$$

Where:

t CO_2-e is the emissions from each gas type and each fuel type measured in CO_2-e tonnes.

Q is the quantity of fuel type, measured in kilolitres or gigajoules, and combusted for transport energy purposes

EC is the energy content factor of fuel type (gigajoules per kilolitre or per cubic metre) used for transport energy purposes as per Table 9.

EF1 is the scope 1 emission factor, in kilograms of CO_2-e per gigajoule, for each transport type and for each fuel type as per Table 9.

EF3 is the scope 3 emission factor, in kilograms of CO_2-e per gigajoule, as per Table 9.

Note:

If **Q** is specified in gigajoules, then EC is 1.

As the emission factors are given in kg CO_2-e, the division by 1,000 is necessary when reporting in t CO_2-e.

Example 7 Calculation of emissions (t CO_2-e) from diesel oil consumption (kL) for transport

A freight company consumes 10,000 kL of automotive diesel for transport purposes, in vehicles that were manufactured after 2004. Scope 1 and scope 3 emissions are estimated as follows:

$$t\ CO_2\text{-}e = \frac{Q \times EC \times (EF1 + EF3)}{1000}$$

Where:

Q = 10,000 kL

EC = 38.6 GJ/kL

EF1 is the Scope 1 emission factor for each individual gas as per Table 9, which can be combined into a single emission factor.

carbon dioxide CO_2 = 69.9 kg CO_2-e/GJ

methane CH_4 = 0.1 kg CO_2-e/GJ

nitrous oxide N_2O = 0.4 kg CO_2-e/GJ

EF3 from Table 9 = 17.3 kg CO_2-e/GJ

Solution 1: Calculation of Total Greenhouse Gas Emissions (t CO_2-e)

Combined emission factor $= 69.9 + 0.1 + 0.4 + 17.3$ = 87.61 kg CO_2-e/GJ

Combined scopes 1 and 3 total greenhouse gas emissions (t CO_2-e)

$= \frac{10,000 \times 38.6 \times 87.61}{1,000}$ = 33,817 t CO_2-e

Solution 2: Calculation of Emissions of Individual Greenhouse Gases (t CO_2-e)		
Scope 1 Emissions of carbon dioxide	$= \frac{10{,}000 \times 38.6 \times 69.90}{1{,}000}$	= 26,981 t CO_2-e
Scope 1 Emissions of methane	$= \frac{10{,}000 \times 38.6 \times 0.1}{1{,}000}$	= 4 t CO_2-e
Scope 1 Emissions of nitrous oxide	$= \frac{10{,}000 \times 38.6 \times 0.40}{1{,}000}$	= 154 t CO_2-e
Scope 3 Emissions	$= \frac{10{,}000 \times 38.6 \times 17.3}{1{,}000}$	= 6,677 t CO_2-e
Total Greenhouse Gas Emissions (t CO_2-e)		= 33,817 t CO_2-e

2.4 Estimating fugitive emissions

Fugitive emissions involve the release of non-combustion, greenhouse gases arising from the production and delivery of fossil fuels. Fugitive emissions from solid fuels arise from the production of coal, and emissions from decommissioned mines and coal mine waste gas flaring. Fugitive emissions from oil and gas extraction, production and transport involve venting, flaring, leakage, evaporation and storage losses. Fugitive emissions from carbon dioxide transport and storage arise from the transport, injection and storage of carbon dioxide associated with carbon capture and storage activities. For factors and methods used for estimating fugitive emissions, please refer to Chapter 3 of the National Greenhouse and Energy Reporting (Measurement) Determination 2008.

3 Industrial processes and product use

Emissions from non-energy related industrial production and processes (IPCC sector 2) includes emissions from hydrofluorocarbons (HFCs), which are used in refrigerants and air conditioning and the use of carbonates. While there are many sectors within industrial processes and product use (IPPU), the most relevant for organisation and individuals preparing a greenhouse gas inventory is likely to be the calculation of refrigerant leakage from refrigeration and air conditioning, and the use of carbonate and soda ash. Methods and factors for estimating greenhouse gas emissions from industrial processes other than those described in this workbook can be found in the National Greenhouse and Energy Reporting (Measurement) Determination 2008.

3.1 Estimating industrial processes emissions

Refrigerant leakage

Many refrigerants used in refrigeration and air conditioning equipment are also greenhouse gases. Refer to the manufacturer's product specification to determine the type and the charge of a refrigerant contained in your appliances. Indicative leakage rates and common refrigerant types with their GWPs are given in Table 10 and Table 11 respectively.

Table 10 Indicative leakage rates for common refrigeration and air-conditioning equipment[1]

Product	Annual leakage rate (%)
Domestic refrigerators	1.7
Transport refrigeration	15.7
Domestic A/C portable	2.5
Domestic A/C split	3.5
Domestic A/C packaged	2.5
Light vehicle A/C	6.7
Heavy vehicle A/C	10.8

Source: National Inventory Report 2021

Table 11 Global warming potentials of common refrigerants

Refrigerant	Global Warming Potentials (AR5)
R22 (HCFC-22)[2]	1,760
R32 (HFC-32)	677
R134A (HFC-134A)	1,300
R410A (HFC blend)	1,924
R404A (HFC blend)	3,943

Factors represent average annual leakages from operation and not leakages during installation or disposal of equipment. Equipment charged with HFC refrigerants should be disposed of in accordance with applicable regulatory requirements.

[2] While emissions of R22 (HCFC-22) are not counted in national inventories submitted under the United Nations Framework Convention on Climate Change and Paris Agreement, its Global Warming Potential is presented here for completeness.

Source: Department of Climate Change, Energy, the Environment and Water.

Note: Global warming potential values for other refrigerants and the compositions of blended refrigerants are located in Appendix 2.

Calculating emissions from refrigerant leakage

The following formula should be used to estimate the CO_2-e emissions from refrigeration and air-conditioning equipment:

$$t\,CO_2\text{-}e = \frac{GWP \times charge \times leakage\ rate}{1{,}000}$$

Where:
t CO_2-e is the emissions measured in CO_2-e tonnes.
GWP is the global warming potential of the gas (see Appendix 2 for a list of GWPs).
Charge is the amount of refrigerant gas contained in the appliance (usually found on the appliance).
Leakage rate is the percentage of total charge leaked from the appliance each year.

Note: As the emission factors are given in kg CO_2-e the division by 1,000 is necessary when reporting in t CO_2-e.

Example 8 Calculation of emissions from refrigerant leakage

A household operates a split system air conditioning unit pre-charged with 3kg of the refrigerant R410A. The emissions are estimated as follows:

$t\,CO_2\text{-}e = \frac{GWP \times charge \times leakage\ rate}{1{,}000}$		
Where: GWP Charge Leakage rate	 = 1,924 = 3.0 kg = 3.5%	
Calculation of annual greenhouse gas emissions (t CO_2-e)		
Total Greenhouse Gas Emissions (t CO_2-e)	$= \frac{1924 \times 3 \times 0.035}{1000}$	= 0.2020 t CO_2-e

Use of carbonates for the production of a product (other than cement clinker, lime or soda ash)

This section applies to calcination or any other use of carbonates that generates CO_2 (excluding cement clinker, lime production or soda ash production) including the in-house lime production in the ferrous metals industry. Other examples of industrial processes involving the consumption of carbonates can be found in the National Greenhouse and Energy Reporting (Measurement) Determination 2008.

Table 12 Direct (scope 1) emission factors for the calcination of carbonates

Source of carbonate consumption	Emission factor (t CO_2/tonne)
Limestone (calcium carbonate)	0.440
Magnesium carbonate	0.522
Dolomite	0.477

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008, Section 4.8, Chapter 4, Part 4.2, Division 4.2.1.

Calculating emissions from carbonate use

The method for estimating emissions from the use of carbonates for the production of a product other than cement clinker, lime or soda ash is described below:

$$t\ CO_2\text{-}e = Q \times EF \times F_{cal}$$

Where:

t CO_2-e the annual emissions of CO_2 from the consumption of carbonate measured in CO_2-e tonnes.

Q is the quantity of raw carbonate material consumed measured in tonnes.

EF is the CO_2 emission factor for each carbonate material type (tonnes CO_2 per tonne of carbonate) as per Table 12.

F_{cal} is the fraction of the carbonate calcined. If the information is not available the degree is assumed to be 100%, that is, F_{cal} =1.

Use of carbonates in clay materials

Process-related emissions from ceramics result from the calcination of carbonates in the clay, as well as the addition of additives. Ceramics include the production of bricks and roof tiles, vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware (household ceramics), sanitary ware, technical ceramics, and inorganic bonded abrasives. Default scope 1 emission factors are provided by State and Territory.

Table 13 Direct (scope 1) emission factors for use of carbonates in clay materials by state and territory

State or Territory	Inorganic carbon content factor	Scope 1 emission factor t CO_2-e/t clay material
New South Wales	0.0061	0.0222
Victoria	0.0002	0.0009
Queensland	0.0025	0.0092
Western Australia	0.0003	0.0012
South Australia	0.0005	0.0019
Tasmania	0.0011	0.0038
Australian Capital Territory	0.0061	0.0222
Northern Territory	0.0005	0.0019

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008, Section 4.23, Chapter 4, Part 4.2, Division 4.2.3.

Calculating emissions from use of carbonates in clay materials

Calculate the emissions of carbon dioxide released from each clay material consumed in the industrial process during the reporting year, measured in CO_2-e tonnes, using the following formula:

$$t\ CO_2\text{-}e = Q \times EF$$

Where:

t CO_2-e is the emissions of carbon dioxide released from the clay material consumed in the industrial process during the reporting year measured in CO_2-e tonnes.

Q is the quantity of clay material consumed in the industrial process during the reporting year in a State or Territory measured in tonnes

EF is the scope 1 emission factor, in tonnes of CO_2-e per tonnes of clay material as per Table 13.

Soda ash use

Soda ash is used in a variety of applications, including glass production, soaps and detergents, flue gas desulphurisation, chemicals, pulp and paper and other common consumer products. Soda ash production and consumption (including sodium carbonate, Na_2CO_3) results in the release of CO_2.

Table 14 Direct (scope 1) emission factors for the consumption of soda ash

Source	Scope 1 emission factor (t CO_2-e/t)
Soda Ash Use	0.415

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008, Section 4.29, Chapter 4, Part 4.2, Division 4.2.4.

Calculating emissions from soda ash consumption

This method is derived from those used in the National Greenhouse Accounts. It involves the multiplication of the quantity of soda ash consumed in the production process by the emission factor for soda ash.

$$t\ CO_2\text{-}e = Q \times EF$$

Where:

t CO_2-e the emissions of CO_2 from the use of soda ash (CO_2-e tonnes)

Q is the amount of soda ash consumed measured in tonnes

EF is the CO_2 emission factor (tonnes of CO_2 / tonnes of soda ash used) as per Table 14.

4 Waste emissions

Emissions from the waste sector (IPCC Sector 5) comprise emissions from the following categories:

- Solid waste disposal
- Wastewater treatment and discharge
- Biological treatment of solid waste
- Incineration and open burning of waste.

Typically, emissions from solid waste disposal are the largest source of greenhouse gas emissions in the waste sector, followed by wastewater treatment and discharge. Emissions from incineration of waste and biological treatment of solid waste are also considered within this chapter.

4.1 Greenhouse gas emissions from waste

Emissions from the waste sector are predominantly CH_4, however small amounts of CO_2 and N_2O are also generated. Emissions of CO_2 generated from solid waste disposal and wastewater treatment and discharge are considered to be of biogenic origin (e.g. paper, wood) and do not need to be estimated. For example, when landfills recover methane for flaring or combustion, the CO_2 emitted is not considered because it is seen as part of the natural carbon cycle.

4.2 Estimating solid waste emissions

For companies and individuals wishing to calculate the indirect emissions (scope 3) from the disposal of their waste outside the organisation boundaries, such as waste taken to municipal landfill, please use Table 15 and Table 16 below.

Table 15 includes emission factors to be used for various waste types when the weight of waste is known. If waste is measured by volume and not by weight, conversion factors are also in 4.

For those who do not know the composition of their waste can use the emission factors in Table 16, which gives the weighted average emission factors for the municipal, commercial and industrial, and construction and demolition waste categories.

For companies that operate landfill sites and wish to calculate scope 1 emissions, please refer to Chapter 5 – Part 5.2 of the National Greenhouse and Energy Reporting (Measurement) Determination 2008 for guidance.

Emissions from solid waste disposal to landfill

Table 15 Waste mix methane conversion factors and emission factors

Waste types	**Scope 3 emission factor (t CO_2-e/t)**	**Volume to mass conversion factor (t/m^3)**
Food	2.1	0.50
Paper and cardboard	3.3	0.09
Garden and green	1.6	0.24
Wood	0.7	0.15
Textiles	2.0	0.14
Sludge	0.4	0.72

Nappies	2.0	0.39
Rubber and leather	3.3	0.14
Inert waste (including concrete/metal/plastics/glass)	-	0.42

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008.

Notes:

- This method is used to produce an estimate of lifetime emissions from waste degradation in a landfill. In reality, waste disposed in a landfill will degrade and emit over a period of decades.
- The method does not take into account any landfill gas capture occurring at the landfill.

Table 16 Indirect (scope 3) waste emission factors for total waste disposed to landfill by broad waste stream category

Waste stream	Scope 3 emission factor (t CO_2-e/t)	Volume to mass conversion factor (t/m^3)
Municipal solid waste	1.6	0.36
Commercial and industrial waste	1.3	0.33
Construction and demolition waste	0.2	0.39

Source: Derived from National Greenhouse and Energy Reporting (Measurement) Determination 2008. Section 5.11

Calculating emissions from waste disposal to landfill

Estimates of Scope 3 greenhouse gas emissions associated with the disposal of waste can be calculated as follows:

When weight of waste is known:

$$t\ CO_2\text{-}e = Q \times EF$$

When weight is not known:

$$t\ CO_2\text{-}e = m^3 \times CF \times EF$$

Where:
t CO_2-e is the emissions measured in CO_2-e tonnes.
Q is the quantity of waste measured in tonnes.
EF is the emission factor of waste type as per Table 15 and Table 16.
m^3 is the volume of waste measure in cubic metres.
CF is the conversation factor of volume to mass as per Table 15 and Table 16.

Example 9 Calculation of lifetime emissions (t CO_2-e) generated from solid waste (t)

A higher education facility produced a total solid waste stream of 240 tonnes which was disposed of in the local landfill. This waste comprises 140 tonnes of food waste, 50 tonnes of paper/paper board, 10 tonnes of garden and park waste and 40 tonnes of inert waste. It is assumed that no methane was recovered at the landfill. The lifetime emissions are estimated as follows:

$t\ CO_2\text{-}e = Q\ \times EF$		
Where: Q Food waste = 140 tonnes Paper/paper board = 50 tonnes Garden and park waste = 10 tonnes Inert waste = 40 tonnes EF as per Table 15 Food waste = 2.1 t CO_2-e/tonne Paper/paper board = 3.3 t CO_2-e/tonne Garden and park waste = 1.6 t CO_2-e/tonne Inert waste = 0.0 t CO_2-e/tonne		
Calculation of Total Greenhouse Gas Emissions (t CO_2 -e)		
Food waste greenhouse gas emissions (t CO_2-e)	$= 140\ \times 2.1$	= 294 t CO_2-e
Paper/paper board greenhouse gas emissions (t CO_2-e)	$= 50 \times 3.3$	= 165 t CO_2-e
Garden and park waste greenhouse gas emissions (t CO_2-e)	$= 10\ \times 1.6$	= 16 t CO_2-e
Inert waste greenhouse gas emissions (t CO_2-e)	$= 40\ \times 0.0$	= 0 t CO_2-e
Total greenhouse gas emissions (t CO_2-e)	= 475 t CO_2-e	

Example 10 Calculation of lifetime emissions (t CO_2-e) generated from commercial and industrial waste

A commercial company in the finance industry disposes 1 kilotonne of commercial and industrial waste. Their lifetime emissions are estimated as follows:

$t\ CO_2\text{-}e = Q\ \times EF$
Where: Q = 1000 tonnes EF for Commercial and industrial waste as per Table 16 = 1.3 t CO_2-e/tonne
Calculation of Total Greenhouse Gas Emissions (t CO_2 -e)
Commercial and Industrial waste greenhouse gas emissions (t CO_2-e) $= 1000\ \times 1.3$ = 1,300 t CO_2-e

Example 11 Calculation of lifetime emissions (t CO_2-e) generated from waste when the weight is unknown, but the volume is known (m^3)

A facility does not capture the number of tonnes of waste produced, but they do have data available for the number of collections (24 collections) of $3m^3$ skips filled and disposed of in the year. The type of waste is food waste. The lifetime emissions are estimated as follows:

$t\ CO_2\text{-}e = m^3 \times CF \times EF$	
Where:	
m^3	= 1000 tonnes
	= 72 m^3 of waste per year
CF as per Table 15	= 0.50 tonnes of waste/m^3
EF as per Table 15	= 2.1 t CO_2-e/t of waste
Calculation of Total Greenhouse Gas Emissions (t CO_2-e)	
Total greenhouse gas emissions (t CO_2-e)	$= 72 \times 0.50 \times 2.1$ = 75.06 t CO_2-e

4.3 Estimating emissions from wastewater treatment

Emissions from wastewater handling (domestic and commercial)

This section discusses emissions from domestic and commercial wastewater treatment and can be used by those who want to capture the emissions from a known number of people. Companies that own and operate wastewater treatment facilities and wish to calculate a scope 1 emissions estimate for this source, please refer to Chapter 5 – Part 5.3 of the National Greenhouse and Energy Reporting (Measurement) Determination 2008 for guidance.

Table 17 Emission factors by wastewater treatment type

Wastewater Treatment Method	Emission factors (t CO_2-e per person)
Managed aerobic treatment	-
Unmanaged aerobic treatment	0.1229
Anaerobic digester/reactor	0.3276
Anaerobic lagoon shallow (<2 metres)	0.0819
Anaerobic lagoon deep (>2 metres)	0.3276

Source: Derived from IPPC guidelines, see Appendix 5 for further details

Calculating emissions from domestic and commercial wastewater

The total quantity of wastewater treated depends on the population that is generating wastewater. The following formula should be used to estimate the emissions (in CO_2-e) from domestic wastewater treatment.

$$t\ CO_2\text{-}e = P \times EF$$

Where:

t CO_2-e is the emissions measured in CO_2-e tonnes.

P is the number of people in the population for which emissions are to be estimated.

EF is the emission factor for each wastewater treatment type according to Table 17.

Example 12 Calculation of emissions (t CO_2-e) from wastewater treatment

A local government area wishes to estimate the emissions from domestic wastewater treatment for a population of 20,000 people, where the treatment is an anaerobic deep lagoon. The emissions are estimated as follows:

$t\ CO_2\text{-}e = P \times EF$	
Where:	
P	= 20,000 people
EF as per Table 17	= 0.3276 t CO_2-e per person
Calculation of Total Greenhouse Gas Emissions (t CO_2-e)	
Total greenhouse gas emissions (t CO_2-e)	$= 20{,}000 \times 0.3276$ = 6,552 t CO_2-e

4.4 Estimating emissions from waste incineration

Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities. Types of waste incinerated include municipal solid waste, industrial waste, hazardous waste, clinical waste and sewage sludge, which are measured in tonnes.

Scope 3 emissions can be calculated with the scope 1 emission factors provided in Table 18, if for example, a company decides to report on emissions from an off-site incineration activity and has the necessary data. However, these emission factors are specific to the incineration activity and do not include the energy consumed in transporting waste off-site.

Table 18 Direct (scope 1) emission factors for the incineration of waste

Waste type	Emission factors (t CO_2-e/t)
Clinical Waste	0.879
Sewage Sludge	-
Fossil Liquid	2.931
Industrial Waste	1.649
Municipal Solid Waste	0.0537

Source: Derived from the NGER Measurement Determination 2008. See Appendix 5 for further details.

Emissions from the incineration of waste may be estimated according to the following formula.

$$t\ CO_2\text{-}e = Q \times EF$$

Where:
t CO_2-e is the emissions of carbon dioxide released from the incineration of waste type measured in CO_2-e tonnes.
Q is the quantity of waste type incinerated in tonnes of wet weight value.
EF is the scope 1 emissions factor in t CO_2-e/tonne of waste as per Table 18.

Example 13 Calculation of emissions (t CO_2-e) from waste incineration

A hospital wishes to estimate the emissions from incinerating 2 tonnes of clinical waste. Using default factors, the emissions are estimated as follows:

$t\ CO_2\text{-}e = Q \times EF$		
Where: Q EF as per Table 18	 = 2 tonnes of clinical waste = 0.879	
Calculation of Total Greenhouse Gas Emissions (t CO_2-e)		
Total greenhouse gas emissions (t CO_2-e)	$= 2 \times 0.879$	=1.758 t CO_2-e

4.5 Estimating emissions from the biological treatment of solid waste – composting and anaerobic digestion

Composting and anaerobic digestion of organic waste, such as food waste, garden and park waste and sludge are considered biological treatments of solid waste.

Anaerobic digestion of organic waste expedites the natural decomposition of organic material without oxygen by maintaining the temperature, moisture content and pH close to their optimum values. N_2O emissions from anaerobic digestion are assumed to be negligible.

Composting, on the other hand, is an aerobic (with oxygen) process and a large fraction of the degradable organic carbon in the waste material is converted into carbon dioxide (CO_2). CH_4 is formed in anaerobic sections of the compost, but it is oxidised to a large extent in the aerobic sections of the compost.

Table 19 Direct emission factors (scope 1) for biological treatment of waste

Waste treatment type	**Scope 1 emission factors (t CO_2-e/t)**
Composting	0.046
Anaerobic digestion	0.028

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008, see Appendix 5 for more details.

Emissions from the biological treatment of waste may be estimated according to the following formula:

$$t\ CO_2\text{-}e = (Q \times EF) - R$$

Where:
t CO_2-e is the emissions measured in CO_2-e tonnes
Q is the quantity of waste, measured in tonnes, being treated
EF is the scope 1 emissions factor in t CO_2-e/tonne of waste as per Table 19.
R is the total amount of CH_4 recovered in inventory year, tonnes CO_2-e. If unknown, assume zero.

Example 14 Calculation of emissions (t CO_2-e) from composting

A household has an open-air composting heap to which they contribute approximately 2.5 kg of food waste each week. Using default factors and no methane recovery, the emissions are estimated as follows:

$t\ CO_2\text{-}e = (Q \times EF) - R$		
Where:		
Q	52 weeks x 2.5 kg ÷ 1000 = 0.130 tonnes each year	
EF as per Table 19	= 0.046	
R	= 0.00	
Calculation of Total Greenhouse Gas Emissions (t CO_2-e)		
Total greenhouse gas emissions (t CO_2-e)	$= (0.130 \times 0.046) - 0$	= 0.006 t CO_2-e

5 Agriculture

Emissions in the Agriculture sector (IPCC Sector 3) arise from livestock, manure management and crop residue, as well as emissions from rice cultivation, application of nitrogen to soils, and burning of agricultural residues.

5.1 Greenhouse gas emissions from agriculture

Emissions of greenhouse gases are produced on agricultural lands as a result of a number of natural and human-induced processes. These include feed digestion by ruminant livestock, the decay or burning of biomass, the addition of nitrogen- and carbon-containing fertiliser and animal manure, crop residues returned to the soil, nitrogen leaching and runoff, atmospheric deposition, and the anaerobic decomposition of organic matter during flood irrigation.

The principal greenhouse gases estimated for agriculture are methane (CH_4) and nitrous oxide (N_2O). The main agricultural sources of CH_4 are the digestion of feed by livestock and manure management. The main agricultural source of N_2O is soils, primarily as a result of the use of nitrogen-based fertilisers on crops and pastures. Manure management is also a source of N_2O. Crop residue burning produces some CH_4 and N_2O, but CO_2 emissions are not estimated because it returns to the atmosphere what was recently removed during crop growth. CO_2 emissions associated with the application of lime and urea are also accounted for in agriculture.

5.2 Estimating agricultural emissions

State and national-level estimates of greenhouse gas emissions from agriculture are prepared using the methodology set out in the National Inventory Report. Organisations wishing to report emissions from their agricultural operations may draw on this national methodology to make indicative estimates but should note that the methodology uses available nationally-consistent activity data, and these are often regional averages not directly applicable to specific operations dependent on local conditions.

Note that emissions from other on-farm activities may be accounted for in other sections, such as:

- Vehicle fuel use (covered in Transport fuels).
- The burning of fuels in plant and equipment (covered in Stationary energy emissions).

6 Land Use, Land Use Change and Forestry

The Land Use, Land Use Change and Forestry (LULUCF) sector is IPCC sector 4. Emissions and sequestration in this sector arise from activities occurring on forest lands, forests converted to other land uses, grasslands, croplands, wetlands and settlements.

6.1 Greenhouse gas emissions from Land Use, Land Use Change and Forestry

This section covers the estimation of emissions and removals of CO_2 associated with activities that change the amount of carbon in the land sector. In the land sector, carbon can either be emitted to the atmosphere, or removed from the atmosphere and stored in plants and soil. Non-CO_2 emissions from biomass burning on managed lands is also included.

For example, this sector includes emissions from forest land remaining forest land and land converted to forest land (e.g. harvest and regeneration of native forests, establishment and harvest of plantations, wildfires and prescribed burning), including sinks from regrowing forest on previously cleared land, and carbon stored in harvested wood products and their disposal in landfill.

Another source of emissions in this sector is forest land converted to cropland, grassland, settlements and wetlands, including direct clearing-related emissions and delayed emissions from previous clearing, mainly through the gradual loss of soil carbon over a number of years.

6.2 Estimating Land Use, Land Use change and forestry emissions

The greenhouse accounts for Australia's land sector reporting use a wide range of spatial data, which include satellite monitoring of changes in land cover and weather records as well as on-ground measurements of trees and soil to calibrate the models. Based on this data, growth of trees and other plants and changes in soil are modelled to estimate carbon stock change and greenhouse gas emissions through time at a fine spatial scale. The model used for Australia's greenhouse accounts is the Full Carbon Accounting Model (FullCAM).

FullCAM simulates all carbon pools, which include living biomass (trees including roots, grass), dead organic matter and soil. The settings in FullCAM are informed by data on management, site, climate and species, which are drawn from resource inventories, field studies and remote sensing methods.

FullCAM is publicly available from the Department's website. The software provides the user with flexibility in entering species parameters and management events which influence carbon stock change. The target audience for the public version of FullCAM is emissions inventory experts, the scientific community, industry, and policy makers with an interest in land sector carbon reporting.

Glossary

Activity - A process that generates greenhouse gas emissions or uptake. In some sectors it refers to the level of energy consumption, production or manufacture for a given process or category or animal numbers.

Activity data - Source data from a generating activity, such as fuel usage and electricity consumption, and can be used to determine greenhouse gas emissions.

ANZSIC - The Australian and New Zealand Standard Industrial Classification (ANZSIC) is derived from international classifications (International Standard Industrial Classifications (ISIC)) and provides a framework for organising data about businesses - by enabling grouping of business units carrying out similar productive activities. The ANZSIC was developed by the Australian Bureau of Statistics (ABS) in collaboration with Statistics New Zealand.

Carbon dioxide equivalence (CO_2-e) - A standard measure that takes account of the global warming potential of different greenhouse gases and expresses the effect in a common unit.

Carbon inventory - A measure of the carbon dioxide equivalent emissions that are attributable to an activity. A carbon inventory can relate to the emissions of an individual, household, organisation, product, service, event, building or precinct. This can also be known as a carbon footprint or carbon account.

Carbon neutral - A situation where the net emissions associated with an activity are equal to zero because emissions have been reduced and offset units cancelled to fully account for all emissions.

Confidentiality - Data that is considered to be commercially sensitive. Confidential emissions are typically reported as an aggregated CO_2 equivalent value.

Emission factor - The quantity of greenhouse gases emitted per unit of some specified activity. Emission factors are used to convert a unit of activity into its emissions equivalent.
E.g. a factor that specifies the kilograms of CO_2-e emissions per unit of activity.

Emission Type - The release of a particular gas to the atmosphere as a result of a certain activity. Emissions can be one of the following four types:

- Generated - the gross result of a process or activity;
- Recovered - the capture of generated emissions for use in a secondary process, such as power generation;
- Sinks - a net gain in carbon stocks, such as those found in forests;
- Net emissions - the remaining gas released to the atmosphere after generation, recovery and sinks are taken into account. This is distinct from the emissions accounting concept of net emissions which are those after the application of offsets or other accounting units.

The most common data in the Australia's National Greenhouse Accounts are net estimates of emissions.

Emissions Projections - Emissions projections detail Australia's greenhouse emissions trends to 2035, analysing the factors driving emissions in each sector and estimating the effort needed to meet Australia's emissions reduction targets.

Emission Source - Any process or activity that releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere.

Energy content factor for a fuel, means gigajoules of energy per unit of the fuel measured as gross calorific value.

Gas - Rules adopted under the Paris Agreement require parties to report seven greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Emissions from these gases are aggregated into carbon dioxide equivalents (CO_2-e) using factors called global warming potentials (GWPs). The default setting for the system is to report emissions of the seven main classes of gases aggregated into a single CO_2-e estimate for each sector. Emissions of other, indirect gases, which cannot be aggregated because they do not have GWPs applied to them, are also reported individually. These gases include nitrogen oxides (NOx), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2).

Global Warming Potential (GWP) - Represents the relative warming effect of a unit mass of a greenhouse gas compared with the same mass of CO_2 over a specific period. Multiplying the actual amount of gas emitted by the GWP gives the CO_2-equivalent (CO_2-e) emissions. The GWPs used in the Paris Agreement inventory are from the IPCC Fifth Assessment Report (AR5), consistent with rules agreed under the Paris Agreement.

Oxidation factors is defined as the proportion of carbon contained in a fuel which is oxidised to CO_2. Oxidation factors for fuels used in stationary energy are consistent with the IPCC 2006 assumption of complete oxidation of carbon contained in fuel.

Appendix 1 Units and conversions

Table 20 Metric prefixes

Abbreviation	Prefix	Symbol	Multiplying factor
10^{15} (10^6x10^9)	peta (million billion [thousand trillion])	P	1,000,000,000,000,000
10^{12} (10^3x10^9)	tera (thousand billion [trillion])	T	1,000,000,000,000
10^9	giga (billion)	G	1,000,000,000
10^6	mega (million)	M	1,000,000
10^3	kilo (thousand)	k	1,000
10^2	hecto	h	100
10^1	deca	da	10
10^0	- (no prefix)	-	1
10^{-1}	deci	d	0.1
10^{-2}	centi	c	0.01
10^{-3}	milli	m	0.001
10^{-6}	micro	µ	0.000 000 1
10^{-9}	nano	n	0.000 000 000 1
10^{-12}	pico	p	0.000 000 000 000 1
10^{-15}	femto	f	0.000 000 000 000 000 1

Table 21 Energy conversion factors

Unit	Energy conversion factor
1 watt	= 1 joule/second
3600 watt-seconds	= 1 watt-hour (3600 seconds in one hour)
1 watt-hour	= 3600 joules
1000 watt-hours	= 1kilowatt hour (kWh)
1 kWh	= 3.6×10^6 joules = 3.6 MJ
1 kWh	= 3.6×10^{-3} GJ
1 GJ	= 278 kWh
1 PJ	= 278×10^6 kWh = 278 GWh

Example: For conversion from kWh to GJ multiply by 0.0036 and for conversion from GJ to kWh multiply by 277.778

Table 22 Unit equivalences

	grams (g)	**kilograms (kg)**	**tonnes (t)**	**kilotonnes (kt)**	**megatonne (Mt)**	**gigatonne (Gt)**
grams (g)	1 gram= 1 microtonne	1kilogram = 1,000 g	1 tonne = 1,000,000 g	1 kilotonne = 1,000,000,000 g	1 megatonne= 1,000,000,000 ,000 g	1 gigatonne = 1,000,000,000 ,000,000 g
kilograms (kg)	1 gram= 0.001 kg	1kilogram = 1 millitonne	1 tonne = 1,000 kg	1 kilotonne = 1,000,000 kg	1 megatonne= 1,000,000,000 kg	1 gigatonne = 1,000,000,000 ,000 kg
tonnes (t)	1 gram= 0.000 000 1 t	1kilogram = 0.001 t	1 tonne = 1 megagram	1 kilotonne = 1,000 t	1 megatonne= 1,000,000 t	1 gigatonne = 1,000,000,000 t
kilotonnes (kt)	1 gram= 0.000 000 000 1 kt	1kilogram = 0.000 000 1 kt	1 tonne = 0.001 kt	1 kilotonne = 1 gigagram	1 megatonne= 1,000 kt	1 gigatonne = 1,000,000 kt
megatonne (Mt)	1 gram= 0.000 000 000 000 1 Mt	1kilogram = 0.000 000 000 1 Mt	1 tonne = 0.000 000 1 Mt	1 kilotonne = 0.001 Mt	1 megatonne= 1 teragram	1 gigatonne = 1,000 Mt
gigatonne (Gt)	1 gram= 0.000 000 000 000 000 1 Gt	1kilogram = 0.000 000 000 000 1 Gt	1 tonne = 0.000 000 000 1 Gt	1 kilotonne = 0.000 000 1 Gt	1 megatonne= 0.001 Gt	1 gigatonne = 1 petagram

Appendix 2 Global Warming Potentials

Global Warming Potentials (GWPs) are used to convert masses of different greenhouse gases into a single carbon dioxide-equivalent metric (CO_2-e). This is done by multiplying the quantity of a gas by its GWP in Table 23 to convert relevant non-carbon dioxide gases to a carbon dioxide equivalent (CO_2-e). Multiplying a mass of a particular gas by its GWP, gives the mass of carbon dioxide emissions that would produce the same warming effect over a 100-year period.

Table 23 Global Warming Potentials[3]

Gas	Chemical formula	Global Warming Potential (AR5)
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265
Sulphur hexafluoride	SF_6	23,500
HFC-23 (R-23)	CHF_3	12,400
HFC-32 (R-32)	CH_2F_2	677
HFC-41 (R-41)	CH_3F	116
HFC-43-10mee (R-4310mee)	$C_5H_2F_{10}$	1,650
HFC-125 (R-125)	C_2HF_5	3,170
HFC-134 (R-134)	$C_2H_2F_4$ (CHF_2CHF_2)	1,120
HFC-134a (R-134a)	$C_2H_2F_4$ (CH_2FCF_3)	1,300
HFC-143 (R-143)	$C_2H_3F_3$ (CHF_2CH_2F)	328
HFC-143a (R-143a)	$C_2H_3F_3$ (CF_3CH_3)	4,800
HFC-152a (R-152a)	$C_2H_4F_2$ (CH_3CHF_2)	138
HFC-227ea (R-227ea)	C_3HF_7	3,350
HFC-236fa (R-236fa)	$C_3H_2F_6$	8,060
HFC-245ca (R-245ca)	$C_3H_3F_5$	716
HFC-245fa (R-245fa)	$CHF_2CH_2CF_3$	858
HFC-365mfc (R-365mfc)	$CH_3CF_2CH_2CF_3$	804
HCFC-22 (R-22)	$CHClF_2$	1760
HCFC-123 (R-123)	$CHCl2_2CF_3$	79
HCFC-124 (R-124)	$CHClFCF_3$	527
HCFC-141b (R-141b)	CH_3CCl_2F	782
HCFC-142b (R-142b)	CH_2CClF_2	1980
HCFC-225ca (R-225ca)	$CHCl_2CF_2CF_3$	127
HCFC-225cb (R-225cb)	$CHClFCF_2CClF_2$	525
PFC-14 Perfluoromethane (tetrafluoromethane)	CF_4	6,630
PFC-116 Perfluoroethane (hexafluoroethane)	C_2F_6	11,100
PFC-218 Perfluoropropane	C_3F_8	8,900
PFC-31-10 Perfluorobutane	C_4F_{10}	9,200
PFC-318 Perfluorocyclobutane	c-C_4F_8	9,540
PFC-41-12 Perfluoropentane	C_5F_{12}	8,550
PFC-51-14 Perfluorohexane	C_6F_{14}	7,910
PFC-91-18 Perflunafene	$C_{10}F_{18}$	7,190

Source: For more details of Global Warming Potentials see Chapter 8, Anthropogenic and Natural Radiative Forcing, Appendix 8.A, Table 8.A.1 (page 731) of the IPCC 5th Assessment Report.

[3] GWP values presented are not limited to gases reportable in national inventories and include Montreal Protocol gases.

Table 24 Blended refrigerants (many containing HFCS and/or PFCS)

Blend	Constituents	Composition (%)
R-400	CFC-12/CFC-114	R-400 can have various proportions of CFC-12 and CFC-114. The exact composition needs to be specified, e.g., R-400 (60/40).
R-401A	HCFC-22/HFC-152a/HCFC-124	(53.0/13.0/34.0)
R-401B	HCFC-22/HFC-152a/HCFC-124	(61.0/11.0/28.0)
R-401C	HCFC-22/HFC-152a/HCFC-124	(33.0/15.0/52.0)
R-402A	HFC-125/HC-290/HCFC-22	(60.0/2.0/38.0)
R-402B	HFC-125/HC-290/HCFC-22	(38.0/2.0/60.0)
R-403A	HC-290/HCFC-22/PFC-218	(5.0/75.0/20.0)
R-403B	HC-290/HCFC-22/PFC-218	(5.0/56.0/39.0)
R-404A	HFC-125/HFC-143a/HFC-134a	(44.0/52.0/4.0)
R-405A	HCFC-22/ HFC-152a/ HCFC142b/PFC-318	(45.0/7.0/5.5/42.5)
R-406A	HCFC-22/HC-600a/HCFC-142b	(55.0/14.0/41.0)
R-407A	HFC-32/HFC-125/HFC-134a	(20.0/40.0/40.0)
R-407B	HFC-32/HFC-125/HFC-134a	(10.0/70.0/20.0)
R-407C	HFC-32/HFC-125/HFC-134a	(23.0/25.0/52.0)
R-407D	HFC-32/HFC-125/HFC-134a	(15.0/15.0/70.0)
R-407E	HFC-32/HFC-125/HFC-134a	(25.0/15.0/60.0)
R-408A	HFC-125/HFC-143a/HCFC-22	(7.0/46.0/47.0)
R-409A	HCFC-22/HCFC-124/HCFC-142b	(60.0/25.0/15.0)
R-409B	HCFC-22/HCFC-124/HCFC-142b	(65.0/25.0/10.0)
R-410A	HFC-32/HFC-125	(50.0/50.0)
R-410B	HFC-32/HFC-125	(45.0/55.0)
R-411A	HC-1270/HCFC-22/HFC-152a	(1.5/87.5/11.0)
R-411B	HC-1270/HCFC-22/HFC-152a	(3.0/94.0/3.0)
R-411C	HC-1270/HCFC-22/HFC-152a	(3.0/95.5/1.5)
R-412A	HCFC-22/PFC-218/HCFC-142b	(70.0/5.0/25.0)
R-413A	PFC-218/HFC-134a/HC-600a	(9.0/88.0/3.0)
R-414A	HCFC-22/HCFC-124/HC-600a/HCFC-142b	(51.0/28.5/4.0/16.5)
R-414B	HCFC-22/HCFC-124/HC600a/HCFC-142b	(50.0/39.0/1.5/9.5)
R-415A	HCFC-22/HFC-152a	(82.0/18.0)
R-415B	HCFC-22/HFC-152a	(25.0/75.0)
R-416A	HFC-134a/HCFC-124/HC-600	(59.0/39.5/1.5)
R-417A	HFC-125/HFC-134a/HC-600	(46.6/50.0/3.4)
R-418A	HC-290/HCFC-22/HFC-152a	(1.5/96.0/2.5)
R-419A	HFC-125/HFC-134a/HE-E170	(77.0/19.0/4.0)
R-420A	HFC-134a/HCFC-142b	(88.0/12.0)
R-421A	HFC-125/HFC-134a	(58.0/42.0)
R-422A	HFC-125/HFC-134a/HC-600a	(85.1/11.5/3.4)
R-422B	HFC-125/HFC-134a/HC-600a	(55.0/42.0/3.0)
R-422C	HFC-125/HFC-134a/HC-600a	(82.0/15.0/3.0)
R-500	CFC-12/HFC-152a	(73.8/26.2)
R-501	HCFC-22/CFC-12	(75.0/25.0)
R-502	HCFC-22/CFC-115	(48.8/51.2)
R-503	HFC-23/CFC-13	(40.1/59.9)
R-504	HFC-32/CFC-115	(48.2/51.8)
R-505	CFC-12/HCFC-31	(78.0/22.0)
R-506	CFC-31/CFC-114	(55.1/44.9)
R-507A	HFC-125/HFC-143a	(50.0/50.0)
R-508A	HFC-23/PFC-116	(39.0/61.0)
R-508B	HFC-23/PFC-116	(46.0/54.0)
R-509A	HCFC-22/PFC-218	(44.0/56.0)

Source: Table 7.8, Chapter 7: Emissions of Fluorinated Substitutes for Ozone Depleting Substances, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Appendix 3 Methodology for calculating scope 3 greenhouse gas emissions from liquid and gaseous fuels

The methods used to develop scope 3 emission factors for liquid and gaseous fuels are consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) and are comparable with international practice.

Gaseous fuels

Scope 3 emissions factors for natural gas have been prepared by Wilkenfeld and Associates (2012) based on data collected under the *National Greenhouse and Energy Reporting (NGER) Act 2007*. Data associated with the following emission sources reported under the NGER Scheme were incorporated in the scope 3 factors:

Emission source	**Fuel combustion**	**Fugitive emissions**
Natural gas exploration	Included	Included
Natural gas production or processing	Included	Included
Natural gas transmission	Included	Included
Natural gas distribution	Included	Not included

Liquid fuels

Scope 3 emission factors for liquid stationary and transport fuels reflect the emissions associated with fuel produced locally and overseas. Of the petroleum products consumed in Australia, some are refined within Australia from crude oil, whereas others are refined overseas and then imported.

Over the past decade, local production of petroleum products has declined while imports have increased (Figure 1). The source countries for crude oil feedstock and refined products have also varied over time. These changes prompted a review of scope 3 factors for liquid fuels in 2022.

The scope 3 liquid fuel emission factors published in the National Greenhouse Accounts Factors are intended to represent 'well-to-pump' emissions.

The calculation method utilised in this analysis separately addresses the following seven components of Australia's well-to-pump liquid fuel emissions:

- Upstream (including all supply chain emissions prior to refining)
    - Crude oil extracted within Australia for use in Australian refineries
    - Crude oil extracted overseas for use in Australian refineries
    - Crude oil extracted within Australia for use in overseas refineries
    - Crude oil extracted overseas for use in overseas refineries
- Midstream (refining)
    - Refining of petroleum products within Australia
    - Refining of petroleum products overseas
- Downstream (distribution)
    - Shipping of refined petroleum products from overseas refineries to Australia.

For each component, volume-weighted emissions factors are calculated based on liquid fuel trade data and emission factors derived from Masnadi et al. (2018) and Jing et al. (2020). Full well-to-pump factors are then aggregated by taking the volume-weighted contribution of each of the seven components from well-to-pump. The calculated scope 3 liquid fuel emission factors for Australia range from 17.1 – 20.2 kg CO_2-e/GJ, with an average of 18.0 kg CO_2-e/GJ. These values are of a similar magnitude to those published in international emissions databases and academic literature as shown in Figure 2.

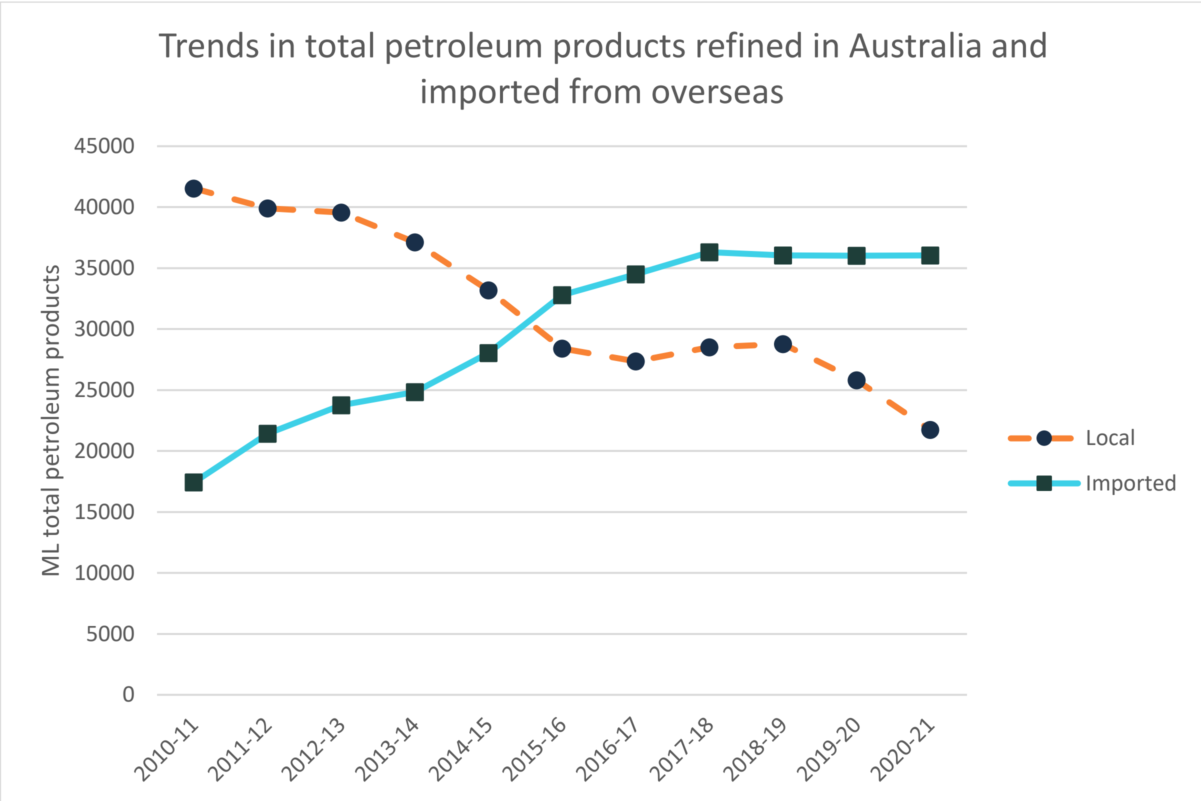

Figure 1 Imported and Local petroleum products

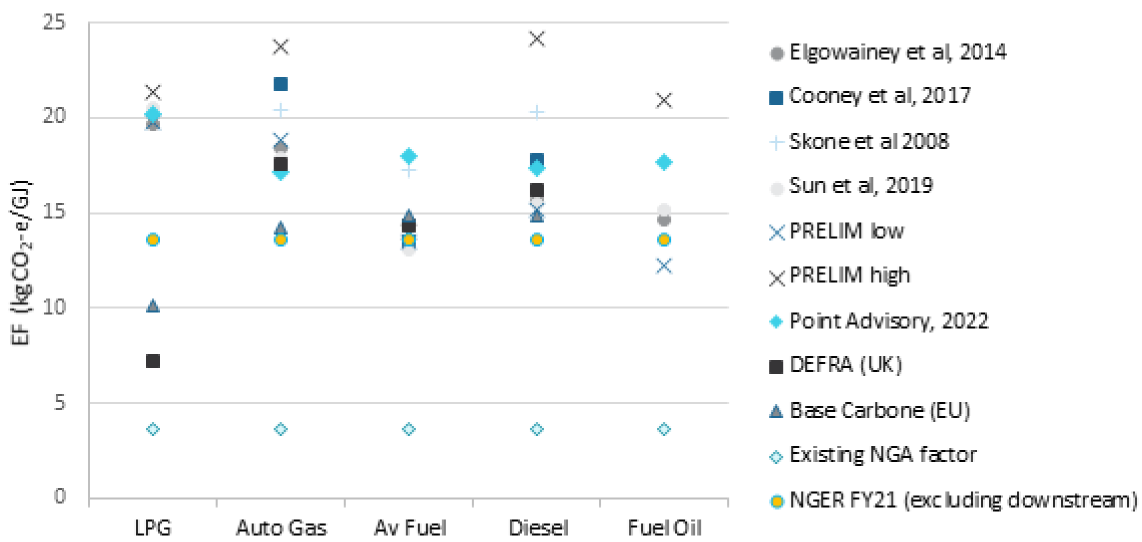

Figure 2 Emission factors in international databases and academic literature

Data for Figure 2.

LPG

Reference	Midstream EF	Total EF
Elgowainey et al, 2014	6.6	19.6
Sun et al, 2019	7.5	20.5
PRELIM low	6.7	19.7
PRELIM high	8.3	21.3
DEFRA (UK)		7.2
Base Carbone (EU)		10.1
Point Advisory, 2022	7.2	20.2
Existing NGA factor		3.6
NGER FY21 (excluding downstream)		13.6

Automotive gasoline

Reference	Midstream EF	Total EF
Elgowainey et al, 2014	7.8	18.4
Cooney et al, 2017	11.2	21.8
Skone et al 2008	9.8	20.4
Sun et al, 2019	7.3	17.9
PRELIM low	8.3	18.9
PRELIM high	13.2	23.8
DEFRA (UK)		17.6
Base Carbone (EU)		14.2
Point Advisory, 2022	6.6	17.2

Aviation turbine fuel

Reference	Midstream EF	Total EF
Elgowainey et al, 2014	2.3	13.5
Cooney et al, 2017	2.3	13.5
Skone et al 2008	6.0	17.2
Sun et al, 2019	1.9	13.1
PRELIM low	2.3	13.5
PRELIM high	2.8	14.0
DEFRA (UK)		14.3
Base Carbone (EU)		14.9
Point Advisory, 2022	6.8	18.0

Diesel

Reference	Midstream EF	Total EF
Elgowainey et al, 2014	4.9	15.6
Cooney et al, 2017	7.0	17.7
Skone et al 2008	9.5	20.2
Sun et al, 2019	4.7	15.4
PRELIM low	4.4	15.1
PRELIM high	13.4	24.1

DEFRA (UK)		16.2
Base Carbone (EU)		14.9
Point Advisory, 2022	6.6	17.3

Fuel oil

Reference	Midstream EF	Total EF
Elgowainey et al, 2014	3.4	14.2
Sun et al, 2019	3.9	14.7
PRELIM low	0.9	11.7
PRELIM high	9.6	20.4
Point Advisory, 2022	6.4	17.1
Existing NGA factor		3.6
NGER derived (excluding downstream)		13.6
Elgowainey et al, 2014	3.4	14.2
Sun et al, 2019	3.9	14.7

References

- Masnadi, Mohammad S. & El-Houjeiri, Hassan & Schunack, Dominik & Li, Yunpo & Englander, Jacob & Badahdah, Alhassan & Monfort, Jean-Christophe & Anderson, James & Wallington, Timothy & Bergerson, Joule & Gordon, Deborah & Koomey, Jonathan & Przesmitzki, Steven & Azevedo, Inês & Bi, Xiaotao & Duffy, James & Heath, Garvin & Keoleian, Gregory & McGlade, Christophe & Brandt, Adam. (2018). Global carbon intensity of crude oil production. Science. 361. 851-853. 10.1126/science.aar6859.
- Jing, Liang & El-Houjeiri, Hassan & Monfort, Jean-Christophe & Brandt, Adam & Masnadi, Mohammad S. & Gordon, Deborah & Bergerson, Joule. (2020). Carbon intensity of global crude oil refining and mitigation potential.
  Nature Climate Change. 10. 1-7. 10.1038/s41558-020-0775-3.

Appendix 4 Methodology for calculating electricity emission factors

Scope 2 emissions result from purchased or acquired electricity from the grid. The emission factor for scope 2 is defined in terms of energy sent out to the grid rather than energy delivered. There are additional emissions that are attributable to the electricity lost in transmission and distribution which form a component of the scope 3 emission factor.

Scope 2 data inputs

The Scope 2 emission factor and residual mix factor for the methods outlined in section 2.2 of this report rely on the following data inputs:

- Greenhouse gas emissions from fossil fuels from NGER for the latest reporting period (on a financial year basis) - including state-based data and the physical characteristics of the electricity supply and demand.
- Interstate trade of electricity from AEMO (sourced through the NEM-Review tool) for the same time period as the NGER emissions data.
- Renewable generation from wind, hydro, large scale solar, and small scale solar (residential and commercial rooftops) data from AEMO (sourced through the NEM-Review software tool) for the same time period as the NGER emissions data.
- Emissions of methane from water reservoirs used for hydroelectricity generation.
- Biofuels calculated using Large-Scale Generation Certificate creations in the Renewable Energy Certificate Register.

Note that some state-based claims are made using market-based methods, such as the Australian Capital Territory which ensures electricity emissions are zero through its 100% renewable electricity commitment from 2020. The Renewable electricity supply in the ACT is calculated based on the *Climate Change and Greenhouse Gas Reduction (Renewable Electricity Target Measurement Method) Determination 2020*.

Care should be taken when comparing such claims to location-based factors – both approaches are equally valid, but not necessarily comparable.

Self-consumption

In calculating the scope 2 emission factors, the department excludes electricity generated by a facility that is consumed on site rather than sent to the grid.

Rooftop small solar generation which is self-consumed 'behind the meter' is calculated at the national level and is estimated to be 47%, with the remainder (53%) assumed to be sent to the grid. This self-consumption has been deducted from the estimated amount of generation from small solar used to calculate both the location-based method emission factors and the market-based method's residual mix factor (RMF). The estimate of rooftop solar self-consumption for Australia has been taken from a peer-reviewed paper, Mckenna et al (2019). The estimate of small solar self-consumption cited in McKenna et al (2019) is consistent with sampled data which the Department extracted from PVoutput.org. The Department will update this estimate in future as this independent dataset grows or other data becomes available.

Residual Mix Factor for the market-based method

Under the market-based method, the national location-based scope 2 emission factor is adjusted to remove the emissions benefit of all claimable renewable generation through LGCs to produce a RMF. This data comes from the Renewable Energy Certificate (REC) Registry.

LGCs are created on a calendar year basis and may be created up to 12 months after the date of generation. As the factors provided in this workbook are on a financial year basis, a lag percentage is introduced into the calculation to estimate how many LGCs are created after the 6 months covering the date range of the other data inputs. This lag adjustment uses a 3-year average of these "lagged" LGC creations.

To calculate the RMF, LGC creations are deducted from electricity generation sent to the grid. The RMF is calculated at the national aggregate level as the LGC market covers all networks and creations can be made from off-grid generation.

Method for calculating the Residual Mix Factor

The RMF is calculated by the Department on the same annual cycle as the location-based method scope 2 emission factors. The calculation method is described below:

$$RMF = E / (Q - (REC \times 1000))$$

Where:

RMF is the residual mix factor for the financial year, measured in kilograms of CO_2-e per MWh.

E is emissions from on-grid generation based on NGER reports for the preceding reporting year, measured in tonnes CO_2-e. Emissions associated with cogeneration facilities and those whose primary purpose for electricity is for self-use and not for the grid (for example a self-generating alumina refinery) are pro-rated based on the proportion of the amount of total generation and that which is sent to the grid, as reported under NGER. ***E*** includes methane emissions from hydro generation dams (defined as a human-made structure built to contain and control a body of water and used to generate hydroelectricity) based on the method applied in the National Greenhouse Gas Inventory.

Q is electricity generation sent out to the grid, measured in kWh, excluding distributed small-scale solar self-consumption. Generation data is from NGER reports and Australian Energy Market Operator data sourced through the NEMReview software package both for the preceding reporting year.

REC is LGC creations for generation which occurred in the same financial year as ***E*** and ***Q***, measured in MWh, and is based on data provided by the CER from the REC Registry.

Notes:

- Grids are the National Electricity Market (NEM), South-West Interconnected System (SWIS), and the Darwin, Katherine Interconnected System (DKIS)

Transmission and distribution network operators

Companies that own or control transmission and distribution networks report their transmission and distribution loss emissions under scope 2. This follows the GHG Protocol guidance that scope 2 emissions be reported by the organisation owning or controlling the plant or equipment where the electricity is consumed.

Scope 3 emission factors for transmission and distribution network operators include only emissions attributable to the extraction, production and transport of fuels and not emissions attributable to the electricity lost in transmission and distribution networks. These factors, in kg CO_2-e/kWh are shown in Table 25.

Table 25 Transmission and distribution losses

State, Territory or grid description	**Transmission and distribution losses kg CO_2-e/kWh**
New South Wales and Australian Capital Territory	0.02
Victoria	0.08
Queensland	0.06
South Australia	0.02
Western Australia - South-West Interconnected System (SWIS)	0.04
Tasmania	0.02
Northern territory - Darwin Katherine Interconnected System (DKIS)	0.03
Western Australia – North-Western Interconnected System (NWIS)	0.05

Calculating Scope 2 emission factors for electricity

The emission factor at generation (EFG scope2^t_i) is used to calculate scope 2 emissions and is defined for state *i* and financial year *t*. For the market-based method RMF estimation, all inputs are aggregated to the national level.

$$EFG\ scope2_i^t = \frac{Combustion\ emissions\ from\ electricity\ consumed\ from\ the\ grid\ in\ state\ i\ \left(CE_{C_i^t}\right)}{Electricity\ sent\ out\ consumed\ from\ the\ grid\ in\ state\ i\ \left(ESO_{C_i^t}\right)}$$

Where:

'Combustion emissions from electricity consumed from the grid in state *i*' ($CE\_C^t_i$) and 'energy sent out consumed from the grid in state *i*' ($ESO\_C^t_i$) are defined in terms of the state's electricity grid generation, imports and exports as follows:

$$CE\_C_i^t = CE\_P_i^t + \sum^{j}\left(\frac{ESO\_M_{j,i}^t}{ESO\_P_j^t} \times CE\_P_j^t\right) - \sum^{k}\left(\frac{ESO\_X_{i,k}^t}{ESO\_P_i^t} \times CE\_P_i^t\right)$$

$$ESO\_C_i^t = ESO\_P_i^t + \sum^{j} ESO\_M_{j,i}^t - \sum^{k} ESO\_X_{i,k}^t$$

Where:

$CE\_P^t_i$ is the total CO_2-e emissions from fuel combustion for generation attributed to the electricity generated/produced for the grid in state *i* in financial year *t*.
$CE\_P^t_j$ is the total CO_2-e emissions from fuel combustion for generation attributed to the electricity generated for the grid in state *j* in financial year *t*.

$\mathbf{ESO\_M}^{t}_{j,i}$ is the imports of energy sent out from state *j* to state *i* in financial year *t*. Imports are calculated from the interregional flows of electricity across the interconnectors.
$\mathbf{ESO\_X}^{t}_{i,k}$ is the exports of energy sent out from state *i* to state *k* in financial year *t*. Exports are calculated from the inter-regional flows of electricity across the interconnectors.
$\mathbf{ESO\_P}^{t}_{j}$ is the total energy sent out on the grid that is generated within state *j* in financial year *t*.
$\mathbf{ESO\_P}^{t}_{i}$ is the total energy sent out on the grid that is generated within state *i* in financial year *t*.

Note:

- The estimated electricity emission factors have been aligned with the definitions used in The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard of the World Resources Institute/World Business Council for Sustainable Development (the GHG Protocol).

Appendix 5 Methodology for calculating greenhouse gas emissions from waste

Calculating emission factors for wastewater treatment

Table 26 Simplification of emissions equations for wastewater treatment methods

Wastewater Treatment Method	Methane correction factor (*MCFw*)	Default Chemical Oxygen Demand (t/person/ year) (*DCw*)	Default methane emissions in wastewater (t CO_2-e/t COD) (*EFw*)	Emission factor (t CO_2-e/person) (*EF*)
Managed aerobic treatment	0	0.0585	7	-
Unmanaged aerobic treatment	0.3	0.0585	7	0.1229
Anaerobic digester/reactor	0.8	0.0585	7	0.3276
Anaerobic lagoon shallow (<2 metres)	0.2	0.0585	7	0.0819
Anaerobic lagoon deep (>2 metres)	0.8	0.0585	7	0.3276

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008, Section 5.25, Chapter 5, Part 5.3, Division 5.3.2

Note: Emission factors constructed using $\boldsymbol{EF = DCw \times EFw \times MCFw}$

Calculating emission factors for waste incineration

Table 27 Simplification of emissions equations for waste incineration

Waste Type	Carbon Content (*CC*)	Fossil Origin (*FCC*)	Default Oxidation Factor (*OF*)	Convert to t CO_2-e	Emission factor t CO_2-e (*EF*)
Clinical Waste	0.6	0.4	1	3.667	0.88
Sewage Sludge	0.5	-	1	3.667	-
Fossil Liquid	0.8	1.0	1	3.667	2.93
Industrial Waste	0.5	0.9	1	3.667	1.65

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008, Section 5.51, Chapter 5, Part 5.5, and Section 5.4.1 Volume 5, Chapter 5 2006 IPCC guidelines.

Note: Emission factors constructed using $\boldsymbol{EF = CC_i \times FCC_i \times OF_i \times 3.667}$

Table 28 Simplification of emissions equations for waste incineration - municipal waste

Waste types in the Municipal Solid Waste broad stream	Proportion of waste stream (%)	Carbon Content (*CC*)	Fossil Origin (*FCC*)	Default Oxidation Factor (*OF*)	Convert to CO_2	Weighted Emission factor t CO_2-e (*EF*)

Food	35.0%	38%	0%	1	3.667	-
Paper	13.0%	46%	1%	1	3.667	0.0022
Garden and Green	16.5%	49%	0%	1	3.667	-
Wood	1.0%	50%	0%	1	3.667	-
Textiles	1.5%	50%	20%	1	3.667	0.0055
Sludge	0.0%	50%	0%	1	3.667	-
Nappies	4.0%	70%	10%	1	3.667	0.0103
Rubber and Leather	1.0%	67%	20%	1	3.667	0.0049
Other	28.0%	3%	100%	1	3.667	0.0308

Weighted Emission factor t CO_2-e = 0.0537

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008, Section 5.11, Chapter 5, Part 5.2, division 5.2.2 and Section 2.3.1 Volume 5, Chapter 2 2006 IPCC guidelines.

Note: Municipal solid waste incineration emission factor constructed using $\boldsymbol{EF} = \% \times \boldsymbol{CC_i} \times \boldsymbol{FCC_i} \times \boldsymbol{OF_i} \times \mathbf{3.667}$

Calculating emission factors for the biological treatment of waste

Table 29 Simplification of emissions equations for biological treatment of waste

Biological treatment type	CH_4 emission factor (CO_2-e)	N_2O emission factor (CO_2-e)	Scope 1 emission factor (CO_2-e)
Composting	0.021	0.025	0.046
Anaerobic Digestion	0.028	0	0.028

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008, Section 5.22, Chapter 5 Waste, Part 5.2, Division 5.2.6

Note: Emission factors constructed using $\boldsymbol{EF} = \boldsymbol{CH_4\ EF} + \boldsymbol{N_2O\ EF}$

Table 30 Simplification of emissions equations for solid waste disposal

Variable	Description and default values
Q (Activity)	Quantity of municipal solid waste expressed in tonnes and sourced from waste records or contractor invoices.
DOC	Degradable Organic Carbon expressed as a proportion of the particular waste type with default values as follows: • Food – 0.15 • Paper and cardboard – 0.4 • Garden and green – 0.2 • Wood – 0.43 • Textiles – 0.24 • Sludge – 0.05 • Nappies – 0.24 • Rubber and leather – 0.39 • Inert waste (including concrete/metal/plastics/glass) - 0 Alternative waste treatment residues – 0.08

DOC_F	Fraction of Degradable Organic Carbon dissimilated for the waste type produced with default values as follows: • Food – 0.84 • Paper and cardboard – 0.49 • Garden and green – 0.47 • Wood – 0.10 • Textiles – 0.5 • Sludge – 0.5 • Nappies – 0.5 • Rubber and leather – 0.5 • Inert waste, including concrete, metal, plastic and glass – 0.0 Alternative waste treatment residues – 0.5
F_1	Methane fraction of landfill gas which has a default value of 0.50.
1.336	Conversion rate of carbon to methane.
R	The quantity of recovered methane during the year, measured and expressed in tonnes. **Note:** Emission factors in Table 15 do not take into account any landfill gas capture occurring at the landfill. If measured, recovered methane must be subtracted from methane generated before applying the oxidation factor. Only the landfill gas that is not captured is subject to oxidation.
OX	Oxidation factor which has a default value of 0.1 for covered, well-managed landfills (and a value of 0 for uncovered landfills).
28	CH_4 global warming potential used to convert the quantity of methane emitted to CO_2-e from the quantity of waste produced.

Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008, Section 5.4, Chapter 5, Part 5.2, Division 5.2.2

Appendix 6 Further Information

Programs and initiatives	Additional Information
Clean Energy Regulator	The Clean Energy Regulator (CER) is an Australian independent statutory authority responsible for implementing legislation to reduce carbon emissions and increase the use of clean energy. The CER manages the Large-Scale Renewable Energy Target, which aims to incentivise the development of renewable energy power stations by meeting the annual target for renewable electricity set out in the Renewable Energy (Electricity) Act 2000 (the Act). The annual target increased each year until 2020 and is now constant at 33,000,000 megawatt hours (MWh) to 2030. The Renewable Power Percentage used in scope 2 market-based method, is determined from the target of renewable energy and total acquisitions.
Climate Active	Climate Active is an ongoing partnership between the Australian Government and Australian businesses to drive voluntary climate action. Climate Active certifies business that have credibly reached a state of carbon neutrality by measuring, reducing and offsetting their carbon emissions. Certification is available for business operations, products and services, buildings, events and precincts. You can find Certified Brands on the Climate Active website. The Tools and Resource section contains the Climate Active Standards, technical guidance, and other useful links and guidance for estimating emissions.
Green Vehicle Guide (GVG)	The GVG helps consumers by providing user friendly tools to search for and compare the environmental performance and fuel consumption of new light vehicles (up to 3.5 tonnes gross vehicle mass) sold in Australia since 2004. It uses the CO_2 emissions values for each light vehicle as the key measure for ranking and comparing all light vehicles
Energy.gov.au	Energy.gov.au provides a starting point for energy information from a range of Australian Government sources. It provides information and advice for householders and businesses as well as explaining Australian Government energy programs and priorities.
Equipment Energy Efficiency (E3) program	The E3 Program helps improve the energy efficiency of a range of appliances and equipment. It is a shared initiative of the Australian Government, states and territories and the New Zealand Government. The program sets out the minimum energy efficiency standards and energy rating labelling requirements for products like fridges, dishwashers, TV's and more. By choosing more efficient models, households and businesses can consume less energy, save money on their energy bills, and help to reduce greenhouse gas emissions.
Your Home	Your Home is Australia's independent guide to designing, building or renovating homes to ensure they are energy efficient, comfortable, affordable and adaptable for the future.
Nationwide House Energy Rating Scheme (NatHERS)	NatHERS measures a home's energy efficiency to generate a star rating. The higher the star rating, the less energy needed to heat and cool the home to keep it comfortable. NatHERS Assessors currently use the house plans and building specifications of a home to input data into a NatHERS accredited software tool. NatHERS tools estimate the amount of heat that needs to be added or removed to keep that home comfortable. The NatHERS tools then generate a NatHERS star rating out of 10 and a Certificate. This star rating

	measures the home's thermal performance, based on its structure, design and materials.
National Australian Building Environment Ratings System (NABERS)	NABERS is a national rating system that measures the environmental performance of Australian buildings and tenancies. NABERS measures the energy efficiency, water usage, waste management and indoor environment quality of a building or tenancy and its impact on the environment.

Appendix 7 NGER legislative amendments for the 2024–25 reporting year

Amendments have been made to the National Greenhouse and Energy Reporting (NGER) scheme legislation. Public consultation took place from 29 April 2024 to 24 May 2024. These amendments:

- introduce a staggered phase out of the use of Method 1 for estimating fugitive methane emissions from the extraction of coal from open-cut mines covered by the Safeguard Mechanism from 1 July 2025.
- add a Method 2B for the estimation of fugitive methane and carbon dioxide emissions from flaring of gas in natural gas production, providing a mass balance approach.
- update Method 2 for the estimation of fugitive methane emissions from produced formation water occurring in oil or gas operations, to reflect onsite operations where the water has not been exposed to atmosphere and where facilities capture and recycle methane back into the gathering line rather than allowing it to dissolve into the resource pond and leak into the atmosphere.
- correct the categorisation of specified instances of Method 1 for estimating emissions of methane from natural gas venting activities that are consistent with Method 2 requirements.
- update Method 2 for the estimation of fugitive emissions of greenhouse gases from the injection of a greenhouse gas into a geological formation to align with Method 2 for onshore natural gas production.
- reinstate a method for estimating emissions of methane from mud de-gassing activities during oil or gas exploration and development.
- enable the market-based reporting of scope 1 emissions from renewable liquid fuels when they are co-mingled with their fossil fuel equivalents and supplied through shared infrastructure.
- enable identification of circumstances in which there exists and overlap between a company's reported scope 1 and scope 2 emissions.
- introduce a reporting requirement for landfills reporting over 100 kilotonnes of carbon dioxide equivalent to provide an estimate of gross emissions from non-legacy waste.

More information is available on the Clean Energy Regulator Measurement Determination webpage.

These amendments took effect on 1 July 2024 and affect reports due by 31 October 2025 for the 2024–25 reporting year.

For additional information, please contact the Clean Energy Regulator.