Suggestions for updating the Product Environmental Footprint (PEF) method

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2019

This JRC technical report is a working document and does not modify Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations

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Foreword

This report represents the outcome of the Administrative Arrangement (No 33446-2013-11 07.0307/ENV/2013/SI2.668694/A1) between the Directorate General for the Environment (DG ENV) and the Joint Research Centre (JRC). Task 5 consisted in taking into account the learnings from the Environmental Footprint pilot phase, organised by the European Commission in the period 2013-18. The information and views set out in this report are those of the author(s) and do not necessarily reflect the official opinion of the Commission

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Abstract

The Product Environmental Footprint (PEF) is a life cycle assessment (LCA) based method to quantify the environmental impacts of products (goods or services). It builds on existing approaches and international standards. The overarching purpose of PEF information is to enable to reduce the environmental impacts of goods and services taking into account supply chain activities (from extraction of raw materials, through production and use and to final waste management). This purpose is achieved through the provision of detailed requirements for modelling the environmental impacts of the flows of material/energy and the emissions and waste streams associated with a product throughout its life cycle.

The rules provided in the PEF method enable to conduct PEF studies that are more reproducible, comparable and verifiable, compared to existing alternative approaches. However, comparability is only possible if the results are based on the same Product Environmental Footprint Category Rules (PEFCR). The development of PEFCRs complements and further specifies the requirements for PEF studies.

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Terminology: shall, should, may

The PEF method uses precise terminology to indicate the requirements, the recommendations and options that the user of the PEF method may choose.

The term "shall" is used to indicate what is required in order for a PEF study to be in conformance with the PEF method.

The term "should" is used to indicate a recommendation rather than a requirement. Any deviation from a "should" requirement has to be justified by the user of the PEF method and made transparent.

The term "may" is used to indicate an option that is permissible without further justification.

List of acronyms

ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie
AF	allocation factor
AR	allocation ratio
B2B	business to business
B2C	business to consumer
BoC	bill of components
BoM	bill of materials
BP	bonne practique
BSI	British Standards Institution
CF	characterization factor
CFCs	Chlorofluorocarbons
CFF	Circular Footprint Formula
CPA	Classification of Products by Activity
DC	distribution centre
DMI	dry matter intake
DNM	Data Needs Matrix
DQR	Data Quality Rating
EC	European Commission
EF	Environmental Footprint
EI	environmental impact
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management Systems
EoL	End of life
EPD	Environmental Product Declaration
FU	functional unit
GE	gross energy intake
GHG	greenhouse gas
GR	geographical representativeness
GRI	Global Reporting Initiative
GWP	global warming potential
ILCD	International Reference Life Cycle Data System
ILCD-EL	International Reference Life Cycle Data System – Entry Level
IPCC	Intergovernmental Panel on Climate Change
ISIC	international standard industrial classification
ISO	International Organisation for Standardisation
IUCN	International Union for Conservation of Nature and Natural Resources
JRC	Joint Research Centre

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LCA	Life Cycle Assessment
LCDN	Life Cycle Data Network
LCI	life cycle inventory
LCIA	life cycle impact assessment
LCT	life cycle thinking
LT	lifetime
NACE	Nomenclature Générale des Activités Economiques dans les Communautés Européennes
NDA	non-disclosure agreement
NGO	non-governmental organisation
NMVOC	non-methane volatile compounds
P	precision
PAS	Publicly Available Specification
PCR	Product Category Rules
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PEF-RP	PEF study of the representative product
RF	reference flow
RP	representative product
SB	system boundary
SMRS	sustainability measurement & reporting system
SS	supporting study
TeR	technological representativeness
TiR	time representativeness
TS	Technical Secretariat
UNEP	United Nations Environment Programme
UUID	Universally Unique Identifier
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Definitions

Activity data - This term refers to information which is associated with processes while modelling Life Cycle Inventories (LCI). The aggregated LCI results of the process chains that represent the activities of a process are each multiplied by the corresponding activity data[1] and then combined to derive the environmental footprint associated with that process. Examples of activity data include quantity of kilowatt-hours of electricity used, quantity of fuel used, output of a process (e.g. waste), number of hours equipment is operated, distance travelled, floor area of a building, etc. Synonym of "non-elementary flow.

Acidification – EF impact category that addresses impacts due to acidifying substances in the environment. Emissions of NO_x, NH_3 and SO_x lead to releases of hydrogen ions (H^+) when the gases are mineralised. The protons contribute to the acidification of soils and water when they are released in areas where the buffering capacity is low, resulting in forest decline and lake acidification.

Additional environmental information – Environmental information outside the EF impact categories that is calculated and communicated alongside PEF results.

Additional technical information – Non-environmental information that is calculated and communicated alongside PEF results.

Aggregated dataset - Complete or partial life cycle of a product system that next to the elementary flows (and possibly not relevant amounts of waste flows and radioactive wastes) lists in the input/output list exclusively the product(s) of the process as reference flow(s), but no other goods or services. Aggregated datasets are also called "LCI results" datasets. The aggregated dataset may have been aggregated horizontally and/or vertically.

Allocation – An approach to solving multi-functionality problems. It refers to "partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems" (ISO 14040:2006).

Application specific – It refers to the generic aspect of the specific application in which a material is used. For example, the average recycling rate of PET in bottles.

Attributional – Refers to process-based modelling intended to provide a static representation of average conditions, excluding market-mediated effects.

Average Data – Refers to a production-weighted average of specific data.

Background processes – Refers to those processes in the product life cycle for which no direct access to information is possible. For example, most of the upstream life-cycle processes and generally all processes further downstream will be considered part of the background processes.

Benchmark – A standard or point of reference against which any comparison may be made. In the context of PEF, the term 'benchmark' refers to the <u>average</u> environmental performance of the representative product sold in the EU market.

Bill of materials – A bill of materials or product structure (sometimes bill of material, BOM or associated list) is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture the product in scope of the PEF study. In some sectors it is equivalent to the bill of components.

Business to Business (B2B) – Describes transactions between businesses, such as between a manufacturer and a wholesaler, or between a wholesaler and a retailer.

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[1] Based on GHG protocol scope 3 definition from the <u>Corporate Accounting and Reporting Standard</u> (World resources institute, 2011).

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Business to Consumers (B2C) – Describes transactions between business and consumers, such as between retailers and consumers. According to ISO 14025:2006, a consumer is defined as "an individual member of the general public purchasing or using goods, property or services for private purposes".

Characterisation – Calculation of the magnitude of the contribution of each classified input/output to their respective EF impact categories, and aggregation of contributions within each category. This requires a linear multiplication of the inventory data with characterisation factors for each substance and EF impact category of concern. For example, with respect to the EF impact category "climate change", CO_2 is chosen as the reference substance and kg CO_2-equivalents as the reference unit.

Characterisation factor – Factor derived from a characterisation model which is applied to convert an assigned life cycle inventory result to the common unit of the EF impact category indicator (based on ISO 14040:2006).

Classification – Assigning the material/energy inputs and outputs tabulated in the life cycle inventory to EF impact categories according to each substance's potential to contribute to each of the EF impact categories considered.

Climate change - All inputs or outputs that result in greenhouse gas emissions. The consequences include increased average global temperatures and sudden regional climatic changes. Climate change is an impact affecting the environment on a global scale.

Co-function - Any of two or more functions resulting from the same unit process or product system.

Commissioner of the EF study - Organisation (or group of organisations) that finances the EF study in accordance with the PEF method and the relevant PEFCR, if available (definition adapted from ISO 14071/2014, point 3.4).

Company-specific data – It refers to directly measured or collected data from one or multiple facilities (site-specific data) that are representative for the activities of the company. It is synonymous to "primary data". To determine the level of representativeness a sampling procedure may be applied.

Company-specific dataset – It refers to a dataset (disaggregated or aggregated) compiled with company-specific data. In most cases the activity data is company-specific while the underlying sub-processes are datasets derived from background databases.

Comparative Assertion – An environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function (including the benchmark of the product category) (adapted from ISO 14044:2006).

Comparison – A comparison, not including a comparative assertion, (graphic or otherwise) of two or more products based on the results of a PEF study and supporting PEFCRs.

Co-product – Any of two or more products resulting from the same unit process or product system (ISO 14040:2006).

Cradle to Gate – A partial product supply chain, from the extraction of raw materials (cradle) up to the manufacturer's "gate". The distribution, storage, use stage and end of life stages of the supply chain are omitted.

Cradle to Grave – A product's life cycle that includes raw material extraction, processing, distribution, storage, use, and disposal or recycling stages. All relevant inputs and outputs are considered for all of the stages of the life cycle.

Critical review – Process intended to ensure consistency between a PEFCR and the principles and requirements of the PEF method.

Data Quality – Characteristics of data that relate to their ability to satisfy stated requirements (ISO 14040:2006). Data quality covers various aspects, such as

technological, geographical and time-related representativeness, as well as completeness and precision of the inventory data.

Data Quality Rating (DQR) - Semi-quantitative assessment of the quality criteria of a dataset based on Technological representativeness, Geographical representativeness, Time-related representativeness, and Precision. The data quality shall be considered as the quality of the dataset as documented.

Delayed emissions - Emissions that are released over time, e.g. through long use or final disposal stages, versus a single emission at time t.

Direct elementary flows (also named elementary flows) – All output emissions and input resource use that arise directly in the context of a process. Examples are emissions from a chemical process, or fugitive emissions from a boiler directly onsite.

Direct land use change (dLUC) – The transformation from one land use type into another, which takes place in a unique land area and does not lead to a change in another system.

Directly attributable – Refers to a process, activity or impact occurring within the defined system boundary.

Disaggregation – The process that breaks down an aggregated dataset into smaller unit process datasets (horizontal or vertical). The disaggregation may help making data more specific. The process of disaggregation should never compromise or threat to compromise the quality and consistency of the original aggregated dataset

Downstream – Occurring along a product supply chain after the point of referral.

Ecotoxicity, freshwater – Environmental footprint impact category that addresses the toxic impacts on an ecosystem, which damage individual species and change the structure and function of the ecosystem. Ecotoxicity is a result of a variety of different toxicological mechanisms caused by the release of substances with a direct effect on the health of the ecosystem.

EF communication vehicles – It includes all the possible ways that may be used to communicate the results of the EF study to the stakeholders (e.g. labels, environmental product declarations, green claims, websites, infographics, etc.).

EF compliant dataset – Dataset developed in compliance with the EF requirements provided at http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml.

Electricity tracking[2] – Electricity tracking is the process of assigning electricity generation attributes to electricity consumption.

Elementary flows – In the life cycle inventory, elementary flows include "material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation" (ISO 14040, 3.12). Elementary flows include, for example, resources taken from nature or emissions into air, water, soil that are directly linked to the characterisation factors of the EF impact categories.

Environmental aspect – Element of an organisation's activities or products or services that interacts or can interact with the environment (ISO 14001:2015).

Environmental Footprint (EF) Impact Assessment – Phase of the PEF analysis aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product (based on ISO 14044:2006). The impact assessment methods provide impact characterisation

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factors for elementary flows in order to aggregate the impact to obtain a limited number of midpoint indicators.

Environmental Footprint (EF) Impact Assessment method – Protocol for quantitative translation of life cycle inventory data into contributions to an environmental impact of concern.

Environmental Footprint (EF) Impact Category – Class of resource use or environmental impact to which the life cycle inventory data are related.

Environmental Footprint (EF) impact category indicator – Quantifiable representation of an EF impact category (based on ISO 14000:2006).

Environmental impact – Any change to the environment, whether adverse or beneficial, that wholly or partially results from an organisation's activities, products or services (EMAS regulation).

Environmental mechanism – System of physical, chemical and biological processes for a given EF impact category linking the life cycle inventory results to EF category indicators (based on ISO 14040:2006).

Eutrophication – Nutrients (mainly nitrogen and phosphorus) from sewage outfalls and fertilised farmland accelerate the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass. Three EF impact categories are used to assess the impacts due to eutrophication: Eutrophication, terrestrial; Eutrophication, freshwater; Eutrophication, marine.

External Communication – Communication to any interested party other than the commissioner or the practitioner of the study.

Extrapolated Data – Refers to data from a given process that is used to represent a similar process for which data is not available, on the assumption that it is reasonably representative.

Flow diagram – Schematic representation of the flows occurring during one or more process stages within the life cycle of the product being assessed.

Foreground elementary flows - Direct elementary flows (emissions and resources) for which access to primary data (or company-specific information) is available.

Foreground Processes – Refer to those processes in the product life cycle for which direct access to information is available. For example, the producer's site and other processes operated by the producer or its contractors (e.g. goods transport, head-office services, etc.) belong to the foreground processes.

Functional unit – The functional unit defines the qualitative and quantitative aspects of the function(s) and/or service(s) provided by the product being evaluated. The functional unit definition answers the questions "what?", "how much?", "how well?", and "for how long?".

Gate to Gate – A partial product supply chain that includes only the processes carried out on a product within a specific organisation or site.

Gate to Grave – A partial product supply chain that includes only the distribution, storage, use, and disposal or recycling stages.

Global warming potential – Capacity of a greenhouse gas to influence radiative forcing, expressed in terms of a reference substance (for example, CO_2-equivalent units) and specified time horizon **(**e.g. GWP 20, GWP 100, GWP 500, for 20, 100, and 500 years respectively)**.** It relates to the capacity to influence changes in the global average surface-air temperature and subsequent change in various climate parameters and their effects, such as storm frequency and intensity, rainfall intensity and frequency of flooding, etc.

Horizontal averaging - it is the action of aggregating multiple unit process datasets or aggregated process datasets in which each provides the same reference flow in order to create a new process dataset (UN Environment, 2011).

Human toxicity – cancer – EF impact category that accounts for adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to cancer.

Human toxicity - non cancer – EF impact category that accounts for the adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to non-cancer effects that are not caused by particulate matter/respiratory inorganics or ionising radiation.

Independent external expert – Competent person, not employed in a full-time or part-time role by the commissioner of the EF study or the user of the EF method, and not involved in defining the scope or conducting the EF study (adapted from ISO 14071/2014, point 3.2).

Indirect land use change (iLUC) – It occurs when a demand for a certain land use leads to changes, outside the system boundary, i.e. in other land use types. These indirect effects may be mainly assessed by means of economic modelling of the demand for land or by modelling the relocation of activities on a global scale.

Input flows – Product, material or energy flow that enters a unit process. Products and materials include raw materials, intermediate products and co-products (ISO 14040:2006).

Intermediate product – Output form a unit process that is input to other unit processes that require further transformation within the system (ISO 14040:2006). An intermediate product is a product that requires further processing before it is saleable to the final consumer.

Ionising radiation, human health – EF impact category that accounts for the adverse health effects on human health caused by radioactive releases.

Land use – EF impact category related to use (occupation) and conversion (transformation) of land area by activities such as agriculture, forestry, roads, housing, mining, etc. Land occupation considers the effects of the land use, the amount of area involved and the duration of its occupation (changes in quality multiplied by area and duration). Land transformation considers the extent of changes in land properties and the area affected (changes in quality multiplied by the area).

Lead verifier – Verifier taking part in a verification team with additional responsibilities compared to the other verifiers in the team.

Life cycle – Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal (ISO 14040:2006).

Life cycle approach – Takes into consideration the spectrum of resource flows and environmental interventions associated with a product from a supply-chain perspective, including all stages from raw material acquisition through processing, distribution, use, and end of life processes, and all relevant related environmental impacts (instead of focusing on a single issue).

Life cycle Assessment (LCA) – Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006).

Life cycle impact assessment (LCIA) – Phase of life cycle assessment that aims at understanding and evaluating the magnitude and significance of the potential environmental impacts for a system throughout the life cycle (ISO 14040:2006). The LCIA methods used provide impact characterisation factors for elementary flows to in order to aggregate the impact to obtain a limited number of midpoint and/or damage indicators.

Life cycle inventory (LCI) - The combined set of exchanges of elementary, waste and product flows in a LCI dataset.

Life cycle inventory (LCI) dataset - A document or file with life cycle information of a specified product or other reference (e.g., site, process), covering descriptive metadata and quantitative life cycle inventory. A LCI dataset could be a unit process dataset, partially aggregated or an aggregated dataset.

Loading rate – Ratio of actual load to the full load or capacity (e.g. mass or volume) that a vehicle carries per trip.

Material-specific – It refers to a generic aspect of a material. For example, the recycling rate of PET.

Multi-functionality – If a process or facility provides more than one function, i.e. it delivers several goods and/or services ("co-products"), then it is "multifunctional". In these situations, all inputs and emissions linked to the process will be partitioned between the product of interest and the other co-products according to clearly stated procedures.

Non-elementary (or complex) flows – In the life cycle inventory, non-elementary flows include all the inputs (e.g. electricity, materials, transport processes) and outputs (e.g. waste, by-products) in a system that need further modelling efforts to be transformed into elementary flows. Synonym of activity data.

Normalisation – After the characterisation step, normalisation is the step in which the life cycle impact assessment results are multiplied by normalisation factors that represent the overall inventory of a reference unit (e.g. a whole country or an average citizen). Normalised life cycle impact assessment results express the relative shares of the impacts of the analysed system in terms of the total contributions to each impact category per reference unit. When displaying the normalised life cycle impact assessment results of the different impact topics next to each other, it becomes evident which impact categories are affected most and least by the analysed system. Normalised life cycle impact assessment results reflect only the contribution of the analysed system to the total impact potential, not the severity/relevance of the respective total impact. Normalised results are dimensionless, but not additive.
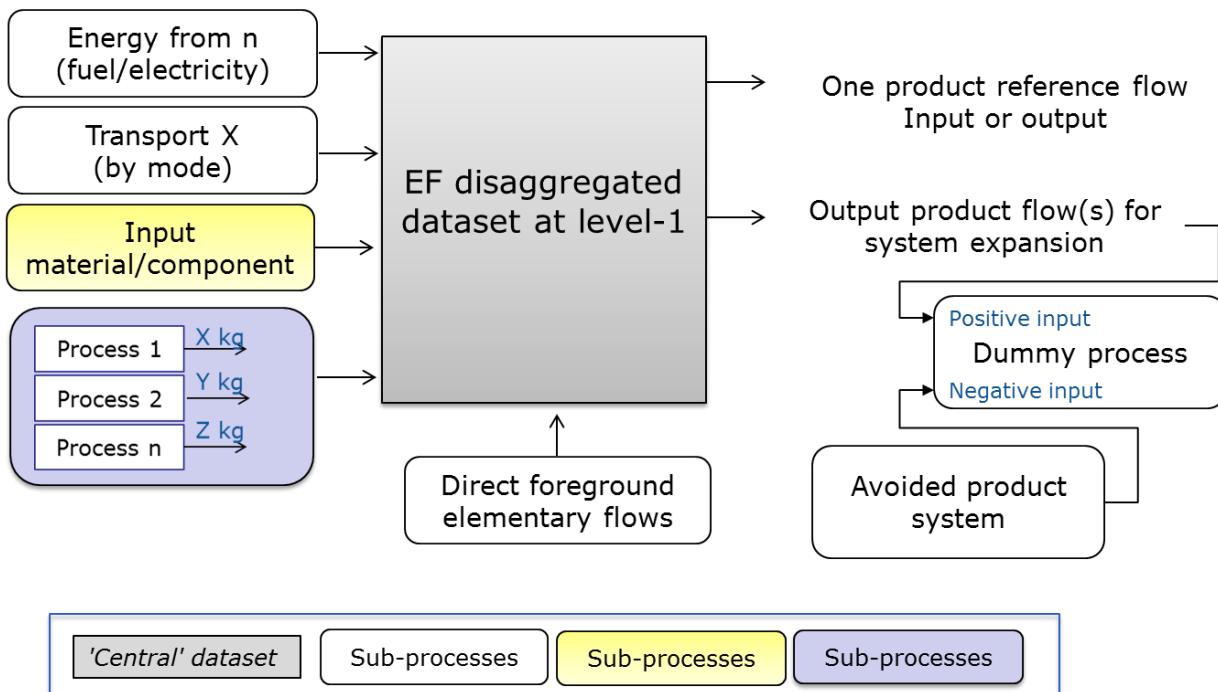
Output flows – Product, material or energy flow that leaves a unit process. Products and materials include raw materials, intermediate products, co-products and releases (ISO 14040:2006).

Ozone depletion – EF impact category that accounts for the degradation of stratospheric ozone due to emissions of ozone-depleting substances, for example long-lived chlorine and bromine containing gases (e.g. CFCs, HCFCs, Halons).

Partially disaggregated dataset - A dataset with a LCI that contains elementary flows and activity data, and that only in combination with its complementing underlying datasets yield a complete aggregated LCI data set.

Partially disaggregated dataset at level-1 - A partially disaggregated dataset at level-1 contains elementary flows and activity data of one level down in the supply chain, while all complementing underlying datasets are in their aggregated form.

Figure 1 Example of dataset partially disaggregated at Level-1

Particulate Matter – EF impact category that accounts for the adverse health effects on human health caused by emissions of Particulate Matter (PM) and its precursors (NO_x, SO_x, NH_3).

PEFCR supporting study – PEF study based on a draft PEFCR. It is used to confirm the decisions taken in the draft PEFCR before the final PEFCR is released.

PEF profile – The quantified results of a PEF study. It includes the quantification of the impacts for the various impact categories and the additional environmental information considered necessary to report.

PEF report – Document that summarises the results of the PEF study.

PEF study of the representative product (PEF-RP) – PEF study carried out on the representative product(s) and intended to identify the most relevant life cycle stages, processes, elementary flows, impact categories and any other major requirements needed for the definition of the benchmark for the product category/ sub-categories in scope of the PEFCR.

PEF study – Term used to identify the totality of actions needed to calculate the PEF results. It includes the modelling, the data collection, and the analysis of the results. It excludes the PEF report and the verification of the PEF study and report.

Photochemical ozone formation – EF impact category that accounts for the formation of ozone at the ground level of the troposphere caused by photochemical oxidation of volatile organic compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NO_x) and sunlight. High concentrations of ground-level tropospheric ozone damage vegetation, human respiratory tracts and manmade materials through reaction with organic materials.

Population - Any finite or infinite aggregation of individuals, not necessarily animate, subject to a statistical study.

Primary data[3] - This term refers to data from specific processes within the supply chain of the user of the PEF method or user of the PEFCR. Such data may take the form of activity data, or foreground elementary flows (life cycle inventory). Primary data are site-specific, company-specific (if multiple sites for the same product) or supply chain specific. Primary data may be obtained through meter readings, purchase records, utility bills, engineering models, direct monitoring, material/product balances, stoichiometry, or other methods for obtaining data from specific processes in the value chain of the user of the PEF method or user of the PEFCR. In this method, primary data is synonym of "company-specific data" or "supply-chain specific data".

Product – Any goods or services (ISO 14040:2006).

Product category – Group of products (or services) that can fulfil equivalent functions (ISO 14025:2006).

Product Category Rules (PCRs) – Set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories (ISO 14025:2006).

Product Environmental Footprint Category Rules (PEFCRs) – Product category specific, life cycle based rules that complement general methodological guidance for PEF studies by providing further specification at the level of a specific product category. PEFCRs help to shift the focus of the PEF study towards those aspects and parameters that matter the most, and hence contribute to increased relevance, reproducibility and consistency of the results by reducing costs versus a study based on the comprehensive requirements of the PEF method. Only the PEFCRs listed on the European Commission website (http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm) are recognised as in line with this method.

Product flow – Products entering from or leaving to another product system (ISO 14040:2006).

Product system – Collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product (ISO 14040:2006).

Raw material – Primary or secondary material that is used to produce a product (ISO 14040:2006).

Reference flow – Measure of the outputs from processes in a given product system required to fulfil the function expressed by the functional unit (based on ISO 14040:2006).

Refurbishment – It is the process of restoring components to a functional and/ or satisfactory state to the original specification (providing the same function), using methods such as resurfacing, repainting, etc. Refurbished products may have been tested and verified to function properly.

Releases – Emissions to air and discharges to water and soil (ISO 14040:2006).

Representative product (model) - The RP may be a real or a virtual (non-existing) product. The virtual product should be calculated based on average European market sales-weighted characteristics of all existing technologies/materials covered by the product category or sub-category. Other weighting sets may be used, if justified, for example weighted average based on mass (ton of material) or weighted average based on product units (pieces).

Representative sample – A representative sample with respect to one or more variables is a sample in which the distribution of these variables is exactly the same (or similar) as in the population from which the sample is a subset.

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[3]   Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute, 20011).

Resource use, fossil – EF impact category that addresses the use of non-renewable fossil natural resources (e.g. natural gas, coal, oil).

Resource use, minerals and metals – EF impact category that addresses the use of non-renewable abiotic natural resources (minerals and metals).

Sample – A sample is a subset containing the characteristics of a larger population. Samples are used in statistical testing when population sizes are too large for the test to include all possible members or observations. A sample should represent the whole population and not reflect bias toward a specific attribute.

Secondary data[4] - It refers to data not from a specific process within the supply-chain of the company performing a PEF study. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third party LCI database or other sources. Secondary data includes industry average data (e.g., from published production data, government statistics, and industry associations), literature studies, engineering studies and patents, and may also be based on financial data, and contain proxy data, and other generic data. Primary data that go through a horizontal aggregation step are considered as secondary data.

Sensitivity analysis – Systematic procedures for estimating the effects of the choices made regarding methods and data on the results of a PEF study (based on ISO 14040: 2006).

Site-specific data – It refers to directly measured or collected data from one facility (production site). It is synonymous to "primary data".

Specific Data – Refers to directly measured or collected data representative of activities at a specific facility or set of facilities. Synonymous with "primary data."

Subdivision – Subdivision refers to disaggregating multifunctional processes or facilities to isolate the input flows directly associated with each process or facility output. The process is investigated to see whether it may be subdivided. Where subdivision is possible, inventory data should be collected only for those unit processes directly attributable to the products/services of concern.

Sub-population – Any finite or infinite aggregation of individuals, not necessarily animate, subject to a statistical study that constitutes a homogenous sub-set of the whole population. Synonymous with "stratum".

Sub-processes - Those processes used to represent the activities of the level 1 processes (=building blocks). Sub-processes may be presented in their (partially) aggregated form (see Figure 1).

Sub-sample - A sample of a sub-population.

Supply chain – It refers to all of the upstream and downstream activities associated with the operations of the user of the PEF method, including the use of sold products by consumers and the end of life treatment of sold products after consumer use.

Supply chain specific – It refers to a specific aspect of the specific supply chain of a company. For example the recycled content value of an aluminium may produced by a specific company.

System boundary – Definition of aspects included or excluded from the study. For example, for a "cradle-to-grave" EF analysis, the system boundary includes all activities from the extraction of raw materials through the processing, distribution, storage, use, and disposal or recycling stages.

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[4]   Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute, 2011)

System boundary diagram – Graphic representation of the system boundary defined for the PEF study.

Temporary carbon storage - happens when a product reduces the GHGs in the atmosphere or creates negative emissions, by removing and storing carbon for a limited amount of time.

Type III environmental declaration – An environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information (ISO 14025:2006). The predetermined parameters are based on the ISO 14040 series of standards, which is made up of ISO 14040 and ISO 14044.

Uncertainty analysis – Procedure to assess the uncertainty in the results of a PEF study due to data variability and choice-related uncertainty.

Unit process – Smallest element considered in the LCI for which input and output data are quantified (based on ISO 14040:2006).

Unit process, black box – Process chain or plant level unit process. This covers horizontally averaged unit processes across different sites. Covers also those multi-functional unit processes, where the different co-products undergo different processing steps within the black box, hence causing allocation problems for this dataset.

Unit process, single operation - Unit operation type unit process that cannot be further subdivided. Covers multi-functional processes of unit operation type.

Upstream – Occurring along the supply chain of purchased goods/ services prior to entering the system boundary.

User of the PEFCR – a stakeholder producing a PEF study based on a PEFCR.

User of the PEF method – a stakeholder producing a PEF study based on the PEF method.

User of the PEF results – a stakeholder using the PEF results for any internal or external purpose.

Verification - Conformity assessment process carried out by an environmental footprint verifier to demonstrate whether the PEF study has been carried out in compliance with the most updated version of the PEF method adopted by the Commission.

Validation - Confirmation by the environmental footprint verifier, that the information and data included in the PEF study, PEF report and the communication vehicles are reliable, credible and correct.

Validation statement – Conclusive document aggregating the conclusions from the verifiers or the verification team regarding the EF study. This document is mandatory and shall carry the electronic or handwritten signature of the verifier or, in case of a verification panel, of the lead verifier.

Verification report – Documentation of the verification process and findings, including detailed comments from the verifier(s), as well as the corresponding responses. This document is mandatory, but it may be confidential. The document shall carry the electronic or handwritten signature of the verifier, or in case of a verification panel, of the lead verifier.

Verification team – Team of verifiers that will perform the verification of the EF study, of the EF report and the EF communication vehicles.

Verifier – Independent external expert performing a verification of the EF study and eventually taking part in a verification team.

Vertical aggregation - Technical- or engineering-based aggregation refers to vertical aggregation of unit processes that are directly linked within a single facility or process

train. Vertical aggregation involves combining unit process datasets (or aggregated process datasets) together linked by a flow (UN Environment, 2011).

Waste – Substances or objects which the holder intends or is required to dispose of (ISO 14040:2006).

Water use – It represents the relative available water remaining per area in a watershed, after the demand of humans and aquatic ecosystems has been met. It assesses the potential of water deprivation, to either humans or ecosystems, building on the assumption that the less water remaining available per area, the more likely another user will be deprived (see also http://www.wulca-waterlca.org/aware.html).

Weighting – Weighting is a step that supports the interpretation and communication of the results of the analysis. PEF results are multiplied by a set of weighting factors, which reflect the perceived relative importance of the impact categories considered. Weighted EF results may be directly compared across impact categories, and also summed across impact categories to obtain a single overall score.

1 Introduction

The Product Environmental Footprint (PEF) is a life cycle assessment (LCA) based method to quantify the environmental impacts of products (goods or services). It builds on existing approaches and international standards. The overarching purpose of PEF information is to enable to reduce the environmental impacts of goods and services taking into account supply chain activities (from extraction of raw materials, through production and use and to final waste management). This purpose is achieved through the provision of detailed requirements for modelling the environmental impacts of the flows of material/energy and the emissions and waste streams associated with a product throughout its life cycle.

The rules provided in the PEF method enable to conduct PEF studies that are more reproducible, comparable and verifiable, compared to existing alternative approaches. However, comparability is only possible if the results are based on the same Product Environmental Footprint Category Rules (PEFCR).

The requirements included in the PEF method may be applied in three possible situations:

    (1)   For PEF studies of products which do not fall within the scope of a valid PEFCR;

    (2)   For PEF studies of products which fall within the scope of a valid PEFCR. The requirements in this PEF method shall be used in addition to the requirements listed in the applicable PEFCR;

    (3)   For developing a PEFCR.

The current document (the PEF method) details rules on how to calculate a PEF in the absence of a PEFCR (item 1 in the list above). Annex A specifies how to develop product category-specific methodological requirements (PEFCRs – item 2 and 3 on the list above). The development of PEFCRs complements and further specifies the requirements for PEF studies.

1.1 Context

In April 2013 the Commission adopted Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations, which had the Product Environmental Footprint (PEF) Guide5 as its annex. The method was part of a wider policy defined by the Communication Building the Single Market for Green Products[6].

The PEF Guide was developed as one of the building blocks of the Flagship initiative of the Europe 2020 Strategy – "A Resource-Efficient Europe."[7] The European Commission's "Roadmap to a Resource Efficient Europe"[8] proposes ways to increase resource productivity and to decouple economic growth from both resource use and environmental impacts, taking a life cycle perspective. One of its objectives is to: "Establish a common methodological approach to enable Member States and the private sector to assess, display and benchmark the environmental performance of products, services and companies based on a comprehensive assessment of environmental impacts over the life-cycle ('environmental footprint')". This objective was confirmed by the European Council conclusions of October 2010[9].

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[5]   OJ L 124, 4.5.2013

[6]   COM/2013/0196 final

[7]   European Commission 2011: COM(2011) 571 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Roadmap to a Resource Efficient Europe.

[8]   http://ec.europa.eu/environment/resource_efficiency/index_en.htm

[9]   http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/envir/118642.pdf

Thus, the Product Environmental Footprint project was initiated with the aim of developing a harmonised EU methodology for EF studies that can accommodate a broader suite of relevant environmental performance criteria using a life cycle approach.

When adopted in 2013, the PEF method, whilst including more specific requirements than any alternative comparable existing method, it still included some generic requirements related to modelling certain activities (e.g. agriculture) and in particular related to the process of developing PEFCRs.

The development of PEFCRs, approaches how to verify and communicate to different stakeholders the resulting information was subject to a pilot phase in the period 2013-18. Volunteering industry was leading the work under the supervision and with the input of different European Commission services, Member States, EU and international stakeholders. In this period, several methodological topics were further developed through this multi-stakeholder process, making the method stronger, more reliable and more implementable.

In this report the Joint Research Centre is proposing how the PEF Guide should be amended in the future to reflect the developments and the practical experience gained during the pilot phase[10]. The suggestions are detailed in the following chapters.

1.2 Main changes proposed by this report

The fundamental principles of the methods did not change. PEF remains a method based on Life Cycle Assessment (LCA), the 16 environmental impact categories in scope are all relying on scientifically sound impact assessment methods that are agreed at international level and the role of industry stakeholders remain essential. The pilot phase, however, was instrumental in strengthening some methodological approaches.

Most of the changes introduced are of methodological nature, but also some procedural or editorial changes have been implemented. For example, terminology and definitions have been aligned to those included in ISO 14040-44, the basic standard from which all LCA methods are derived. Other elements are described better are:

(a) the process for developing Product Environmental Footprint Category Rules (PEFCRs),

(b) the minimum requirements that the user of the method has to fulfil in order to prepare a PEF study,

(c) the verification and validation procedures of PEF studies (essential to guarantee the reliability of the information communicated).

From the methodological viewpoint, the pilot phase produced an incredible amount of knowledge from the different sectors and experts involved. These methodological improvements can be grouped into three main areas: i) modelling requirements, ii) data and data quality requirements and iii) life cycle impact assessment.

Regarding modelling requirements, the main changes are:

(a) the modelling of agricultural production was improved, based on inputs received from the many food-related pilots but also building on the deliverables of the FAO LEAP Initiative (e.g. emissions of pesticides, fertilizers, heavy metals emissions, allocation of emissions at farming level, etc.);

(b) electricity modelling (electricity product or mixes to be used, minimum criteria to ensure contractual instruments from suppliers, how to deal with on-site electricity generation, etc.);

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[10] Final deliverables and reports on the pilot phase are available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm

(c) transport and logistics (including default data to be used in different situations);

(d) exclusion from the system modelling of capital goods and their infrastructure, unless there is evidence from previous studies that they are relevant);

(e) use stage (distinction between product dependent and independent processes, better definition of system boundaries of the use stage);

(f) development of a new approach for end-of-life modelling (recovery, recycling, final treatment) in collaboration with all industry sectors and life cycle assessment experts; this resulted in a harmonised approach that can better reflect market realities of different recycled and recyclable materials;

(g) better alignment of the method to account for greenhouse gas (GHG) emissions and removals with the standard ISO 14067:2018;

(h) development of a structured and detailed procedure to identify the most relevant impact categories, life cycle stages, processes and elementary flows (i.e. emissions);

(i) definition of classes of environmental performance.

Regarding data and data quality requirements, the main changes are:

(a) implementation of the Data Needs Matrix (used to evaluate data requirements, including source and quality), depending on the control the company has on a specific process within the system boundary);

(b) calculation of Data Quality Ratings for company-specific and secondary datasets and for PEF studies;

(c) hierarchy of data sources to be used in PEF studies;

(d) cut-off: the processes that in total account less than 3.0% of the material and energy flow and environmental impact for each impact category may be excluded from PEF studies (starting from the less relevant).

(e) clear rules and references related to technical aspects of EF-compliant datasets.

Regarding life cycle impact assessment, the main changes are:

(a) updated characterization models for some of the EF impact categories (water use, land use, resource use - minerals and metals; fossils), particulate matter, human toxicity cancer, human toxicity non-cancer, ecotoxicity freshwater);

(b) updated characterization factors (ozone depletion, climate change);

(c) provision of default normalization factors;

(d) development of default weighting factors.

All these changes have been discussed all along the pilot phase during numerous meetings with the participation of Member States, industry stakeholders, and NGOs representatives.

1.3 Objectives and target audience

The main part of this document is primarily aimed at technical experts who need to perform a PEF study, for example engineers and environmental managers in companies and other institutions.

Note that in order to perform a PEF study the following two requirements shall be met: i) The bill of material shall be specific of the product in scope, and ii) the modelling of the

manufacturing processes shall be based on company-specific data (e.g. energy needed for the assembly of the materials/components of the product in scope). For companies producing more than one product the activity data used (including the BoM) shall be specific to the product in scope of the study.

The intended audience of Annex A includes:

- stakeholders participating in the development of PEFCRs;
- users of a PEFCR[11] when conducting a PEF study.

1.4 Relationship to other methods and standards

Each requirement specified in the PEF method was developed taking into consideration the recommendations of similar, widely recognised product environmental accounting methods and guidance documents. Specifically, the methodological guides considered were:

ISO standards[12], in particular:

- ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework;
- ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines;
- ISO 14067:2018 Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification;
- ISO 14046:2014 Environmental management — Water footprint — Principles, requirements and guidelines;
- ISO 14020:2000 Environmental labels and declarations — General principles;
- ISO 14021:2016 Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling)
- ISO 14025:2006 Environmental labels and declarations – Type III environmental declarations – Principles and procedures;
- ISO 14050:2009 Environmental management — vocabulary
- ISO/TS 14071:2014 Environmental management — Life cycle assessment — Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006
- ISO 17024:2012 Conformity assessment – General requirements for bodies operating certification of persons.
- PEF Guide, Annex to Commission Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations (April 2013);
- ILCD (International Reference Life Cycle Data System) Handbook[13];
- Ecological Footprint Standards[14];
- Greenhouse Gas Protocol - Product Life Cycle Accounting and Reporting Standard [15] (WRI/ WBCSD);

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[11]   List of available PEFCRs: http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm
[12]   Available online at https://www.iso.org/standards-catalogue/browse-by-ics.html
[13]   Available online at http://eplca.jrc.ec.europa.eu/?page_id=86
[14]   Global Footprint Network Standards Committee (2009) Ecological Footprint Standards 2009.
[15]   WRI/WBCSD 2011, Greenhouse Gas Protocol – Product Life Cycle Accounting and Reporting Standard.

- BP X30-323-0:2015 General principles for an environmental communication on mass market products (ADEME)[16];
- PAS 2050:2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services (BSI)[17];
- ENVIFOOD Protocol[18].
- FAO:2016. Environmental performance of animal feeds supply chains: Guidelines for assessment. LEAP Partnership.

A detailed description of most of the analysed methods and of the outcome of the analysis is available in "Analysis of Existing Environmental Footprint methodologies for Products and Organisations: Recommendations, Rationale, and Alignment"[19]. Whereas existing methods may provide several alternatives for a given methodological decision point, the intention of the PEF method is (wherever feasible) to identify a single requirement for each decision point, or to provide additional guidance, in order to support more consistent, robust and reproducible studies.

1.5 Product Environmental Footprint Category Rules (PEFCRs)

The primary objective of a PEFCR is to fix a consistent and specific set of rules to calculate the relevant environmental information of products belonging to the product category in scope. An important objective is to focus on what matters most for a specific product category to make PEF studies easier, faster and less costly.

An equally important objective is to enable comparisons and comparative assertions in all cases where this is feasible, relevant and appropriate. Comparisons and comparative assertions are allowed only if PEF studies are conducted in compliance with a PEFCR. A PEF study shall be conducted in compliance with a PEFCR, if a PEFCR is available for the product in scope.

Requirements for the development of PEFCRs are specified in Annex A to the PEF method. A PEFCR may further specify requirements made in the PEF method and add new requirements where the PEF method leaves more than one choice. The objective is to ensure that PEFCRs are developed according to the PEF method and that they provide the specifications needed to achieve the comparability, increased reproducibility, consistency, relevance, focus and efficiency of PEF studies.

Rules similar to PEFCRs exist in standards for other types of life cycle based product claims, such as ISO 14025:2006 (type III environmental declarations). Those were not seen as sufficiently stringent and clear to achieve the required objectives of PEF studies based on category rules. PEFCRs were named differently to prevent confusion with other similar rules and to uniquely identify rules under the PEF method.

PEFCRs should, to the extent possible, and recognising the different application contexts, be in conformity with existing relevant international Product Category Rules (PCR). If other PCRs are available from other schemes, these are to be listed and evaluated. They may be used as a basis for developing a PEFCR, in line with the requirements provided in Annex A.

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[16] Withdrawn on May 2016.

[17] Available online at http://www.bsigroup.com/en/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-2050/

[18] ENVIFOOD Protocol, Environmental Assessment of Food and Drink Protocol, European Food Sustainable Consumption and Production Round Table (SCP RT), Working Group 1, Brussels, Belgium

[19] European Commission - Joint Research Centre - Institute for Environment and Sustainability (2011b). Analysis of Existing Environmental Footprint methodologies for Products and Organisations: Recommendations, Rationale, and Alignment. EC – IES - JRC, Ispra, November 2011. http://ec.europa.eu/environment/archives/eussd/pdf/Deliverable.pdf

1.6 Approach and examples for potential applications

The rules provided in the PEF method enable practitioners to conduct PEF studies that are more reproducible, consistent, robust, verifiable and comparable. Results of PEF studies are the basis for the provision of EF information and they may be used in a diverse number of potential fields of applications.

Potential applications of PEF studies without an existing PEFCR for the product(s) in scope are:

- In-house applications
  - optimisation of processes along the life cycle of a product,
  - support to environmental management,
  - identification of environmental hotspots,
  - support for product design minimising environmental impacts along the life cycle,
  - environmental performance improvement and tracking,
- External applications: (e.g. business to business (B2B), business to consumer (B2C)):
  - responding to customers and consumers demands,
  - marketing,
  - co-operation along supply chains to optimise the product along the life cycle,
  - participation in 3rd party schemes related to environmental claims or giving visibility to products that calculate and communicate their life cycle environmental performance.

Potential applications of PEF studies performed in compliance with an existing PEFCR for the product in scope, in addition to the ones listed above, are:

- Comparisons and comparative assertions (i.e. claims of overall superiority or equivalence of the environmental performance of one product compared to another (based on ISO 14040:2006)) based on PEF studies,

- Comparison and comparative assertions against the benchmark of the product category followed by a grading of other products according to their performance versus the benchmark,

- Identification of significant environmental impacts common to a product group,

- Reputational schemes giving visibility to products that calculate their life cycle environmental performance,

- Green procurement (public and corporate).

2 General considerations for Product Environmental Footprint (PEF) studies

2.1 How to use this method

This method provides the rules necessary to conduct a PEF study and is presented in a sequential manner, in the order of the methodological steps that shall be completed when calculating a PEF.

Where appropriate, sections begin with a general description of the methodological step, along with an overview of necessary considerations and supporting examples.

When additional requirements for creating PEFCRs are specified, these are available in Annex A.

2.2 Principles for Product Environmental Footprint studies

To produce reliable, reproducible, and verifiable PEF studies, a core suite of analytical principles shall be adhered to. These principles provide overarching guidance in the application of the PEF method. They shall be considered with respect to each phase of PEF studies, from the definition of goal and the scope, through data collection, impact assessment, reporting and verification of study outcomes.

Users of this method shall observe the following principles in conducting a PEF study:

(1) Relevance

All methods used and data collected for the purpose of quantifying the PEF shall be as relevant to the study as possible.

(2) Completeness

Quantification of the PEF shall include all environmentally relevant material/energy flows and other environmental interventions as required for adherence to the defined system boundary, the data requirements, and the impact assessment methods employed.

(3) Consistency

Strict conformity to this method shall be observed in all steps of the PEF study to ensure internal consistency and comparability.

(4) Accuracy

All reasonable effort shall be taken to reduce uncertainties in product system modelling and the reporting of results.
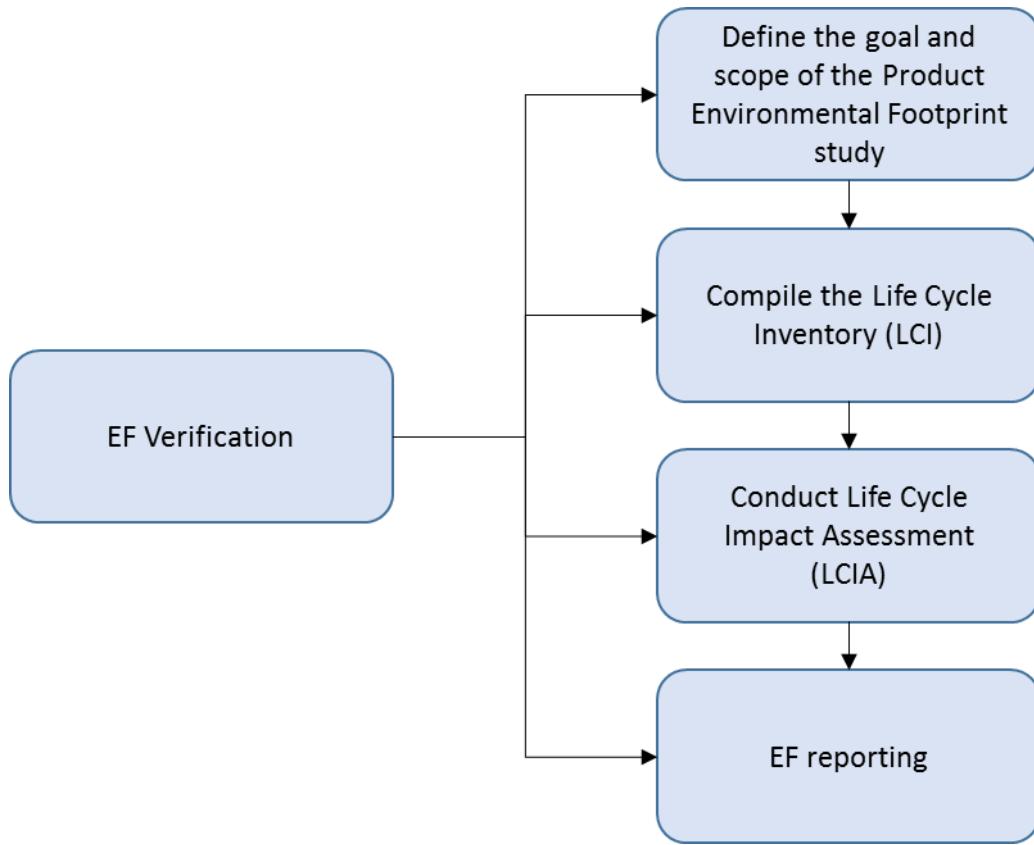
(5) Transparency

PEF information shall be disclosed in such a way as to provide intended users with the necessary basis for decision-making, and for stakeholders to assess its robustness and reliability.

2.3 Phases of a Product Environmental Footprint study

A number of phases shall be completed in carrying out a PEF study in line with this method - i.e. goal definition, scope definition, life cycle inventory, life cycle impact assessment, interpretation of PEF results and PEF reporting – see Figure 2.

Figure 2 Phases of a Product Environmental Footprint study

In the goal step, the aims of the study are defined, namely the intended application, the reasons for carrying out the study and the intended audience. Main methodological choices are made in scope phase, for example the exact definition of the functional unit, the identification of the system boundary, the selection of additional environmental and technical information, main assumptions and limitations.

The life cycle inventory (LCI) step involves the data collection and the calculation procedure for the quantification of inputs and outputs of the studied system. Inputs and outputs concern energy, raw material and other physical inputs, products and co-products and waste, emissions to air/water/soil. Data collected concern foreground processes and background processes. Data are put in relationship to the process units and functional unit. The LCI is an iterative process. In fact, as data are collected and more is learned about the system, new data requirements or limitations may be identified that require a change in the data collection procedures so that the goals of the study will still be met.

In the impact assessment step, LCI results are associated to environmental impact categories and indicators. This is done through LCIA methods, which first classify emissions into impact categories and then characterize them to common units (e.g. CO_2 and CH_4 emissions are both expressed in CO_2 equivalent emissions by using their global warming potential). Examples of impact categories are climate change, acidification or resource use.

Finally, in the interpretation step, results from LCI and LCIA are interpreted in accordance to the stated goal and scope. In this phase, most relevant impact categories, life cycle stages, processes and elementary flows are identified. Conclusions and recommendations can be drawn, based on the analytical results.

3 Defining the goal(s) and scope of the Product Environmental Footprint study

3.1 Goal definition

Goal definition is the first step of a PEF study, and sets the overall context for the study. The purpose of clearly defining goals is to ensure that the aims, methods, results and intended applications are aligned, and that a shared vision is in place to guide participants in the study. The decision to use the PEF method implies that some aspects of the goal definition will be decided a priori, due to the specific requirements provided by the PEF method.

In defining goals, it is important to identify the intended applications and the degree of analytical depth and rigour of the study. This should be reflected in the defined study limitations (scope definition phase).

Goal definition for a PEF study shall include:

- Intended application(s);
- Reasons for carrying out the study and decision context;
- Target audience;
- Commissioner of the study;
- Identity of the verifier.

Table 1 Example of goal definition - Product Environmental Footprint of a T-shirt

Aspects	Detail
Intended application(s):	Provide product information to customer
Reasons for carrying out the study and decision context:	Respond to a request from a customer
Target audience:	External technical audience, business-to-business.
Verifier:	Independent external verifier, Mr Y
Commissioner of the study:	G company limited

3.2 Scope Definition

The scope of the PEF study describes in detail the system to be evaluated and the technical specifications.

The scope definition shall be in line with the defined goals of the study and shall include (see subsequent sections for a more detailed description):

- Functional unit and reference flow;
- System boundary;

- EF impact categories[20];
- Additional information to be included;
- Assumptions/Limitations.

3.2.1 Functional unit and reference flow

The functional unit (FU) is the quantified performance of a product system, to be used as a reference unit. The functional unit qualitatively and quantitatively describes the function(s) and duration of the product in scope.

The reference flow is the amount of product needed to provide the defined function. All other input and output flows in the analysis quantitatively relate to it. The reference flow may be expressed in direct relation to the functional unit or in a more product-oriented way.

Users of the PEF method shall define the functional unit and the reference flow for the PEF study.

The functional unit for a PEF study shall be defined according to the following aspects:

- The function(s)/service(s) provided: "**what**";
- The extent of the function or service: "**how much**";
- The expected level of quality: "**how well**";
- The duration/life time of the product: "**how long**";

In case applicable standards exist, they shall be used and cited in the PEF study when defining the FU.

Example 1

Define the functional unit of decorative paint: the functional unit is to protect and decorate 1 m^2 of substrate for 50 years at a specified quality level (minimum 98% opacity).

What: Provide decoration and protection of a substrate,

How much: coverage of 1 m^2 of substrate,

How well: with a minimum 98% opacity

How long: for 50 years (life time of the building)

Reference flow: amount of product needed to fulfil the defined function and shall be measured in kg of paint.

Example 2

Define the functional unit and reference flow for the PEF of pet food.

Functional Unit (pet food)

What: To serve the recommended daily intake in kilocalories of metabolizable energy (kcal ME) ("daily ration") of prepared pet food to a cat or dog,

How much: Daily ration

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[20] The term "EF impact category" will be used throughout this method in place of the term "impact category" used in ISO 14044.

How well: To meet the daily caloric and nutritional requirements of an average cat or dog (where average refers to the pet weight: 4 kg for a cat and 15 kg for a dog)

How long: 1 day of serving prepared pet food to a cat or dog.

Reference flow: amount of product needed to fulfil the defined function and shall be measured in grams (g) per day.

For intermediate products, the FU is more difficult to define as it may often fulfil multiple functions and the whole life cycle of the product is not known. Therefore, a declared unit should be applied, for example, mass (kilogram) or volume (cubic meter). In this case, the reference flow may correspond to the FU.

3.2.2 System boundary

The system boundary defines which parts of the product life cycle and which associated life cycle stages and processes belong to the analysed system (i.e. are required for carrying out its function as defined by the functional unit), except for those processes excluded based on the cut-off rule (see section 4.6.4). The reason for and potential significance of any exclusion shall be justified and documented.

The system boundary shall be defined following a general supply-chain logic, including all stages from raw material acquisition and pre-processing, production of the main product, product distribution and storage, use stage and end of life treatment of the product (if appropriate). The co-products, by-products and waste streams of at least the foreground system shall be clearly identified.

System boundary diagram

A system boundary diagram (or flow diagram) is a schematic representation of the analysed system. It shall clearly indicate the activities or processes that are included and those that are excluded from the analysis. The user of the PEF method shall highlight where company-specific data were used.

The activity and/or process names in the system diagram and in the PEF report shall be aligned. The system diagram shall be included in the scope definition and included in the PEF report.

3.2.3 Environmental Footprint impact categories

The purpose of life cycle impact assessment is to group and aggregate the collected LCI data according to the respective contributions to each EF impact category. The selection of EF impact categories is comprehensive in the sense that they cover a broad range of relevant environmental issues related to the product supply chain of interest, following the general requirements of completeness of PEF studies.

EF impact categories[21] refer to specific categories of impacts considered in a PEF study and they constitute the EF impact assessment method. Characterization models are used to quantify the environmental mechanism between the LCI (i.e. inputs (e.g. resources) and emissions associated with the product life cycle) and the category indicator of each EF impact category. Each impact category hence refers to a certain stand-alone characterization model.

Table 2 provides a default list of EF impact categories and related assessment methods. For a PEF study, all EF impact categories shall be applied, without exclusion. The full list of CFs to be used is available at http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml. Users of the PEF method shall report in the PEF report the version of the EF reference package used in the PEF study.

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[21] The term "EF impact category" is used throughout the PEF method in place of the term "impact category" used in ISO 14044.

More details on how the CFs were calculated is available at: http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml (see also Fazio et al., 2018a, Fazio et al. 2018b). For the EF impact categories human toxicity, cancer', 'human toxicity, non-cancer' and 'ecotoxicity, freshwater', all CFs have been calculated with the USEtox 2.1 model using new input data for physicochemical properties, aquatic ecotoxicity and human toxicity (see Saouter et al. (2018)[22]).

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[22] CFs calculated according to the technical report shall not be mixed with existing USEtox 2.1 CF database as the methodology to calculate some of the input parameters has changed. The report is available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

This JRC technical report is a working document and does not modify Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations

Table 2 *EF impact categories with respective impact category indicators and characterization models. The CFs that shall be used are available at: http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.*

EF Impact category	Impact category Indicator	Unit	Characteri-zation model	Robust-ness
Climate change, total[23]	Radiative forcing as global warming potential (GWP100)	kg $CO_{2\ eq}$	Baseline model of 100 years of the IPCC (based on IPCC 2013)	I
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 $_{eq}$	Steady-state ODPs as in (WMO 2014 + integrations)	I
Human toxicity, cancer	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model 2.1 (Fankte et al, 2017)	III
Human toxicity, non-cancer	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model 2.1 (Fankte et al, 2017)	III
Particulate matter	Impact on human health	disease incidence	PM method recomended by UNEP (UNEP 2016)	I
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq $U^{235}_{\ eq}$	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)	II
Photochemical ozone	Tropospheric ozone concentration increase	kg NMVOC $_{eq}$	LOTOS-EUROS model (Van	II

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[23] The indicator "Climate Change, total" is constituted by three sub-indicators: Climate Change, fossil; Climate Change, biogenic; Climate Change, land use and land use change. The sub-indicators are further described in section 4.4.10. The sub-categories 'Climate change –fossil', 'Climate change – biogenic' and 'Climate change - land use and land use change', shall be reported separately if they show a contribution of more than 5% each to the total score of climate change.

formation, human health			Zelm et al, 2008) as implemented in ReCiPe 2008	
Acidification	Accumulated Exceedance (AE)	mol H+ eq	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N eq	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P eq	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	II
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N eq	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	II
Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTU$_e$)	CTUe	USEtox model 2.1 (Fankte et al, 2017)	III
Land use	• Soil quality index[24] • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Dimensionless (pt) • kg biotic production • kg soil • m^3 water • m^3 groundwater	Soil quality index based on LANCA (Beck et al. 2010 and Bos et al. 2016)	III

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[24] This index is the result of the aggregation, performed by JRC, of the 4 indicators provided by LANCA model as indicators for land use.

Water use	User deprivation potential (deprivation-weighted water consumption)	m³ world $_{eq}$	Available WAter REmaining (AWARE) as recommended by UNEP, 2016	III
Resource use[25], minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb $_{eq}$	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.	III
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)[26]	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002	III

Further information on impact assessment calculations is provided in Chapter 5.

3.2.4 Additional information to be included in the PEF

Relevant potential environmental impacts of a product may go beyond the EF impact categories. It is important to consider and report them, whenever feasible, as additional environmental information.

Similarly, relevant technical aspects and/or physical properties of the product in scope may need to be considered. These aspects shall be reported as additional technical information.

3.2.4.1 Additional environmental information

Additional environmental information shall be:

- Based on information that is substantiated and has been reviewed or verified in accordance with the requirements of the Unfair Commercial Practices Directive (UCPD)[27] and related guidance, ISO 14020 and Clause 5 of ISO 14021:2016;
- Specific, accurate and not misleading;
- Relevant to the particular product category;
- Life cycle based information additional to the EF impact categories.

Additional environmental information shall only be related to environmental aspects. Information and instructions, e.g. product safety sheets that are not related to the environmental performance of the product shall not be part of additional environmental information.

Additional environmental information shall not reflect the same or similar EF impact categories, shall not substitute the characterization models of the EF impact categories and shall not report results of new CFs added to EF impact categories. The supporting models

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[25] The results of this impact category shall be interpreted with caution, because the results of ADP after normalization may be overestimated. The European Commission intends to develop a new method moving from depletion to dissipation model to better quantify the potential for conservation of resources

[26] In the EF flow list, and for the current recommendation, Uranium is included in the list of energy carriers, and it is measured in MJ.

[27] The UCPD and related guidance is available at https://ec.europa.eu/info/law/law-topic/consumers/unfair-commercial-practices-law/unfair-commercial-practices-directive_en

of this additional information shall be clearly referenced and documented together with the corresponding indicators.

For example, biodiversity impacts due to land use changes may occur in association with a specific site or activity. This may require the application of additional impact categories that are not included among the EF impact categories, or even additional qualitative descriptions where impacts may not be linked to the product supply chain in a quantitative manner. Such additional methods should be viewed as complementary to the EF impact categories.

Additional environmental information may include:

(a) Information on local/site-specific impacts;

(b) Offsets;

(c) Environmental indicators or product responsibility indicators (as per the Global Reporting Initiative (GRI));

(d) For gate-to-gate assessments, number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk;

(e) Description of significant impacts of activities, products, and services on biodiversity in protected areas and in areas of high biodiversity value outside protected areas;

(f) Noise impacts;

(g) Other environmental information considered relevant within the scope of the PEF study.

Biodiversity

The PEF method does not include any impact category named "biodiversity", as currently there is no international consensus on a life cycle impact assessment method capturing that impact. However, the PEF method includes at least eight impact categories that have an effect on biodiversity (i.e., climate change, eutrophication aquatic freshwater, eutrophication aquatic marine, eutrophication terrestrial, acidification, water use, land use, ecotoxicity freshwater).

Considering the high relevance of biodiversity for many product groups, however, biodiversity should be addressed separately (in addition to the EF impact categories). Each study shall explain whether biodiversity is relevant for the product in scope. If that is the case, the user of the PEF method shall include biodiversity indicators under additional environmental information.

The following suggestions may be taken into account to cover biodiversity:

- To express the (avoided) impact on biodiversity as the percentage of material that comes from ecosystems that have been managed to maintain or enhance conditions for biodiversity, as demonstrated by regular monitoring and reporting of biodiversity levels and gains or losses (e.g. less than 15% loss of species richness due to disturbance, but the PEF studies may set their own level provided this is well justified and not in contradiction to a relevant existing PEFCR). The assessment should refer to materials that end up in the final products and to materials that have been used during the production process. For example, charcoal that is used in steel production processes, or soy that is used to feed cows that produce dairy etc.

- To report additionally the percentage of such materials for which no chain of custody or traceability information can be found.

- To use a certification system as a proxy. The user of the PEF method should determine which certification schemes provide sufficient evidence for ensuring biodiversity maintenance and describe the criteria used. A useful overview of standards is available on http://www.standardsmap.org/.

3.2.4.2 Additional technical information

Additional technical information may include (non-exhaustive list):

(a) Bill of materials data;

(b) Dismantleability, reparability and other circular economy related information;

(c) Information on the use of hazardous substances;

(d) Information on the disposal of hazardous/non-hazardous waste;

(e) Information on energy consumption;

(f) Technical parameters, such as the use of renewable versus non-renewable energy, the use of renewable versus non-renewable fuels, the use of secondary materials, the use of fresh water resources;

(g) Total weight of waste by type and disposal method;

(h) Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention Annexes I, II, III, and VIII, and percentage of transported waste shipped internationally;

(i) Information and data related to the functional unit and technical performance of the product.

When the product in scope is an intermediate product, additional technical information shall include:

(a) The biogenic carbon content at factory gate (physical content and allocated content);

(b) Recycled content (R_1);

(c) Results with application-specific A-values of the Circular Footprint Formula, if relevant.

3.2.5 Assumptions/ limitations

In PEF studies, several limitations to carrying out the analysis may arise and therefore assumptions need to be made. All limitations (e.g. data gaps) and assumptions shall be transparently reported.

4 Life Cycle Inventory

An inventory of all material, energy and waste inputs and outputs and emissions into air, water and soil for the product supply chain shall be compiled as a basis for modelling the PEF. This is called the life cycle inventory.

Detailed data requirements and quality requirements are described in section 4.6.

The life cycle inventory shall adopt the following classification of flows[28] included:

- **Elementary flows,** which are "*material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation.*" (ISO 14040:2006, 3.12). Elementary flows are, for example, resources extracted from nature or emissions into air, water, soil that are directly linked to the characterisation factors of the EF impact categories;

- **Non-elementary (or complex) flows**, which are all the remaining inputs (e.g. electricity, materials, transport processes) and outputs (e.g. waste, by-products) in a system that require further modelling efforts to be transformed into elementary flows.

Within the PEF study, all non-elementary flows in the life cycle inventory shall be modelled up to the level of elementary flows, apart from the product flow of the product in scope. For example, waste flows shall not only be included in the study as kg of household waste or hazardous waste, but shall be modelled until the emissions into water, air and soil due to the treatment of the solid waste. The LCI modelling is therefore only completed when all non-elementary flows are expressed as elementary flows. Therefore, the LCI dataset of the PEF study shall only contain elementary flows, apart from the product flow of the product in scope.

4.1 Screening step

An initial screening of the LCI, referred to as the screening step, is highly recommended because it helps focussing data collection activities and data quality priorities. A screening step shall include the LCIA phase and allow to further refine the life cycle model of the product in scope in an iterative way, as more information becomes available. Within a screening step no cut-off is allowed and readily available primary or secondary data may be used, fulfilling the data quality requirements to the extent possible (as defined in section 4.6). Once the screening is performed, the initial scope settings may be refined.

4.2 Life cycle stages

The default life cycle stages included in a PEF study shall be as a minimum:

- Raw material acquisition and pre-processing (including production of parts and unspecific components);

- Manufacturing (production of the main product);

- Distribution (product distribution and storage);

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[28] Classification is defined as assigning the material/energy/waste inputs and outputs tabulated in the LCI to EF impact categories according to each substance's potential to contribute to each of the EF impact categories considered.

- Use stage;
- End of life (including product recovery or recycling).

In case the naming of the default life cycle stages is changed, the user shall specify which default life cycle stage it corresponds to.

If justified, the user of the PEF method may decide to split or add life cycle stages .The justification shall be included in the PEF report. For example, the life cycle stage 'Raw material acquisition and pre-processing' may be split into 'Raw material acquisition', 'pre-processing', and 'raw materials supplier transport'.

For intermediate products, the following life cycle stages shall be excluded:

- Use stage;
- End of life (including product, recovery / recycling).

4.2.1 Raw material acquisition and pre-processing

This life cycle stage starts when resources are extracted from nature and ends when product components enter (through the gate of) the product's production facility. Examples for processes that may occur in this stage include (non-exhaustive list):

- Mining and extraction of resources;
- Pre-processing of all material inputs to the studied product, including recyclable materials;
- Agricultural and forestry activities;
- Transportation within and between extraction and pre-processing facilities, and to the production facility.

Packaging production shall be modelled as part of the "Raw material acquisition and pre-processing" life cycle stage.

4.2.2 Manufacturing

The production stage begins when the product components enter the production site and ends when the finished product leaves the production facility. Examples of production-related activities include (non-exhaustive list):

- Chemical processing;
- Manufacturing;
- Transport of semi-finished products between manufacturing processes;
- Assembly of material components.

The waste of products used during the manufacturing shall be included in the modelling of the manufacturing stage. The Circular Footprint Formula (section 4.4.8) shall be applied to such waste.

4.2.3 Distribution stage

Products are distributed to users and may be stored at various points along the supply chain. The distribution stage includes the transport from factory gate to warehouse /retail, storage at warehouse/retail, and transport from warehouse/ retail to consumer home.

Examples of processes to include (non-exhaustive list):

- Energy inputs for warehouse lighting and heating;
- Use of refrigerants in warehouses and transport vehicles;

- Fuel use by vehicles;
- Roads and trucks.

The waste of products used during distribution and storage shall be included in the modelling. The Circular Footprint Formula (section 4.4.8) shall be applied to such waste. Default loss rates per type of product during distribution and at consumer are provided in Annex F and shall be used in case no specific information are available. Allocation rules on energy consumption at storage are presented in section 4.4.5 while for transport see section 4.4.3.

4.2.4 Use stage

The use stage describes how the product is expected to be used by the end user (e.g. the consumer). The use stage starts at the moment the end user uses the product till it leaves its place of use and enters the end of life (EoL) life cycle stage (e.g., recycling or final treatment). The transport to EoL is excluded from the use stage and is part of the end of life stage. The use stage includes all activities and products that are needed for a proper use of the product (i.e. the provision of the original function is kept throughout its lifetime). The waste of the product in use, such as food waste and its primary packaging or the product left at its end of use, is excluded from the use stage and shall be part of the EoL stage of the product.

For example, the provision of tap water when cooking pasta; the manufacturing, distribution and waste of materials needed for maintenance, repair or refurbishment (e.g. spare parts needed to repair the product, the coolant production and waste management due to losses); the EoL of paper filter for coffee making, belong to the use stage. Instead, the EoL of coffee capsules, residues for coffee making and packaging of ground coffee belong to the end of life stage.

In some cases, some products are needed for a proper use of the product in scope and they are used in a way that they become physically integrated: in this case, the waste treatment of these products belongs to the EoL of the product in scope. For example, when the product in scope is a detergent, the wastewater treatment of the water, used to fulfil the function of the detergent, belongs to the end of life stage.

The use scenario also needs to reflect whether or not the use of the analysed products might lead to changes in the systems in which they are used.

The following sources of technical information on the use scenario should be taken into account (non-exhaustive list):

- Market surveys or other market data;
- Published international standards that specify guidance and requirements for the development of scenarios for the use stage and scenarios for (i.e. estimation of) the service life of the product;
- Published national guidelines for the development of scenarios for the use stage and scenarios for (i.e. estimation of) the service life of the product;
- Published industry guidelines for the development of scenarios for the use stage and scenarios for (i.e. estimation of) the service life of the product.

The manufacturer's recommended method to be applied in the use stage (e.g. cooking in an oven at a specified temperature for a specified time) should be used to provide a basis for determining the use stage of a product. The actual usage pattern may, however, differ from those recommended and should be used if this information is available and documented.

Default loss rates per type of product during distribution and at consumer are provided in Annex F and shall be used in case no specific information are available.

The following processes are excluded from the use stage:

    (d)   If a product is reused (see also section 4.4.9.2), the processes needed to collect the product and make it ready for the new use cycle are excluded (e.g. the impacts from collection and cleaning reusable bottles). These processes are included in the EoL stage if the product is reused into a product with different specifications (see section 4.4.9 for further details). If the product lifetime is extended into a product with original product specifications (providing the same function) these processes shall be included in the FU and reference flow.

    (e)   Transport from retail to consumer home shall be excluded from the use stage and shall be included in the distribution stage.

The waste of products used during the use stage shall be included in the modelling of the use stage. The Circular Footprint Formula (section 4.4.8) shall be applied to such waste.

Documentation of methods and assumptions shall be provided. All relevant assumptions for the use stage shall be documented.

Technical specifications to model the use stage are available in Section 4.4.7.

4.2.5 End of life (including product recovery and recycling)

The end of life stage begins when the product in scope and its packaging is discarded by the user and ends when the product is returned to nature as a waste product or enters another product's life cycle (i.e. as a recycled input).In general it includes the waste of the product in scope, such as food waste, and primary packaging.

Other waste (different from the product in scope) generated during the manufacturing, distribution, retail, use stage or after use shall be included in the life cycle of the product and modelled at the life cycle stage where it occurs.

The end of life stage shall be modelled using the Circular Footprint Formula and requirements provided in section 4.4.8. The user of the PEF method shall include all EoL processes applicable to the product in scope. Examples of processes to include in this life cycle stage are (non-exhaustive list):

- Collection and transport of product in scope and its packaging to end of life treatment facilities;
- Dismantling of components;
- Shredding and sorting;
- Wastewater of products used dissolved in or with water (e.g. detergents, shower gels, etc.);
- Conversion into recycled material;
- Composting or other organic-waste-treatment methods;
- Incineration and disposal of bottom ash;
- Landfilling and landfill operation and maintenance.

For intermediate products, the EoL of the product in scope shall be excluded.

4.3 Nomenclature for the life cycle inventory

LCI data shall be compliant with EF requirements:

- For the elementary flows, the nomenclature shall be aligned with the most recent version of the EF reference package available on the EF developer's page at the following link http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml. Details to

fulfil this aspect are available at http://eplca.jrc.ec.europa.eu/uploads/MANPROJ-PR-ILCD-Handbook-Nomenclature-and-other-conventions-first-edition-ISBN-fin-v1.0-E.pdf.

- For the process datasets and product flow, the nomenclature shall be compliant with the "ILCD Handbook – Nomenclature and other conventions" (available at: http://eplca.jrc.ec.europa.eu/repository/EF).

4.4 Modelling requirements

This section provides detailed guidance and requirements on how to model specific life cycle stages, processes and other aspects of the product life cycle, in order to compile the life cycle inventory. Covered aspects include:

- Agricultural production;
- Electricity use;
- Transport and logistics;
- Capital goods (infrastructure and equipment);
- Storage at distribution center or retail;
- Sampling procedure;
- Use stage;
- End of life modelling;
- Extended product lifetime;
- Packaging;
- Greenhouse gas emissions and removals;
- Offsets;
- Handling multi-functional processes;
- Data collection requirements and quality requirements;
- Cut-off.

4.4.1 Agricultural production

4.4.1.1 Handling multi-functional processes

The rules described in the LEAP Guideline shall be followed: Environmental performance of animal feeds supply chains (pages 36-43), FAO 2016, available at http://www.fao.org/partnerships/leap/publications/en/.

4.4.1.2 Crop type specific and country, region or climate specific data

Crop type specific and country-region-or-climate specific data for yield, water and land use, land use change, fertiliser (artificial and organic) amount (N, P amount) and pesticide amount (per active ingredient), per hectare per year, should be used.

4.4.1.3 Averaging data

Cultivation data shall be collected over a period of time sufficient to provide an average assessment of the life cycle inventory associated with the inputs and outputs of cultivation

that will offset fluctuations due to seasonal differences. This shall be undertaken as described in the LEAP guidelines[29], set out below:

- For annual crops, an assessment period of at least three years shall be used (to level out differences in crop yields related to fluctuations in growing conditions over the years such as climate, pests and diseases, et cetera). Where data covering a three-year period is not available i.e. due to starting up a new production system (e.g. new greenhouse, newly cleared land, shift to other crop), the assessment may be conducted over a shorter period, but shall be not less than 1 year. Crops or plants grown in greenhouses shall be considered as annual crops/ plants, unless the cultivation cycle is significantly shorter than a year and another crop is cultivated consecutively within that year. Tomatoes, peppers and other crops, which are cultivated and harvested over a longer period through the year are considered as annual crops.

- For perennial plants (including entire plants and edible portions of perennial plants) a steady state situation (i.e. where all development stages are proportionally represented in the studied time period) shall be assumed and a three-year period shall be used to estimate the inputs and outputs[30].

- Where the different stages in the cultivation cycle are known to be disproportional, a correction shall be made by adjusting the crop areas allocated to different development stages in proportion to the crop areas expected in a theoretical steady state. The application of such correction shall be justified and recorded. The LCI of perennial plants and crops shall not be undertaken until the production system actually yields output.

- For crops that are grown and harvested in less than one year (e.g. lettuce produced in 2 to 4 months) data shall be gathered in relation to the specific time period for production of a single crop, from at least three recent consecutive cycles. Averaging over three years may best be done by first gathering annual data and calculating the LCI per year and then determining the three years average.

4.4.1.4 Pesticides

Pesticide emissions shall be modelled as specific active ingredients. The USEtox life cycle impact assessment method has a built-in multimedia fate model which simulates the fate of the pesticides starting from the different emission compartments. Therefore, default emission fractions to environmental emission compartments are needed in the LCI modelling (Rosenbaum et al., 2015). The pesticides applied on the field shall be modelled as 90% emitted to the agricultural soil compartment, 9% emitted to air and 1% emitted to water (based on expert judgement due to current limitations[31]). More specific data may be used if available.

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[29] Environmental performance of animal feeds supply chains, FAO 2016, available at http://www.fao.org/partnerships/leap/publications/en/.

[30] The underlying assumption in the cradle to gate life cycle inventory assessment of horticultural products is that the inputs and outputs of the cultivation are in a 'steady state', which means that all development stages of perennial crops (with different quantities of inputs and outputs) shall be proportionally represented in the time period of cultivation that is studied. This approach gives the advantage that inputs and outputs of a relatively short period can be used for the calculation of the cradle-to-gate life cycle inventory from the perennial crop product. Studying all development stages of a horticultural perennial crop can have a lifespan of 30 years and more (e.g. in case of fruit and nut trees).

[31] Several databases consider a 100% emitted to soil out of simplification (e.g. Agribalyse and Ecoinvent). It is recognized that emissions to freshwater and air do occur. However, emission fractions vary significantly depending on the type of pesticide, the geographical location, time of application and application technique (ranging from 0% to 100%). Especially the % emitted to water can be strongly debated, however, overall it seems that 1% indicates a reasonable average (e.g. WUR-Alterra 2016: Emissies landbouwbestrijdingsmiddelen).

4.4.1.5 Fertilisers

Fertiliser (and manure) emissions shall be differentiated per fertiliser type and cover as a minimum:

- NH_3, to air (from N-fertiliser application);

- N_2O, to air (direct and indirect) (from N-fertiliser application);

- CO_2, to air (from lime, urea and urea-compounds application);

- NO_3, to water unspecified (leaching from N-fertiliser application);

- PO_4, to water unspecified or freshwater (leaching and run-off of soluble phosphate from P-fertiliser application);

- P, to water unspecified or freshwater (soil particles containing phosphorous, from P-fertiliser application).

The impact assessment model for freshwater eutrophication starts (i) when P leaves the agricultural field (run off) or (ii) from manure or fertiliser application on agricultural field. Within LCI modelling, the agricultural field (soil) is often seen as belonging to the technosphere and thus included in the LCI model. This aligns with approach (i), where the impact assessment model starts after run-off, i.e. when P leaves the agricultural field. Therefore, within the EF context, the LCI should be modelled as the amount of P emitted to water after run-off and the emission compartment 'water' shall be used. When this amount is not available, the LCI may be modelled as the amount of P applied on the agricultural field (through manure or fertilisers) and the emission compartment 'soil' shall be used. In this case, the run-off from soil to water is part of the impact assessment method and included in the CF for soil.

The impact assessment marine eutrophication starts after N leaves the field (soil). Therefore, N emissions to soil shall not be modelled. The amount of emissions ending up in the different air and water compartments per amount of fertilisers applied on the field shall be modelled within the LCI. Nitrogen emissions shall be calculated from nitrogen applications of the farmer on the field and excluding external sources (e.g. rain deposition). To avoid strong inconsistencies among different PEFCRs, the number of emissions factors is fixed in the EF context by following a simplified approach. For Nitrogen-based fertilisers, the Tier 1 emissions factors of Table 2-4 of IPCC 2006 shall be used, as reproduced in **Table 3**, except when better data is available. In case better data is available, a more comprehensive nitrogen field model may be used in the PEF study, provided (i) it covers at least the emissions requested above, (ii) nitrogen shall be balanced in inputs and outputs and (iii) it shall be described in a transparent way.

Table 3 Tier 1 emissions factors of IPCC 2006 (modified). Note that these values shall not be used to compare different types of synthetic fertilizers.

Emission	Compartment	Value to be applied
N_2O (synthetic fertiliser and manure; direct and indirect)	Air	**0.022 kg N_2O/ kg N fertilizer applied**
NH_3 (synthetic fertiliser)	Air	kg NH_3= kg N * FracGASF= 1*0.1* (17/14)= **0.12 kg NH_3/ kg N fertilizer applied**

Emission	Compartment	Value to be applied
NH_3 (manure)	Air	kg NH_3= kg N*FracGASF= 1*0.2*(17/14)= **0.24 kg NH_3/ kg N manure applied**
NO_3^- (synthetic fertiliser and manure)	Water	kg NO_3^- = kg N*FracLEACH = 1*0.3*(62/14) = **1.33 kg NO_3^-/ kg N applied**

FracGASF: fraction of synthetic fertiliser N applied to soils that volatilises as NH_3 and NO_x.
FracLEACH: fraction of synthetic fertiliser and manure lost to leaching and runoff as NO3-
.

The above nitrogen field model has limitations, therefore, a PEF study which has agricultural modelling in scope may test the following alternative approach and report the results in an Annex of the PEF report:

The N-balance is calculated using the parameters in Table 4 and the formula below. The total NO_3-N emission to water is considered a variable and its total inventory shall be calculated as:

"Total NO_3-N emission to water" = "NO_3^- base loss" + "additional NO_3-N emissions to water", with

"Additional NO_3-N emissions to water" = "N input with all fertilisers" + "N_2 fixation by crop" – "N-removal with the harvest" – "NH_3 emissions to air" – "N_2O emissions to air" – "N_2 emissions to air" -"NO_3^- base loss".

If in certain low-input schemes the value for "additional NO_3-N emissions to water" becomes negative, the value is to be set to "0". Moreover, in such cases the absolute value of the calculated "additional NO_3-N emissions to water" is to be inventoried as additional N-fertiliser input into the system, using the same combination of N-fertilisers as employed to the analysed crop. This last step serves to avoid fertility-depletion schemes by capturing the N-depletion by the analysed crop that is assumed to lead to the need for additional fertiliser later on and to keep the same soil fertility level.

Table 4 Alternative approach to nitrogen modelling

Emission	Compart-ment	Value to be applied
NO_3^- base loss (synthetic fertiliser and manure)	Water	kg NO_3^-= kg N*FracLEACH = 1*0.1*(62/14) = 0.44 kg NO_3^-/ kg N applied
N_2O (synthetic fertiliser and manure; direct and indirect)	Air	0.022 kg N_2O/ kg N fertilizer applied
NH_3 - Urea (synthetic fertiliser)	Air	kg NH_3= kg N * FracGASF= 1*0.15* (17/14)= 0.18 kg NH_3/ kg N fertilizer applied

Emission	Compart-ment	Value to be applied
NH$_3$ - Ammonium nitrate (synthetic fertiliser)	Air	kg NH$_3$= kg N * FracGASF= 1*0.1* (17/14)= 0.12 kg NH$_3$/ kg N fertilizer applied
NH$_3$ - others (synthetic fertiliser)	Air	kg NH$_3$= kg N * FracGASF= 1*0.02* (17/14)= 0.024 kg NH$_3$/ kg N fertilizer applied
NH$_3$ (manure)	Air	kg NH$_3$= kg N*FracGASF= 1*0.2* (17/14)= 0.24 kg NH$_3$/ kg N manure applied
N$_2$-fixation by crop		For crops with symbiotic N$_2$-fixation: the fixed amount is assumed to be identical to the N-content in the harvested crop
N$_2$	Air	0.09 kg N$_2$/ kg N applied

4.4.1.6 Heavy metal emissions

Heavy metal emissions from field inputs shall be modelled as emission to soil and/or leaching or erosion to water. The inventory to water shall specify the oxidation state of the metal (e.g., Cr^{+3}, Cr^{+6}). As crops assimilate part of the heavy metal emissions during their cultivation clarification is needed on how to model crops that act as a sink. Two different modelling approaches are allowed:

- The final fate of the heavy metals elementary flows are not further considered within the system boundary: the inventory does not account for the final emissions of the heavy metals and therefore shall not account for the uptake of heavy metals by the crop. For example, heavy metals in agricultural crops cultivated for human consumption end up in the plant. Within the EF context human consumption is not modelled, the final fate is not further modelled and the plant acts as a heavy metal sink. Therefore, the uptake of heavy metals by the crop shall not be modelled.

- The final fate (emission compartment) of the heavy metal elementary flows is considered within the system boundary: the inventory does account for the final emissions (release) of the heavy metals in the environment and therefore shall also account for the uptake of heavy metals by the crop. For example, heavy metals in agricultural crops cultivated for feed will mainly end up in the animal digestion and used as manure back on the field where the metals are released in the environment and their impacts are captured by the impact assessment methods. Therefore, the inventory of the agricultural stage shall account for the uptake of heavy metals by the crop. A limited amount ends up in the animal, which may be neglected for simplification.

4.4.1.7 Rice cultivation

Methane emissions from rice cultivation shall be included based on the calculation rules of IPCC (2006) (Volume 4, Chapter 5.5, page 44-53).

4.4.1.8 Peat soils

Drained peat soils shall include carbon dioxide emissions on the basis of a model that relates the drainage levels to annual carbon oxidation.

4.4.1.9 Other activities

If applicable, the following activities shall be included in agricultural modelling, unless its exclusion is allowed based on the cut-off criteria:

- Input of seed material (kg/ha),

- Input of peat to soil (kg/ha + C/N ratio),

- Input of lime (kg $CaCO_3$/ha, type),

- Machine use (hours, type) (to be included if there is high level of mechanisation),

- Input N from crop residues that stay on the field or are burned (kg residue + N content/ha). Including emissions from residues burning, drying and storage of products.

Unless it is clearly documented that operations are carried out manually, field operations shall be accounted for through total fuel consumption or through inputs of specific machinery, transports to/ from the field, energy for irrigation, etc.

4.4.2 Electricity use

Electricity from the grid shall be modelled as precisely as possible giving preference to supplier-specific data. If (part of) the electricity is renewable it is important that no double counting occurs. Therefore, the supplier shall guarantee that the electricity supplied to the organisation to produce the product is effectively generated using renewable sources and is not available anymore for other consumers.

4.4.2.1 General guidelines

The following chapter introduces two types of electricity mixes: (i) the consumption grid mix which reflects the total electricity mix transferred over a defined grid including green claimed or tracked electricity, and (ii) the residual grid mix, consumption mix (also named residual consumption mix), which characterizes the unclaimed, untracked or publicly shared electricity only.

In PEF studies the following electricity mix shall be used, in hierarchical order:

(a) Supplier-specific electricity product[32] shall be used if for a country there is a 100% tracking system in place, or if :

    (i) available, and

    (ii) the set of minimum criteria to ensure the contractual instruments are reliable is met.

(b) The supplier-specific total electricity mix shall be used if:

    (i) available, and

    (ii) the set of minimum criteria to ensure the contractual instruments are reliable is met.

(c) The 'country-specific residual grid mix, consumption mix' shall be used. Country-specific means the country in which the life cycle stage or activity occurs. This may be an EU country or non-EU country. The residual grid mix

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[32] See ISO 14067

This JRC technical report is a working document and does not modify Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations

প্রেvents double counting with the use of supplier-specific electricity mixes in (a) and (b).

    (d) As a last option, the average EU residual grid mix, consumption mix (EU-28 +EFTA), or region representative residual grid mix, consumption mix, shall be used.

The environmental integrity of the use of supplier-specific electricity mix depends on ensuring that contractual instruments (for tracking) **reliably and uniquely convey claims to consumers**. Without this, the PEF lacks the accuracy and consistency necessary to drive product/corporate electricity procurement decisions and accurate consumer (buyer of electricity) claims. Therefore, a set of **minimum criteria** that relate to the integrity of the contractual instruments as reliable conveyers of environmental footprint information has been identified. They represent the minimum features necessary to use supplier-specific mix within PEF studies.

4.4.2.2 Set of minimum criteria to ensure contractual instruments from suppliers

A supplier-specific electricity product/ mix may only be used if the user of the PEF method ensures that the contractual instrument meets the criteria specified below. If contractual instruments do not meet the criteria, then country-specific residual electricity consumption-mix shall be used in the modelling.

The list of criteria below is based on the criteria of the GHG Protocol Scope 2 Guidance – An amendment to the GHG Protocol Corporate Standard (Mary Sotos, World Resource Institute). A contractual instrument used for electricity modelling shall:

Criterion 1 – Convey attributes

Convey the energy type mix associated with the unit of electricity produced.

The energy type mix shall be calculated based on delivered electricity, incorporating certificates sourced and retired (obtained or acquired or withdrawn) on behalf of its customers. Electricity from facilities for which the attributes have been sold off (via contracts or certificates) shall be characterized as having the environmental attributes of the country residual consumption mix where the facility is located.

Criterion 2 – Be a unique claim

Be the only instruments that carry the environmental attribute claim associated with that quantity of electricity generated.

Be tracked and redeemed, retired, or cancelled by or on behalf of the company (e.g. by an audit of contracts, third party certification, or may be handled automatically through other disclosure registries, systems, or mechanisms).

Criterion 3 – Be as close as possible to the period to which the contractual instrument is applied

Table 5 Minimum criteria to ensure contractual instruments from suppliers – guidance to fulfil criteria

Criterion 1	CONVEY ENVIRONMENTAL ATTRIBUTES AND GIVE EXPLANATION ABOUT THE CALCULATION METHOD • Convey the energy type mix (or other related environmental attributes) associated with the unit of electricity produced. • Give explanation about the calculation method used to determine this mix

Context	Each programme or policy will establish their own eligibility criteria and the attributes to be conveyed. These criteria specify energy resource type and certain energy generation facility characteristics, such as type of technologies, facility ages, or facility locations (but differ from one programme/ policy to another). These attributes specify the energy resource type and sometimes some energy generation facility characteristics.
Conditions for satisfying the criterion	1. Convey the energy mix: If there is no energy type mix specified in the contractual instruments, ask your supplier to receive this information or other environmental attributes (e.g. GHG emission rate). If the supplier does not answer, use the 'country-specific residual grid mix, consumption mix'. If the supplier answers, go to step 2).
	2. Give explanation about the calculation method used: Ask your supplier to provide calculation method details to ensure that they follow the above principle. If the supplier does not provide the information, apply the supplier-specific electricity mix, include the information received and document that it was not possible to check for double counting.
Criterion 2	**UNIQUE CLAIMS** • Be the only instrument that carries the environmental attribute claim associated with that quantity of electricity generation. • Be tracked and redeemed, retired, or cancelled by or on behalf of the company (e.g. by an audit of contracts, third party certification, or may be handled automatically through other disclosure registries, systems, or mechanisms).
Context	Certificates generally serve four main purposes, including (i) supplier disclosure, (ii) supplier quotas for the delivery or sales of specific energy sources, (iii) tax exemption, (iv) voluntary consumer programmes. Each programme or policy will establish their own eligibility criteria. These criteria specify certain energy generation facility characteristics, such as type of technologies, facility ages, or facility locations (but differ from one program/policy to another one). Certificates shall come from facilities meeting these criteria to be eligible for use in that programme. In addition, individual country markets or policy-making bodies may accomplish these different functions using a single certificate system or a multi-certificate system.
Conditions for satisfying the criterion	1. Is the plant located in a country with no tracking system? Consult the following report – Table 2: https://www.aib-net.org/documents/103816/176792/AIB_2016_Residual_Mix_Results.pdf/6b49295b-ad99-a189-579e-877449778f62 If yes, use the 'country-specific residual grid mix, consumption mix'; If no, go to the second question.

	2. Is the plant located in a country with a part of untracked consumption (> 95%)?
	If yes, use the 'country-specific residual grid mix, consumption mix' as the best data available to approximate the residual consumption mix;
	If no, go to the 3rd question.
	3. Is the plant located in a country with a single certificate system or a multi-certificate system? Consult the following report: https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/e-track_ii_guarantees_of_origin_in_europe.pdf. Then :
	If the plant is located in a region/country with a single certificate system the unique claim criteria is met. Use energy type mix mentioned on the contractual instrument.
	If the plant is located in a region/country with a multi-certificate system, the unique claim is not ensured. Contact the country-specific issuing body (The European organisation which governs the European Energy Certificate System, http://www.aib-net.org) to identify if there is a need to ask for more than one contractual instrument(s) to be sure there is no risk of double counting.
	If more than one contractual instrument is needed, request all contractual instruments at the supplier to avoid double counting;
	If it is not possible to avoid double counting, report this risk of double counting in the PEF study and use the 'country-specific residual grid mix, consumption mix'.
Criteria 3	**Be issued and redeemed as close as possible to the period of electricity consumption to which the contractual instrument is applied.**

4.4.2.3 How to model 'country-specific residual grid mix, consumption mix'

Datasets for residual grid mix, consumption mix, per energy type, per country and per voltage are made available by data providers.

If no suitable dataset is available, the following approach should be used:

Determine the country consumption mix (e.g. X% of MWh produced with hydro energy, Y% of MWh produced with coal power plant) and combine them with LCI datasets per energy type and country/region (e.g. LCI dataset for the production of 1MWh hydro energy in Switzerland):

- Activity data related to non-EU country consumption mix per detailed energy type shall be determined based on:
  - o Domestic production mix per production technologies;
  - o Import quantity and from which neighbouring countries;
  - o Transmission losses;
  - o Distribution losses;
  - o Type of fuel supply (share of resources used, by import and / or domestic supply).

These data may be found in the publications of the International Energy Agency (IEA) (www.iea.org).

- Available LCI datasets per fuel technologies. The LCI datasets available are generally specific to a country or a region in terms of:
  - o fuel supply (share of resources used, by import and/ or domestic supply);
  - o energy carrier properties (e.g. element and energy contents);
  - o technology standards of power plants regarding efficiency, firing technology, flue-gas desulphurisation, NOx removal and de-dusting.

4.4.2.4 A single location with multiple products and more than one electricity mix

This chapter describes how to proceed if only a part of the electricity use is covered by a supplier-specific mix or on-site electricity generation and how to attribute the electricity mix among products produced at the same location. In general, the subdivision of electricity supply used among multiple products is based on a physical relationship (e.g. number of pieces or kg of product). If the consumed electricity comes from more than one electricity mix, each mix source shall be used in terms of its proportion in the total kWh consumed. For example, if a fraction of this total kWh consumed is coming from a specific supplier, a supplier-specific electricity mix shall be used for this part. See section 4.4.2.7 for on-site electricity use.

A specific electricity type may be allocated to one specific product in the following conditions:

- (a) If the production (and related electricity consumption) of a product occurs in a separate site (building), the energy type that is physically related to this separated site may be used.

- (b) If the production (and related electricity consumption) of a product occurs in a shared space with specific energy metering or purchase records or electricity bills, the product-specific information (measure, record, bill) may be used.

- (c) If all the products produced in the specific plant are supplied with a publically available PEF study, the company wanting to make the claim shall make all PEF studies available. The allocation rule applied shall be described in the PEF study, consistently applied in all PEF studies connected to the site and verified. An example is the 100% allocation of a greener electricity mix to a specific product.

4.4.2.5 For multiple locations producing one product

In case a product is produced in different locations or sold in different countries, the electricity mix shall reflect the ratios of production or ratios of sales between EU countries/ regions. To determine the ratio, a physical unit shall be used (e.g. number of pieces or kg of product). For PEF studies where such data are not available, the average EU residual consumption mix (EU-28 +EFTA), or region-representative residual mix, shall be used. The same general guidelines mentioned above shall be applied.

4.4.2.6 Electricity use at the use stage

For the use stage the consumption grid mix shall be used. The electricity mix shall reflect the ratios of sales between EU countries/ regions. To determine the ratio, a physical unit shall be used (e.g. number of pieces or kg of product). Where such data are not available,

the average EU consumption mix (EU-28 +EFTA), or region-representative consumption mix, shall be used.

4.4.2.7 How to deal with on-site electricity generation?

If on-site electricity production is equal to the site own consumption, two situations apply:

- No contractual instruments have been sold to a third party: the user of the PEF method shall model its own electricity mix (combined with LCI datasets).

- Contractual instruments have been sold to a third party: the user of the PEF method shall use 'country-specific residual grid mix, consumption mix' (combined with LCI datasets).

If electricity is produced in excess of the amount consumed on-site within the defined system boundary and is sold to, for example, the electricity grid, this system may be seen as a multifunctional situation. The system will provide two functions (e.g. product + electricity) and the following rules shall be followed:

- If possible, apply subdivision. Subdivision applies both to separate electricity productions or to a common electricity production where you may allocate based on electricity amounts the upstream and direct emissions to your own consumption and to the share you sell out of your company (e.g. if a company has a windmill on its production site and exports 30% of the produced electricity, emissions related to 70% of produced electricity should be accounted in the PEF study).

- If not possible, direct substitution shall be used. The country-specific residual consumption electricity mix shall be used as substitution[33].

- Subdivision is considered as not possible when upstream impacts or direct emissions are closely related to the product itself.

4.4.3 Transport and logistics

Important parameters that shall be taken into account when modelling transport include:

(1) **Transport type:** The type of transport, e.g. by land (truck, rail, pipe), by water (boat, ferry, barge), or air (airplane);

(2) **Vehicle type & fuel consumption:** The type of vehicle by transport type, as well as the fuel consumption when fully loaded and empty. An adjustment shall be applied to the consumption of a fully-loaded vehicle according to loading rate[34];

(3) **Loading rate (=utilisation ratio):** Environmental impacts are directly linked to the actual loading rate, which shall therefore be considered;

(4) **Number of empty returns:** the number of empty returns (i.e. the ratio of the distance travelled to collect the next load after unloading the product to the distance travelled to transport the product), when applicable and relevant, shall be taken into account .The kilometres travelled by the empty vehicle shall be allocated to the product. In default transport datasets this is often already taken into account in the default utilisation ratio;

(5) **Transport distance**: Transport distances shall be documented, applying average transport distances specific to the context being considered;

(6) **Fuel production:** Fuel production shall be taken into account;

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[33] For some countries, this option is a best case rather than a worst case.
[34] The loading rate is the ratio of actual load to the full load or capacity (e.g. mass or volume) that a vehicle carries per trip.

(7) **Infrastructure:** the transport infrastructure, that of road, rail and water, unless they may be excluded based on section 4.4.4 or the cut-off criteria;

(8) **Resources and tools:** the amount and type of additional resources and tools needed for logistic operations such as cranes and transporters, unless they may be excluded based on the cut-off criteria.

4.4.3.1 Allocation of impacts from transport – truck transport

EF compliant datasets for truck transport are per tkm (tonne*km) expressing the environmental impact for 1 tonne of product that is transported for 1km in a truck with certain load. The transport payload (=maximum mass allowed) is indicated in the dataset. For example, a truck of 28-32t has a payload of 22t; the LCA dataset for 1 tkm (fully loaded) expresses the environmental impact for 1 ton of product that is transported for 1km within a 22t loaded truck. The transport emissions are allocated based on the mass of the product transported and you get only 1/22 share of the full emissions of the truck. When the mass of a full freight is lower than the load capacity of the truck (e.g., 10t), the transport of the product may be considered volume limited. In this case, the truck has less fuel consumption per total load transported and the environmental impact for the full load is 10/22 of the total emissions of the volume limited truck. Therefore, the allocation of truck impact shall be based on mass.

In EF compliant datasets the transport payload is modelled in a parameterised way through the utilisation ratio. The utilisation ratio is calculated as the kg real load divided by the kg payload and shall be adjusted upon the use of the dataset. In case the real load is 0 kg, a real load of 1 kg shall be used to allow the calculation. Empty return trips may be included in the utilisation ratio by considering the % of empty km driven. E.g., if the truck is fully loaded for delivery but half empty at its return, the utilisation ratio is (22t real load / 22t payload * 50% km + 11t real load / 22t payload * 50% km) = 75%

PEF studies shall specify the utilisation ratio to be used for each truck transport modelled and clearly indicate whether the utilisation ratio includes empty return trips.

- If the load is mass-limited: a default utilisation ratio of 64%[35] shall be used, unless specific data is available. This default utilisation ratio includes empty return trips and thus shall not be modelled separately.

- Bulk transport (e.g., gravel transport from mining pit to concrete plant) shall be modelled with a default utilisation ratio of 50% (100% loaded outbound and 0% loaded inbound), unless specific data is available.

4.4.3.2 Allocation of impacts from transport – van transport

Vans are often used for home delivery products like books and clothes or home delivery from retailers. For vans volume is the limiting factor, rather than mass. Often the van is half empty. If no specific information is available to perform the PEF study, a lorry of <1.2t with a default utilisation ratio of 50% shall be used. In case no dataset of a lorry of <1.2t is available, a lorry of <7.5t shall be used as approximation, with an utilisation ratio of 20%. A lorry of <7.5t with a payload of 3.3t and an utilisation ratio of 20% comes to the same load as a van with payload of 1.2t and utilisation ratio of 50%.

4.4.3.3 Allocation of impacts from transport – consumer transport

Allocation of the car impact shall be based on volume. The maximum volume to be considered for consumer transport is 0.2 m^3 (around 1/3 of a trunk of 0.6 m^3). For products larger than 0.2 m^3 the full car transport impact shall be considered. For products sold through supermarkets or shopping malls, the product volume (including packaging and empty spaces such as between fruits or bottles) shall be used to allocate the transport

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[35] Eurostat 2015 indicates that 21% of the km truck transport are driven with empty load and 79% are driven loaded (with an unknown load). In Germany only, the average truck load is 64%.

burdens between the products transported. The allocation factor shall be calculated as the volume of the product transported divided by 0.2 m^3. To simplify the modelling, all other types of consumer transport (like buying in specialised shops or using combined trips) shall be modelled as if sold through a supermarket.

4.4.3.4 Default scenarios – from supplier to factory

If no specific data are available to perform the PEF study, then the default data provided below shall be used:

For suppliers located within Europe

For packaging materials from manufacturing plants to filler plants (beside glass; values based on Eurostat 2015[36]), the following scenario shall be used:

- 230 km by truck (>32 t, EURO 4); and
- 280 km by train (average freight train); and
- 360 km by ship (barge).

For transport of empty bottles, the following scenario shall be used:

- 350 km by truck (>32 t, EURO 4); and
- 39 km by train (average freight train); and
- 87 km by ship (barge).

For all other products from supplier to factory (values based on Eurostat 2015[37]), the following scenario shall be used:

- 130 km by truck (>32 t, EURO 4); and
- 240 km by train (average freight train); and
- 270 km by ship (barge).

For suppliers located outside of Europe

- 1000 km by truck (>32 t, EURO 4), for the sum of distances from harbour/ airport to factory outside and inside Europe; and
- 18,000 km by ship (transoceanic container) or 10,000 km by plane (cargo).
- If producers' country (origin) is known: the adequate distance for ship and airplane should be determined using https://www.searates.com/services/distances-time/ or https://co2.myclimate.org/en/flight_calculators/new

In case it is not known whether the supplier is located within or outside of Europe, transport shall be modelled as if the supplier was located outside of Europe.

4.4.3.5 Default scenarios – from factory to final client

The transport from factory to final client (including consumer transport) shall be included in the distribution stage of the PEF study. In case no specific information is available, the default scenario outlined below shall be used as a basis (see Figure 3). The following values shall be determined by the user of the PEF method (specific information shall be used, unless it is not available):
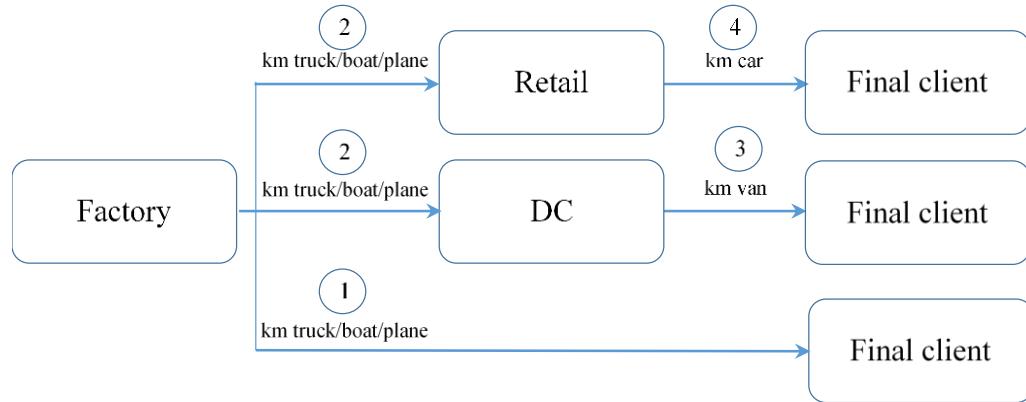
- Ratio between products sold through retail, distribution centre (DC) and directly to the final client;

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[36] Calculated as the mass weighted average of the goods categories 06, 08 and 10 using the Ramon goods classification for transport statistics after 2007. The category 'non-metallic mineral products' are excluded as they can double count with glass.

[37] Calculated as the mass weighted average of the goods of all categories.

- For factory to final client: Ratio between local, intracontinental and international supply chains;

- For factory to retail: distribution between intracontinental and international supply chains.

Figure 3 *Default transport scenario*

(1) X% from factory to final client:

- X% local supply chain: 1,200 km by truck (>32 t, EURO 4)

- X% intracontinental supply chain: 3,500 km by truck (>32 t, EURO 4)

- X% international supply chain: 1,000 km by truck (>32 t, EURO 4) and 18'000 km by ship (transoceanic container). Note that for specific cases, plane or train may be used instead of ship.

(2) X% from factory to retail/ distribution centre (DC):

- X% local supply chain: 1,200 km by truck (>32 t, EURO 4).

- X% intracontinental supply chain: 3,500 km by truck (>32 t, EURO 4).

- X% international supply chain: 1,000 km truck (>32 t, EURO 4), and 18'000 km by ship (transoceanic container). Note that for specific cases, plane or train may be used instead of ship.

(3) X% from DC to final client:

- 100% Local: 250 km round trip by van (lorry <7.5t, EURO 3, utilisation ratio of 20%).

(4) X% from retail to final client:

- 62%: 5 km, by passenger car (average)

- 5%: 5 km round trip, by van (lorry <7.5t, EURO 3 with utilisation ratio of 20%)

- 33%: no impact modelled

For reusable products the return transport from retail/ DC to factory shall be modelled in addition to the transport needed to go to retail/ DC. The same transport distances as from

product factory to final client shall be used (see above), however the truck utilisation ratio might be volume limited depending on the type of product.

Products frozen or cooled shall be transported in freezers or coolers.

4.4.3.6 Default scenarios – from EoL collection to EoL treatment

The transport from collection place to EoL treatment may already be included in the landfill, incineration and recycling LCA datasets.

However, there are some cases where additional default data may be needed in the PEF study. The following values shall be used in case no better data is available:

- Consumer transport from home to sorting place: 1 km by passenger car;
- Transport from collection place to methanisation: 100 km by truck (>32 t, EURO 4);
- Transport from collection place to composting: 30 km by truck (lorry <7.5t, EURO).

4.4.4 Capital goods – infrastructure and equipment

Capital goods (including infrastructures) and their end of life should be excluded, unless there is evidence from previous studies that they are relevant. If capital goods are included, the PEF report shall include a clear and extensive explanation, reporting all assumptions made.

4.4.5 Storage at distribution centre or retail

Storage activities consume energy and refrigerant gases. The following default data shall be used, unless better data is available:

Energy consumption at distribution centre: the storage energy consumption is 30 kWh/m²·year and 360 MJ bought (= burnt in boiler) or 10 Nm³ natural gas/m²·year (if using the value per Nm³, do not forget to consider emissions from combustion and not only production of natural gas). For centres that contain cooling systems, the additional energy use for the chilled or frozen storage is 40 kWh/m³·year (with an assumption of 2m high for the fridges and freezers). For centres with both ambient and cooled storage: 20% of the area of the DC is chilled or frozen. Note: the energy for chilled or frozen storage is only the energy to maintain the temperature.

Energy consumption at retail: A general energy consumption of 300 kWh/m²·year for the entire building surface shall be considered as default. For retail specialized in non-food/ non-beverage products a 150 kWh/m²·year for the entire building surface shall be considered. For retail specialized in food/ beverage products a 400 kWh/m²·year for the entire building surface plus energy consumption for chilled and frozen storage of 1,900 kWh/m²·year and 2700 kWh/m²·year respectively is to be considered (PERIFEM and ADEME, 2014).

Refrigerant gases consumption and leakages at DCs with cooling systems: gas content in fridges and freezers is 0.29 kg R404A per m² (retail OEFSR[38]). A 10% annual leakage is considered (Palandre 2003). For the portion of refrigerant gases remaining in the equipment at end of life, 5% is emitted at end of life and the remaining fraction is treated as hazardous waste.

Only part of the emissions and resources emitted or used at storage systems shall be allocated to the product stored. This allocation shall be based on the space (in m³) and time (in weeks) occupied by the product stored. For this the total storage capacity of the system shall be known, and the product specific volume and storage time shall be used to

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[38] The OEFSR of the retail sector (v 1.0) is available at http://ec.europa.eu/environment/eussd/smgp/pdf/OEFSR-Retail_15052018.pdf.

calculate the allocation factor (as the ratio between product-specific volume*time and storage capacity volume*time).

An average DC is assumed to store 60,000 m^3 of product, out of which 48,000 m^3 for ambient storage and 12,000 m^3 for chilled or frozen storage. For a storage time of 52 weeks, a default total storage capacity of 3,120,000 m^3*weeks/year shall be assumed.

An average retail place is assumed to store 2000 m^3 of products (assuming 50% of the 2000 m^2 building is covered by shelves of 2 m high) during 52 weeks, i.e. 104,000 m^3 * weeks/year.

4.4.6 Sampling procedure

In some cases, a sampling procedure is needed by the user of the PEF method to limit the data collection only to a representative sample of plants, farms etc. The user of the PEF method shall (i) specify in the PEF report if sampling was applied, (ii) follow the requirements described in this section and (iii) indicate which approach was chosen.

Examples of cases when the sampling procedure may be needed are in case multiple production sites are involved in the production of the same product. E.g., in case the same raw material/input material comes from multiple sites or in case the same process is outsourced to more than one subcontractor/ supplier.

The representative sample shall be derived via a stratified sample, i.e. one that ensures that sub-populations (strata) of a given population are each adequately represented within the whole sample of a research study.

Using a stratified sample allows to achieve greater precision than a simple random sample, provided that the sub-populations have been chosen so that the items of the same sub-population are as similar as possible in terms of the characteristics of interest. In addition, a stratified sample guarantees better coverage of the population[39].

The following procedure shall be applied in order to select a representative sample as a stratified sample:

     (1)   define the population;

     (2)   define homogeneous sub-populations (stratification);

     (3)   define the sub-samples at sub-population level;

     (4)   define the sample for the population starting from the definition of sub-samples at sub-population level.

4.4.6.1 How to define homogeneous sub-populations (stratification)

Stratification is the process of dividing members of the population into homogeneous subgroups (sub-populations) before sampling. The sub-populations should be mutually exclusive: every element in the population shall be assigned to only one sub-population.

Aspects at least to be taken into consideration in the identification of the sub-populations:

- Geographical distribution of sites;

- Technologies/ farming practices involved;

- Production capacity of the companies/ sites taken into consideration.

Additional aspects to be taken into consideration may be added.

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[39]   The researcher has control over the sub-populations that are included in the sample, whereas simple random sampling does not guarantee that sub-populations (strata) of a given population are each adequately represented within the final sample. However, one main disadvantage of stratified sampling is that it may be difficult to identify appropriate sub-populations for a population.

The number of sub-populations shall be identified as:

$$Nsp = g * t * c \quad \text{[Equation 1]}$$

- Nsp: number of sub-populations
- g : number of countries in which the sites/plants/farms are located
- t : number of technologies/farming practices
- c : number of classes of capacity of companies

In case additional aspects are taken into account, the number of sub-populations is calculated using the formula just provided and multiplying the result with the numbers of classes identified for each additional aspect (e.g., those sites which have an environmental management or reporting systems in place).

Example 1

Identify the number of sub-populations for the following population:

350 farmers located in the same region in Spain, all the farmers have more or less the same annual production and are characterized by the same harvestings techniques.

In this case:

g=1 : all the farmers are located in the same country

t=1 : all the framers are using the same harvesting techniques

c=1 : the capacity of the companies is almost the same (i.e. the have the same annual production)

$$Nsp = g * t * c = 1 * 1 * 1 = 1$$

Only one sub-population may be identified that coincides with the population.

Example 2

350 farmers are distributed in three different countries (100 in Spain, 200 in France and 50 in Germany). There are two different harvesting techniques that are used that differ in a relevant way (Spain: 70 technique A, 30 technique B; France: 100 technique A, 100 technique B; Germany: 50 technique A). The capacity of the farmers in term of annual production varies between 10,000t and 100,000t. According to expert judgement/ relevant literature, it has been estimated that farmers with an annual production lower than 50,000t are completely different in terms of efficiency compared to the farmers with an annual production higher than 50,000t. Two classes of companies are defined based on the annual production: class 1, if production is lower than 50000 and class 2, if production if higher than 50,000. (Spain: 80 class 1, 20 class 2; France: 50 class 1, 150 class 2; Germany: 50 class 1).

Table **6** includes the details about the population.

Table 6 Identification of the sub-population for Example 2

Sub-population	Country		Technology		Capacity	
1	Spain	100	Technique A	70	Class 1	50
2	Spain		Technique A		Class 2	20

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Sub-population	Country		Technology		Capacity	
3	Spain		Technique B	30	Class 1	30
4	Spain		Technique B		Class 2	0
5	France	200	Technique A	100	Class 1	20
6	France		Technique A		Class 2	80
7	France		Technique B	100	Class 1	30
8	France		Technique B		Class 2	70
9	Germany	50	Technique A	50	Class 1	50
10	Germany		Technique A		Class 2	0
11	Germany		Technique B	0	Class 1	0
12	Germany		Technique B		Class 2	0

In this case:

g=3 : three countries

t=2 : two different harvesting techniques are identified

c=2 : two classes of production are identified

$$Nsp = g * t * c = 3 * 2 * 2 = 12$$

It is possible to identify maximum 12 sub-populations that are summarized in Table 7:

Table 7 *Summary of the sub-population for example 2*

Sub-population	Country	Technology	Capacity	Number of companies in the sub-population
1	Spain	Technique A	Class 1	50
2	Spain	Technique A	Class 2	20
3	Spain	Technique B	Class 1	30
4	Spain	Technique B	Class 2	0
5	France	Technique A	Class 1	20
6	France	Technique A	Class 2	80
7	France	Technique B	Class 1	30

Sub-population	Country	Technology	Capacity	Number of companies in the sub-population
8	France	Technique B	Class 2	70
9	Germany	Technique A	Class 1	50
10	Germany	Technique A	Class 2	0
11	Germany	Technique B	Class 1	0
12	Germany	Technique B	Class 2	0

4.4.6.2 How to define sub-sample size at sub-population level

Once the sub-populations have been identified, for each sub-population the size of sample shall be calculated (the sub-sample size). Two approaches are possible:

(1) Based on the total production of the sub-population:

The user of the PEF method shall identify the percentage of production to be covered by each sub-population. The percentage of production to be covered by each sub-population shall not be lower than 50%, expressed in the relevant unit. This percentage determines the sample size within the sub-population.

(2) Based on the number of sites/farms/plants involved in the sub-population:

The required sub-sample size shall be calculated using the square root of the sub-population size.

$$n_{SS} = \sqrt{n_{SP}} \qquad \text{[Equation 2]}$$

- n_{SS}: required sub-sample size
- n_{SP}: sub-population size

The chosen approach shall be specified in the PEF report. The same approach shall be used for all the sub-populations selected.

Example

Table 8 Example: how to calculate the number of companies in each sub-sample

Sub-population	Country	Technology	Capacity	Number of companies in the sub-population	Number of companies in the sample (sub-sample size, [n_{SS}])
1	Spain	Technique A	Class 1	50	7
2	Spain	Technique A	Class 2	20	5

Sub-population	Country	Technology	Capacity	Number of companies in the sub-population	Number of companies in the sample (sub-sample size, [n_{SS}])
3	Spain	Technique B	Class 1	30	6
4	Spain	Technique B	Class 2	0	0
5	France	Technique A	Class 1	20	5
6	France	Technique A	Class 2	80	9
7	France	Technique B	Class 1	30	6
8	France	Technique B	Class 2	70	8
9	Germany	Technique A	Class 1	50	7
10	Germany	Technique A	Class 2	0	0
11	Germany	Technique B	Class 1	0	0
12	Germany	Technique B	Class 2	0	0

4.4.6.3 How to define the sample for the population

The representative sample of the population corresponds to the sum of the sub-samples at sub-population level.

4.4.6.4 What to do in case rounding is necessary

In case rounding is necessary, the general rule used in mathematics shall be applied:

- If the number you are rounding is followed by 5, 6, 7, 8, or 9, round the number up.
- If the number you are rounding is followed by 0, 1, 2, 3, or 4, round the number down.

4.4.7 Use stage

The use stage often involves multiple processes. A distinction shall be made between (i) product independent and (ii) product dependent processes.

(i) **Product independent processes** have no relationship with the way the product is designed or distributed. The use stage process impacts will remain the same for all products in this product (sub-)category even if the producer changes the product's characteristics. Therefore, they do not contribute to any form of differentiation between two products or might even hide the difference. Examples are the use of a glass for drinking wine (considering that the product doesn't determine a difference in glass use); frying time when using olive oil; energy use for boiling one litre of water to be used for preparing

coffee made from bulk instant coffee; the washing machine used for heavy laundry detergents (capital good).

(ii) **Product dependent processes** are directly or indirectly determined or influenced by the product design or are related to instructions for use of the product. These processes depend on the product characteristics and therefore contribute to differentiation between two products. All instructions provided by the producer and directed towards the consumer (through labels, websites or other media) shall be considered as product dependent. Examples of instructions are indications on how long the food must be cooked, how much water must be used, or in the case of drinks the recommended serving temperature and storage conditions. An example of a direct dependent process is the energy use of electric equipment when used in normal conditions.

Product dependent processes shall be included in the system boundary of the PEF study. Product independent processes shall be excluded from the system boundary and qualitative information may be provided.

For final products the LCIA results of the use stage shall be reported separately and as sum with all other life cycle stages (total life cycle).

4.4.7.1 Main function approach or delta approach

Modelling of the use stage may be done in different ways. Very often the related impacts and activities are modelled fully. For example, the total electricity consumption when using a coffee machine, or the total cooking time and related gas consumption when boiling pasta. In these cases, the use stage processes for drinking coffee or eating pasta are related to the main function of the product (referred to as "main function approach").

In some cases, the use of one product may influence the environmental impact of another product. Some examples:

- A toner cartridge is not "responsible" for the paper it prints on. But if a remanufactured toner cartridge works less efficiently and causes more paper loss compared to an original cartridge, the additional paper loss should be considered. In that case, the paper loss is a product-dependent process of the use stage of a remanufactured cartridge.

- The energy consumption during the use stage of the battery/ charger system is not related to the amount of energy stored and released from the battery. It only refers to the energy loss in each loading cycle. That energy loss may be caused by the loading system or the internal losses in the battery.

In these cases, only the additional activities and processes should be allocated to the product (e.g. paper and energy of remanufactured toner cartridge and battery). The allocation method consists in taking all associated products in the system (here paper and energy), and allocating the excess consumption of these associated products to the product which is considered responsible for this excess. This requires a reference consumption to be defined for each associated product (e.g. of energy and materials), which refers to the minimum consumption that is essential for providing the function. The consumption above this reference (the delta) will then be allocated to the product (referred to as "Delta approach")[40].

This approach should only be used for increasing impacts and to account for additional consumptions above the reference. To define the reference situation, the following shall be considered, if available:

- Regulations applicable to the product in scope;

- Standards or harmonised standards;

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[40] Specifications for drafting and revising product category rules (10.12.2014), ADEME.

- Recommendations from manufacturers or manufacturers' organisations;
- Use agreements established by consensus in sector-specific working groups.

The user of the PEF method decides which approach is taken and shall describe the one applied in the PEF report (main function approach or delta approach).

4.4.7.2 Modelling the use stage

Annex D provides default data to be used to model use stage activities. If available, better data should be used, and shall be made transparent and justified in the PEF report.

4.4.8 End of life modelling

The end of life stage shall be modelled using the Circular Footprint Formula (CFF). The following sections describe the formula and parameters to be used and how the formula and parameters shall be applied to final products and to intermediate products (section 4.4.8.12).

4.4.8.1 The Circular Footprint Formula (CFF)

The Circular Footprint Formula is a combination of "material + energy + disposal", i.e.:

Material

$$(1 - R_1)E_V + R_1 \times \left(AE_{recycled} + (1 - A)E_V \times \frac{Q_{Sin}}{Q_p} \right) + (1 - A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P} \right)$$

Energy

$$(1 - B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$$

Disposal

$$(1 - R_2 - R_3) \times E_D$$

Equation 3– The Circular Footprint Formula (CFF)

Parameters of the CFF

A: allocation factor of burdens and credits between supplier and user of recycled materials.

B: allocation factor of energy recovery processes. It applies both to burdens and credits.

Qs$_{in}$: quality of the ingoing secondary material, i.e. the quality of the recycled material at the point of substitution.

Qs$_{out}$: quality of the outgoing secondary material, i.e. the quality of the recyclable material at the point of substitution.

Q$_p$: quality of the primary material, i.e. quality of the virgin material.

R$_1$: it is the proportion of material in the input to the production that has been recycled from a previous system.

R$_2$: it is the proportion of the material in the product that will be recycled (or reused) in a subsequent system. R2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R2 shall be measured at the output of the recycling plant.

R$_3$: it is the proportion of the material in the product that is used for energy recovery at EoL.

E_recycled (E_rec): specific emissions and resources consumed (per functional unit) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.

E_recyclingEoL (E_recEoL): specific emissions and resources consumed (per functional unit) arising from the recycling process at EoL, including collection, sorting and transportation process.

E_v: specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material.

E*_v: specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials.

E_ER: specific emissions and resources consumed (per functional unit) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, etc.).

E_SE,heat and E_SE,elec: specific emissions and resources consumed (per functional unit) that would have arisen from the specific substituted energy source, heat and electricity respectively.

ED: specific emissions and resources consumed (per functional unit) arising from disposal of waste material at the EoL of the analysed product, without energy recovery.

X_ER,heat and X_ER,elec: the efficiency of the energy recovery process for both heat and electricity.

LHV: lower heating value of the material in the product that is used for energy recovery.

Users of the PEF method shall report all the parameters used. Default values for some parameters (A, R_1, R_2, R_3 and Q_s/Q_p for packaging) are available in Annex C[41] (see following sections for further details): users of the PEF method shall refer to the version of Annex C they are using. Annex C is available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

If a default value for R_1 and R_2 is not included in Annex C, users of the PEF method may provide new values to the Commission. Such values shall be part of a study that has been reviewed by an external independent third party reviewer. The Commission will take the decision if the new values are acceptable and can be implemented in an updated version of Annex C.

4.4.8.2 The A factor

The A factor allocates burdens and credits from recycling and virgin material production between two life cycles (i.e. the one supplying and the one using recycled material) and it aims to reflect market realities.

An A factor equal to 1 would reflect a 100:0 approach (i.e. credits are given to the recycled content), an A factor equal to 0 would reflect a 0:100 approach (i.e. credits are given to the recyclable materials at the end of life).

In PEF studies the A factor values shall be in the range **0.2 ≤ A ≤ 0.8**, to always capture both aspects of recycling (recycled content and recyclability at end of life).

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[41] The list of values in the Annex C is periodically reviewed and updated by the European Commission; users of the PEF method are invited to check and use the most updated values provided in the Annex.

The driver to determine the values of the A factor is the analysis of the market situation. This means:

- **A=0.2.** Low offer of recyclable materials and high demand: the formula focuses on recyclability at end of life**.**

- **A=0.8.** High offer of recyclable materials and low demand: the formula focuses on recycled content.

- **A=0.5.** Equilibrium between offer and demand: the formula focuses both on recyclability at end of life and recycled content.

Default application-specific and material-specific A values are available in Annex C. The following procedure shall be applied (in hierarchical order) to select the value of A to be used in a PEF study:

- Check in Annex C the availability of an application-specific A value which fits the PEF study,

- If an application-specific A value is not available, the material-specific A value in Annex C shall be used,

- If a material-specific A value is not available, the A value shall be set equal to 0.5.

4.4.8.3 The B factor

The B factor is used as an allocation factor of energy recovery processes. It applies both to burdens and credits. Credits refer to the amount of heat and electricity sold, not to the total produced, taking into account relevant variations over a 12-months period, e.g. for heat.

In PEF studies the B value shall be equal to 0 as default.

To avoid double-counting between the current and the subsequent system in case of energy recovery, the subsequent system shall model its own energy use as primary energy.

4.4.8.4 The point of substitution

It is necessary to determine the point of substitution to apply the "material" part of the formula. The point of substitution corresponds to the point in the value chain where secondary materials substitute primary materials.

The point of substitution shall be identified in correspondence to the process where input flows are coming from 100% primary sources and 100% secondary sources (level 1 in Figure 4). In some cases, the point of substitution may be identified after some mixing of primary and secondary material flows has occurred (level 2 in Figure 4).

- **Point of substitution at level 1**: this point of substitution corresponds to e.g. metal scrap, glass cullet and pulp input to the process.

- **Point of substitution at level 2**: this point of substitution corresponds to e.g. metal ingots, glass and paper.

The point of substitution at this level may be applied only if the datasets used to model e.g. E_{rec} and E_v take into account the real (average) flows regarding primary and secondary material. For example, if E_{rec} corresponds to the "production of 1 t of secondary material" (see Figure 4) and it has an average input of 10% from primary raw materials, the amount of primary materials, together with their environmental burdens, shall be included in the E_{rec} dataset.

Figure 4 Point of substitution at level 1 and at level 2
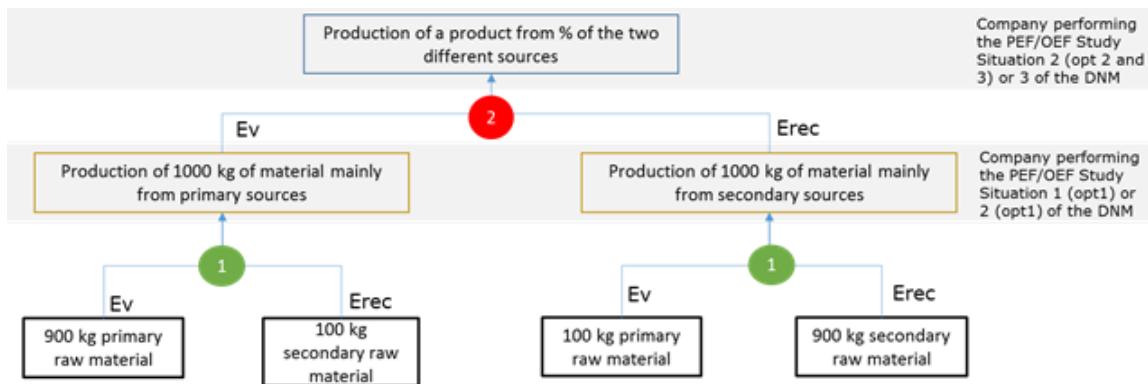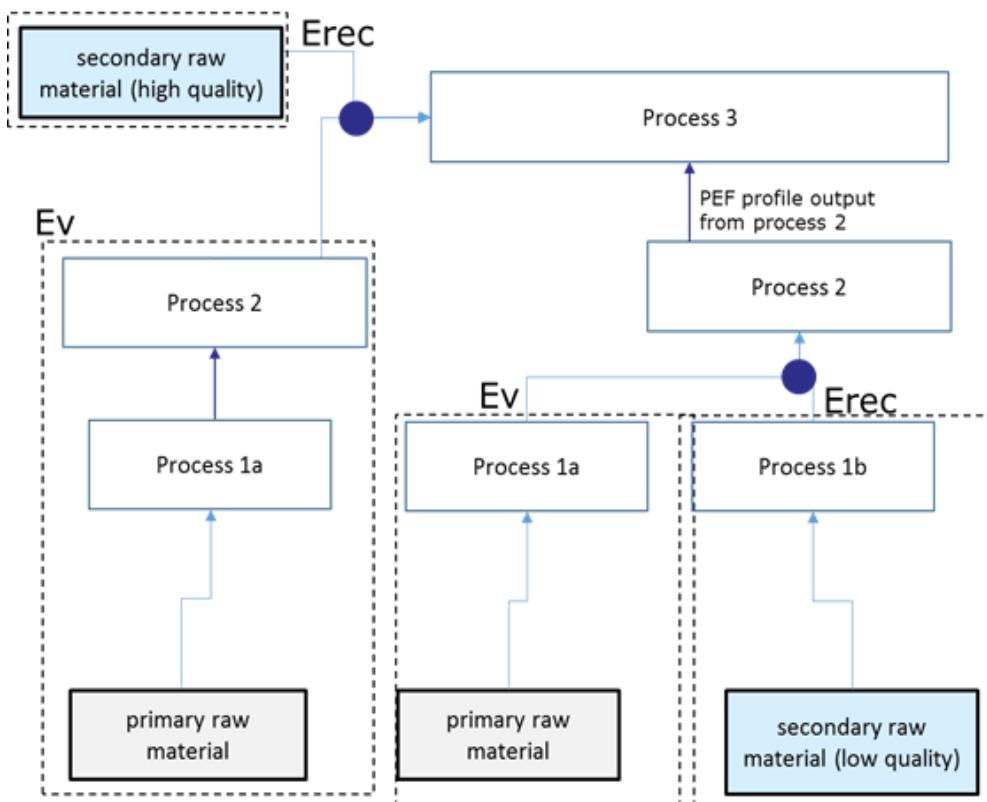
Figure 4 is a schematic representation of a generic situation (flows are 100% primary and 100% secondary). In practice in some situations, more than one point of substitution may be identified at different steps in the value chain, as represented in Figure 5, where e.g. scrap of two different qualities is processed at different steps.

Figure 5 Example of point of substitutions at different steps in the value chain.

4.4.8.5 The quality ratios: Qs_{in}/Q_p and Qs_{out}/Q_p

Two quality ratios are used in the CFF, to take into account the quality of both the ingoing and the outgoing recycled materials.

Two further cases are distinguished:

(a) **If Ev=E*v**, the two quality ratios are needed: Qs_{in}/Q_p associated to the recycled content, and Qs_{out}/Q_p associated to recyclability at EoL. The quality

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factors are there to capture the downcycling of a material compared to the original primary material and, in some cases, may capture the effect of multiple recycling loops.

(b) **If Ev≠E*v**, one quality ratio is needed: Qs_{in}/Q_p associated to the recycled content. In this case E*v refers to the functional unit of the material substituted in a specific application. For example, plastic recycled to produce a bench modelled via substitution of cement shall take into account also the "how much", "how long" and "how well". Therefore, the E*v parameter indirectly integrates the Qs_{out}/Q_p parameter, and therefore the Qs_{out} and Qp parameters are not part of the CFF.

The quality ratios shall be determined at the point of substitution and per application or material.

The quantification of the quality ratios shall be based on:

- Economic aspects: i.e. price ratio of secondary compared to primary materials at the point of substitution. In case the price of secondary materials is higher than that of the primary ones, the quality ratios shall be set equal to 1.

- When economic aspects are less relevant than physical aspects, the latter may be used.

Packaging materials used by industry are often the same within different sectors and product groups: Annex C provides one worksheet with Qs_{in}/Q_p and Qs_{out}/Q_p values applicable to packaging materials. The company performing a PEF study may use different values and they shall be made transparent and justified in the PEF report.

4.4.8.6 Recycled content (R_1)

The R_1 values applied shall be supply-chain or application-specific, depending on the information accessible by the company performing the PEF study. Default application specific R_1 values are available in Annex C. The following procedure shall be applied (in hierarchical order) to select the value of R_1 to be used in a PEF study:

- Supply-chain specific values shall be used when the process is run by the company performing the PEF study or when the process is not run by the company performing the PEF study but the company has access to (company-)specific information. (Situation 1 and Situation 2 of the Data Needs Matrix, see section 4.6.5.4).

- In all other cases, the default secondary R_1 values of Annex C (application-specific) shall be applied. R_1 shall be set to 0% when no application-specific value is available.

- Material-specific values based on supply market statistics are not accepted as a proxy and therefore shall not be used.

The applied R_1 values shall be subject to PEF study verification.

4.4.8.7 Guidelines when using supply chain specific R_1 values

When using supply-chain specific R_1 values other than 0, traceability throughout the supply chain is mandatory. The following general guidelines shall be followed:

- The supplier information (through e.g., statement of conformity or delivery note) shall be maintained during all stages of production and delivery at the converter;

- Once the material is delivered to the converter for production of the end products, the converter shall handle information through their regular administrative procedures;

- The converter for production of the end products claiming recycled content shall demonstrate through its management system the [%] of recycled input material into the respective end product(s).

- The latter demonstration shall be transferred upon request to the user of the end product. In case a PEF profile is calculated and reported, this shall be stated as additional technical information of the PEF profile.

- Industry- or company-owned traceability systems may be applied as long as they cover the general guidelines outlined above. If not, they shall be supplemented with the general guidelines above.

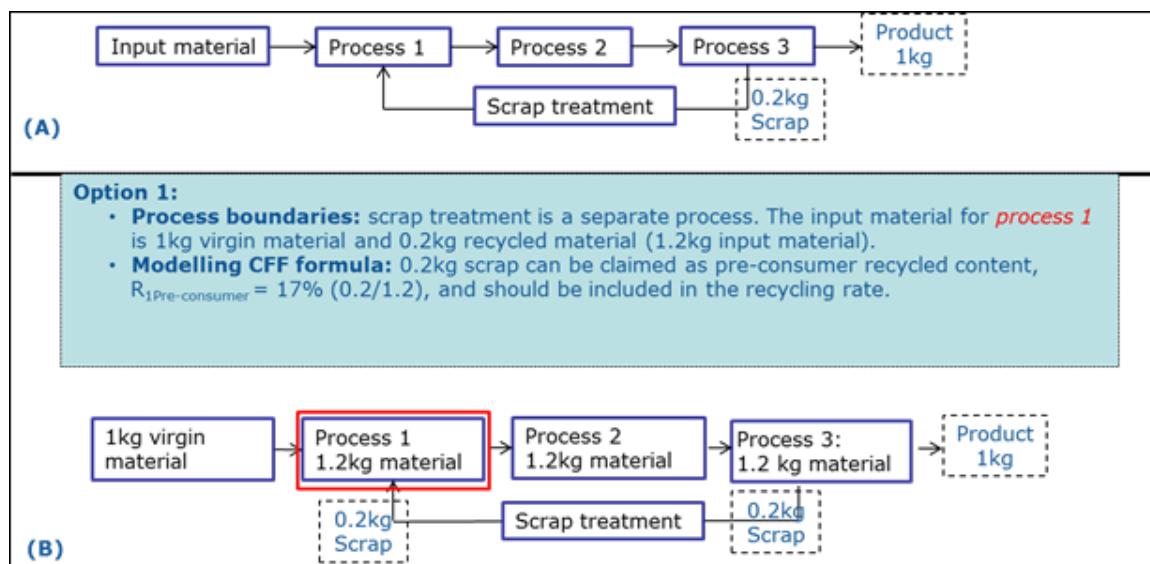For the packaging industry, the following industry-specific guidelines are recommended:

- For the container glass industry (FEVE - The European Container Glass Federation): the European Commission regulation no 1179/2012. This regulation requests a statement of conformity delivered by the cullet producer.

- For the paper industry: European Recovered Paper Identification System (CEPI – Confederation of European Paper Industries, 2008). This document prescribes rules and guidance on necessary information and steps, with a delivery note that shall be received at the reception of the mill.

- For beverage cartons no recycled content is used so far and thus sector specific rules are redundant for the moment. However, if needed, the same guidelines as for paper shall be used as being most suitable (beverage cartons are covered by a recovered paper grade category under EN643).

- For the plastics industry: EN standard 15343:2007. This standard prescribes rules and guidelines on traceability. The supplier of the recyclate is requested to provide specific information.

4.4.8.8 Guidelines on how to deal with pre-consumer scrap

When dealing with pre-consumer scrap, two options may be applied:
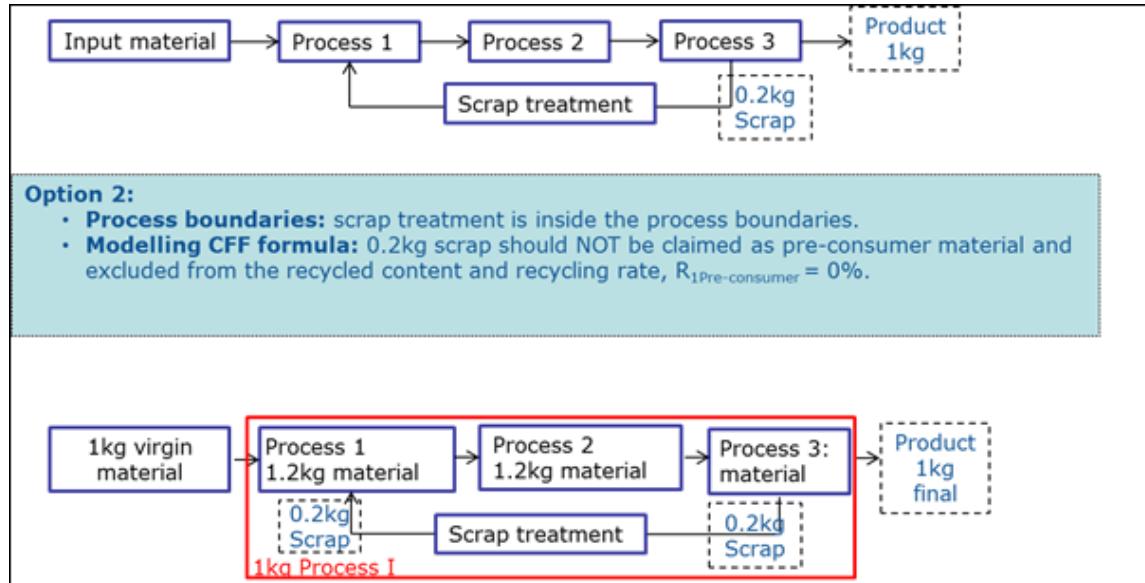
Option 1: the impacts to produce the input material that leads to the pre-consumer scrap in question shall be allocated to the product system that generated this scrap. Scrap is claimed as pre-consumer recycled content. Process boundaries and modelling requirements applying the CFF are shown in Figure 6.

Figure 6 Modelling option when pre-consumer scrap is claimed as pre-consumer recycled content

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Option 2: Any material that circulates within a process chain or pool of process chains is excluded from being defined as recycled content and it is not included in R_1. Scrap is not claimed as pre-consumer recycled content. Process boundaries and modelling requirements applying the CFF are shown in **Figure 7**.

Figure 7 Modelling option when pre-consumer scrap is not claimed as pre-consumer recycled content
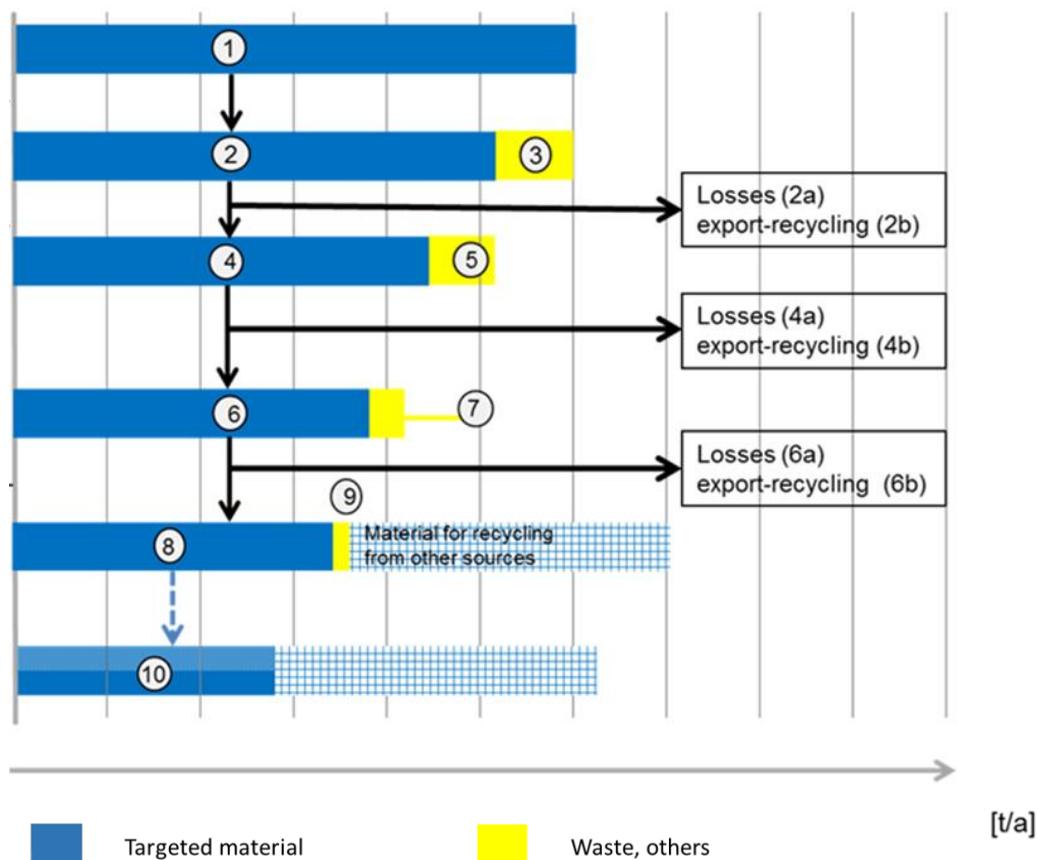
4.4.8.9 Recycling output rate (R_2)

The R_2 parameter refers to the "recycling output rate": Figure 8 provides a visual representation. Often, values are available for point 8[42] in Figure 8, therefore such values shall be corrected to the actual output recycling rate (point 10) taking into account possible process losses. In Figure 8 the output recycling rate (R_2) is in correspondence of point 10.

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[42] Statistical data gathered in correspondence of point 8 in Figure 8 may be used to inform the calculation of the recycling output rate. Point 8 corresponds to recycling targets calculated according to the general rule provided in Directive (EU) 2018/851 of 30 May 2018. In some cases, under strict conditions and by way of derogation from the general rule, data may be available at point 6 in Figure 8 and may be used to inform the calculation of the recycling output rate.

Figure 8 *Simplified collection recycling scheme of a material*

The product design and composition will determine if the material in the specific product is actually suitable for recycling. Therefore, before selecting the appropriate R_2 value, an evaluation of the recyclability of the material shall be made and the PEF study shall include a statement on the recyclability of the materials/ products:

The statement on recyclability shall be provided together with an evaluation for recyclability that includes evidence for the following three criteria (as described by ISO 14021:2016, section 7.7.4 'Evaluation methodology'):

> (1) The collection, sorting and delivery systems to transfer the materials from the source to the recycling facility are conveniently available to a reasonable proportion of the purchasers, potential purchasers and users of the product;
>
> (2) The recycling facilities are available to accommodate the collected materials;
>
> (3) Evidence is available that the product for which recyclability is claimed is being collected and recycled. For PET bottles the EPBP guidelines should be used (https://www.epbp.org/design-guidelines), while for generic plastics the recyclability by design should be used (www.recoup.org).

If one criterion is not fulfilled, or the sector-specific recyclability guidelines indicate limited recyclability, an R_2 value of 0% shall be applied. Point 1 and 3 may be proven by recycling statistics (country specific) derived from industry associations or national bodies. Approximation to evidence at point 3 may be provided by applying for example the design for recyclability evaluation outlined in EN 13430 Material recycling (Annexes A and B) or other sector-specific recyclability guidelines if available.

Default application-specific R_2 values are available in Annex C. The following procedure shall be followed to select the R_2 value to be used in a PEF study:

- Company-specific values shall be used when available and following the evaluation of recyclability.

- If no company-specific values are available and the criteria for the evaluation of recyclability are fulfilled (see above), application-specific R_2 values shall be used selecting the appropriate value available in Annex C:

  - If an R_2 value is not available for a specific country, then the European average shall be used;

  - If an R_2 value is not available for a specific application, the R_2 values of the material shall be used (e.g. materials' average);

  - In case no R_2 values are available, R_2 shall be set equal to 0 or new statistics may be generated in order to assign an R_2 value in the specific situation.

The applied R_2 values shall be subject to the PEF study verification.

Background information to calculate the R_2 values for packaging materials is available in Annex C.

4.4.8.10 $E_{recycled}$ (E_{rec}) and $E_{recyclingEoL}$ (E_{recEoL})

The system boundary of E_{rec} and E_{recEoL} shall consider all the emissions and resources consumed starting from collection up to the defined point of substitution.

If the point of substitution is identified at "level 2" E_{rec} and E_{recEoL} shall be modelled using the real input flows. Therefore, if a portion of the input flows are from primary raw materials, they shall be included in the datasets used to model E_{rec} and E_{recEoL}.

In some cases E_{rec} may correspond to E_{recEoL}, for example in cases where close loops occur.

4.4.8.11 The E*$_v$

When default $E*_v$ equals E_v, the user shall assume that a recyclable material at end of life is replacing the same virgin material which was used at the input side to produce the recyclable material.

In some cases $E*_v$ will be different from E_v. In this case, the user shall provide evidence that a recyclable material is substituting a different virgin material than the one producing the recyclable material.

If $E*_v \neq E_v$, $E*_v$ represents the actual amount of virgin material substituted by the recyclable material. In such cases $E*_v$ is not multiplied by Qs_{out}/Q_p, because this parameter is indirectly taken into account when calculating the "actual amount" of virgin material substituted: such amount shall be calculated taking into account that the virgin material substituted and the recyclable material fulfil the same function in terms of "how long" and "how well". $E*_v$ shall be determined based on evidence of actual substitution of the selected virgin material.

4.4.8.12 How to apply the formula to intermediate products (cradle-to-gate studies)

In cradle-to-gate PEF studies the parameters related to the end of life of the product (i.e. recyclability at end of life, energy recovery, disposal) shall not be accounted for.

If the formula is applied in PEF studies for intermediate products (cradle-to-gate studies), the user of the PEF study shall:

- Use of Equation 3 (CFF), and

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- Exclude the end of life by setting the parameters R_2, R_3, and E_d equal to 0, for the products in scope;
- Use and report the results with two A values for the product in scope:
  - Setting A = 1: to be used as default in the PEF profile calculation. The purpose of this setting is to allow to focus the hotspot analysis on the actual system.
  - Setting A = the application- or material-specific default values: these results shall be reported as 'additional technical information' and to be used when creating EF compliant datasets. The purpose of this setting is to allow the use of the correct A value when the dataset is used in future modelling.

Table 9 provides a summary on how to apply the CFF, depending on a study focusing on final products, or intermediate products.

Table 9 Summary table on how to apply the CFF in different situations

A value	*Final products*	*Intermediates*
A = 1	-	shall (hotspot and PEF profile)
A = default	shall	shall (additional technical info. And EF compliant dataset)

4.4.8.13   *How to deal with specific aspects*

Recovery of bottom ashes or slag from incineration

Recovery of bottom ashes/ slag shall be included in the R_2 value (recycling output rate) of the original product/ material. Their treatment is within the E_{recEoL}.

Landfill and incineration with energy recovery

Whenever a process, such as landfill with energy recovery or municipal solid waste incineration with energy recovery is leading to an energy recovery, it shall be modelled under the "energy" part in Equation 3 (CFF). The credit is calculated based on the amount of output energy that is used outside the process.

Municipal solid waste

Annex C contains default values per country that shall be used to quantify the share to landfill and the share to incineration, unless supply-chain specific values are available.

Compost and anaerobic digestion/ sewage treatment

Compost, including digestate coming out of the anaerobic digestion, shall be treated in the "material" part (Equation 3) like a recycling with A = 0.5. The energy part of the anaerobic

digestion shall be treated as a normal process of energy recovery under the "energy" part of

Equation 3 3 (CFF).

Waste materials used as fuel

When a waste material is used as a fuel (e.g. waste plastic used as fuel in cement kilns), it shall be treated as an energy recovery process under the "energy" part of

Equation **3** (CFF).

Modelling complex products

When considering complex products (e.g. printed wiring boards) with complex end of life management, the default datasets for end of life treatment processes may already implement the CFF. The default values of the parameters shall refer to the ones in Annex C and shall be available as metadata information in the dataset. The Bill of Material (BoM) should be taken as a starting point for calculations if no default data is available.

Reuse and refurbishment

If the reuse/ refurbishment of a product results in a product with different product specifications (providing another function), this shall be considered as part of the CFF, as a form of recycling. Old parts that were changed during refurbishment shall be modelled under the CFF.

In this case, reuse/ refurbishment activities are part of the E_{recEoL} parameter, while the alternative function provided (or the avoided production of parts or components) falls under the E*v parameter.

4.4.9 Extended product lifetime

Extending a product lifetime due to reuse or refurbishment of a product may result into two situations:

1. Resulting in a product with the original product specifications (providing the same function)

   In this situation, the product lifetime is extended to a product with the original product specifications (providing the same function) and shall be included in the FU and reference flow. The user of the PEF method shall describe how reuse or refurbishment is included in the calculations of the reference flow and the full life cycle model, taking into account the "how long" of the FU.

2. Resulting in a product with different product specifications (providing another function).

   This shall be considered as part of the CFF, as a form of recycling (see section 4.4.8.13). Also, old parts that have been changed during refurbishment shall be modelled under the CFF.

4.4.9.1 Reuse rates (situation 1)

The reuse rate is the number of times a material is used at the factory. This is often also called trip rates, reuse time or number of rotations. This may be expressed as the absolute number of reuse or as % of reuse rate.

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For example: a reuse rate of 80% equals 5 reuses. Equation 4 describes the conversion:

$$\text{Number of reuse} = \frac{1}{100\% - \% \text{ reuse rate}} \qquad \text{[Equation 4]}$$

The number of reuse applied here refers to the total number of uses during the life of the material. It includes both the first use and all the following reuses.

4.4.9.2 How to apply and model the 'reuse rate' (situation 1)

The number of times a material is reused affects the environmental profile of the product at different life cycle stages. The following five steps explain how the user shall model the different life cycle stages with reusable materials, using packaging as an example:

1. Raw material acquisition: The reuse rate determines the quantity of packaging material consumed per product sold. The raw material consumption shall be calculated by dividing the actual weight of the packaging by the number of times this packaging is reused. For example, a 1l glass bottle weights 600 grams and is reused 10 times (reuse rate of 90%). The raw material use per litre is 60 gram (= 600 gram per bottle / 10 reuses).

2. Transport from packaging manufacturer to the product factory (where the products are packed): The reuse rate determines the quantity of transport that is needed per product sold. The transport impact shall be calculated by dividing the one-way trip impact by the number of times the packaging is reused.

3. Transport from product factory to final client and back: additionally to the transport needed to go to the client, the return transport shall also be taken into account. To model the total transport, section 4.4.3 on modelling transport shall be followed.

4. At product factory: once the empty packaging is returned to the product factory, energy and resource use shall be accounted for cleaning, repairing or refilling (if applicable).

5. Packaging end of life: the reuse rate determines the quantity of packaging material (per product sold) to be treated at the end of life. The amount of packaging treated at the end of life shall be calculated by dividing the actual weight of the packaging by the number of times this packaging was reused.

4.4.9.3 Packaging reuse rates

A packaging return system is organized by:

1. The company owning the packaging material (company-owned pools), or

2. A third party e.g., the government or a pooler (third party operated pools).

This may have an influence on the lifetime of the material as well as the data source to be used. Therefore, it is important to separate these two return systems.

For company owned packaging pools the reuse rate shall be calculated using supply chain specific data. Depending on the data available within the company, two different calculation approaches may be used (see Option a and b presented below). Returnable glass bottles are used as example but the calculations also apply for other company-owned reusable packaging.

Option a: use supply-chain-specific data, based on accumulated experience over the lifetime of the previous glass bottle pool. This is the most accurate way to calculate the reuse rate of bottles for the previous bottle pool and is a proper estimate for the current bottle pool. The following supply chain-specific data is collected:

- Number of bottles filled during the lifetime of the bottle pool (#F$_i$)
- Number of bottles at initial stock plus purchased over the lifetime of the bottle pool (#B)

Reuse rate of the bottle pool $= \frac{\#F_i}{\#B}$ [Equation 5]

The net glass use (kg glass/l beverage) $= \frac{\#B \times (kg\ glass/bottle)}{\#F_i}$ [Equation 6]

This calculation option shall be used:

(i) With data of the previous bottle pool when the previous and current bottle pool are comparable. Meaning, the same product category, similar bottle characteristics (e.g., size), comparable return systems (e.g., way of collection, same consumer group and outlet channels), etc.

(ii) With data of the current bottle pool when future estimations/ extrapolations are available on (i) the bottle purchases, (ii) the volumes sold, and (iii) the lifetime of the bottle pool.

The data shall be supply-chain-specific and shall be verified through external verification, including the reasoning for the method choice.

Option b: If no real data is tracked, the calculation shall be done partly based on assumptions. This option is less accurate due to the assumptions made and therefore conservative/ safe estimates shall be used. The following data is needed:

Average number of rotations of a single bottle, during one calendar year (if not broken). One loop consists of filling, delivery, use and back to brewer for washing (#Rot);

Estimated lifetime of the bottle pool (LT, in years);

Average percentage of loss per rotation. This refers to the sum of losses at consumer and the bottles scrapped at filling sites (%Los).

Reuse rate of the bottle pool $= \frac{LT}{(LT \times \%Los) + \left(\frac{1}{\#Rot}\right)}$ [Equation 7]

This calculation option shall be used when option "a" is not applicable (e.g., the previous pool is not usable as reference). The data used shall be verified by an external verification, including the reasoning of the choice between option "a" and "b".

4.4.9.4 Average reuse rates for company-owned pools

PEF studies that have company owned reusable packaging pools in scope shall use company specific reuse rates, calculated following rules outlined in section 4.4.9.3.

4.4.9.5 Average reuse rates for third party operated pools

The following reuse rates shall be used in those PEF studies that have third party operated reusable packaging pools in scope, unless data of better quality is available:

- Glass bottles: 30 trips for beer and water, 5 trips for wine[43];
- Plastic crates for bottles: 30 trips[44];

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[43] Assumption based on the monopoly system of Finland.
http://ec.europa.eu/environment/waste/studies/packaging/finland.pdf

[44] Technical approximation as no data source could be found. Technical specifications guarantee a lifetime of 10 years. A return of 3 times per year (between 2 to 4) is taken as a first approximation.

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- Plastic pallets: 50 trips (Nederlands Instituut voor Bouwbiologie en Ecologie, 2014)[45];
- Wooden pallets: 25 trips (Nederlands Instituut voor Bouwbiologie en Ecologie, 2014)[46].

The user of the PEF method may use other values if they are justified and data sources are provided.

The user of the PEF method shall indicate if company owned or third party operated pools were in scope and which calculation method or default reuse rates were used.

4.4.10 Greenhouse gas emissions and removals

Three main categories of greenhouse (GHG) emissions and removals shall be distinguished, each contributing to a specific sub-category of the impact category 'climate change':

1. Fossil GHG emissions and removals (contributing to the sub-category 'Climate change – fossil');

2. Biogenic carbon emissions and removals (contributing to the sub-category 'Climate change – biogenic');

3. Carbon emissions from land use and land use change (contributing to the sub-category 'Climate change – land use and land use change').

Credits associated with temporary and permanent carbon storage and/or delayed emissions shall not be considered in the calculation of the climate change indicator. This means that all emissions and removals shall be accounted for as emitted "now" and there is no discounting of emissions over time (in line with ISO 14067:2018).

The sub-categories 'climate change – fossil', 'climate change – biogenic' and 'climate change - land use and land transformation', shall be reported separately if they show a contribution of more than 5%[47] each to the total score of climate change.

4.4.10.1 Sub-category 1: Climate change – fossil

This category covers greenhouse gas (GHG) emissions to any media originating from the oxidation and/or reduction of fossil fuels by means of their transformation or degradation (e.g. combustion, digestion, landfilling, etc.). This impact category includes emissions from peat and calcination, and uptakes due to carbonation.

Fossil CO_2 uptake and corresponding emissions (e.g. due to carbonation) shall be modelled in a simplified way when calculating the PEF profile (meaning, no emissions or uptakes shall be modelled). When the amount of fossil CO_2 uptake is required for additional environmental information, the CO_2 uptake may be modelled with the flow "CO_2 (fossil), uptake from air".

The flows falling under this definition shall be modelled consistently with the elementary flows in the most updated EF reference package and using the names ending with '(fossil)', if available (e.g., 'carbon dioxide (fossil)' and 'methane (fossil)').

4.4.10.2 Sub-category 2: Climate change – biogenic

This sub-category covers carbon emissions to air (CO_2, CO and CH_4) originating from the oxidation and/or reduction of aboveground biomass by means of its transformation or degradation (e.g. combustion, digestion, composting, landfilling) and CO_2 uptake from the

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[45] The less conservative number is used.
[46] Half of plastic pallets is used as approximation.
[47] For example: Let us assume that 'Climate change – biogenic' contributes with 7% (using absolute values) to the total climate change impact and 'Climate change – land use and land use change' contributes with 3% to the total climate change impact. In this case, the total climate change impact and the 'Climate change – biogenic' shall be reported.

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atmosphere through photosynthesis during biomass growth – i.e. corresponding to the carbon content of products, biofuels or above ground plant residues such as litter and dead wood. Carbon exchanges from native forests[48] shall be modelled under sub-category 3 (including connected soil emissions, derived products or residues).

Modelling requirements: the flows falling under this definition shall be modelled consistently with the elementary flows in the most recent version of the EF package and using the flow names ending with '(biogenic)'. Mass allocation shall be applied to model the biogenic carbon flows.

A simplified modelling approach should be used if only the flows influencing climate change impact results (namely biogenic methane emissions) are modelled. This option may apply for example to food PEF studies as it avoids modelling human digestion while arriving eventually at a zero balance. In this case, the following rules apply:

(i) Only the emission 'methane (biogenic)' is modelled;

(ii) No further biogenic emissions and uptakes from atmosphere are modelled;

(iii) If methane emissions are both fossil or biogenic, the release of biogenic methane shall be modelled first and then the remaining fossil methane.

For intermediate products (cradle-to-gate), the biogenic carbon content at factory gate (physical content) shall always be reported as 'additional technical information'.

4.4.10.3 Sub-category 3: Climate change – land use and land use change (LULUC)

This sub-category accounts for carbon uptakes and emissions (CO_2, CO and CH_4) originating from carbon stock changes caused by land use change and land use. This sub-category includes biogenic carbon exchanges from deforestation, road construction or other soil activities (including soil carbon emissions). For native forests, all related CO_2 emissions are included and modelled under this sub-category (including connected soil emissions, products derived from native forest[49] and residues), while their CO_2 uptake is excluded.

A distinction is made between direct and indirect land use change. Direct land use change occurs as the result of a transformation from one land use type into another, which takes place in a unique land cover, possibly incurring changes in the carbon stock of that specific land, but not leading to a change in other systems. Examples of direct land use change are the conversion of land used for growing crops to industrial use or conversion from forestland to cropland.

Indirect land use change occurs when a certain change in land use, or in the use of the feedstock grown on a given piece of land, induces changes in land use outside the system boundary, i.e. in other land use types. The PEF method only considers direct land use change, while indirect land use change, due to the lack of an agreed methodology, shall not be taken into account in PEF studies, unless reported under additional environmental information.

Modelling requirements: the flows falling under this definition shall be modelled consistently with the elementary flows in the most recent version of the EF package and using the flow names ending with '(land use change)'. Biogenic carbon uptakes and emissions shall be inventoried separately for each elementary flow.

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[48] Native forests – represents native or long-term, non-degraded forests. Definition adapted from table 8 in Annex V C(2010)3751 to Directive 2009/28/EC. In principle, this definition excludes short term forests, degraded forests, managed forest, and forests with short-term or long-term rotations.

[49] Following the instantaneous oxidation approach in IPCC 2013 (Chapter 2).

For **land use change**: all carbon emissions and removals shall be modelled following the modelling guidelines of PAS 2050:2011 (BSI 2011) and the supplementary document PAS2050-1:2012 (BSI 2012) for horticultural products.

Quoting PAS 2050:2011 (BSI 2011):

"Large emissions of GHGs can result as a consequence of land use change. Removals as a direct result of land use change (and not as a result of long-term management practices) do not usually occur, although it is recognized that this could happen in specific circumstances. Examples of direct land use change are the conversion of land used for growing crops to industrial use or conversion from forestland to cropland. All forms of land use change that result in emissions or removals are to be included. Indirect land use change refers to such conversions of land use as a consequence of changes in land use elsewhere. While GHG emissions also arise from indirect land use change, the methods and data requirements for calculating these emissions are not fully developed. Therefore, the assessment of emissions arising from indirect land use change is not included.

The GHG emissions and removals arising from direct land use change shall be assessed for any input to the life cycle of a product originating from that land and shall be included in the assessment of GHG emissions. The emissions arising from the product shall be assessed on the basis of the default land use change values provided in PAS 2050:2011 Annex C, unless better data is available. For countries and land use changes not included in this annex, the emissions arising from the product shall be assessed using the included GHG emissions and removals occurring as a result of direct land use change in accordance with the relevant sections of the IPCC (2006). The assessment of the impact of land use change shall include all direct land use change occurring not more than 20 years, or a single harvest period, prior to undertaking the assessment (whichever is the longer). The total GHG emissions and removals arising from direct land use change over the period shall be included in the quantification of GHG emissions of products arising from this land on the basis of equal allocation to each year of the period[50].

1. Where it can be demonstrated that the land use change occurred more than 20 years prior to the assessment being carried out, no emissions from land use change should be included in the assessment.

2. Where the timing of land use change cannot be demonstrated to be more than 20 years, or a single harvest period, prior to making the assessment (whichever is the longer), it shall be assumed that the land use change occurred on 1 January of either:

    - the earliest year in which it can be demonstrated that the land use change had occurred; or

    - on 1 January of the year in which the assessment of GHG emissions and removals is being carried out.

The following hierarchy shall apply when determining the GHG emissions and removals arising from land use change occurring not more than 20 years or a single harvest period, prior to making the assessment (whichever is the longer):

1. where the country of production is known and the previous land use is known, the GHG emissions and removals arising from land use change shall be those resulting from the change in land use from the previous land use to the current land use in that country (additional guidelines on the calculations can be found in PAS 2050-1:2012);

2. where the country of production is known, but the former land use is not known, the GHG emissions arising from land use change shall be the estimate

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[50]   In case of variability of production over the years, a mass allocation should be applied.

of average emissions from the land use change for that crop in that country (additional guidelines on the calculations can be found in PAS 2050-1:2012);

3. where neither the country of production nor the former land use is known, the GHG emissions arising from land use change shall be the weighted average of the average land use change emissions of that commodity in the countries in which it is grown.

Knowledge of the prior land use can be demonstrated using a number of sources of information, such as satellite imagery and land survey data. Where records are not available, local knowledge of prior land use can be used. Countries in which a crop is grown can be determined from import statistics, and a cut-off threshold of not less than 90% of the weight of imports may be applied. Data sources, location and timing of land use change associated with inputs to products shall be reported."

Intermediate products (cradle to gate) derived from native forest shall always report as meta-data (in the 'additional technical information' section of the PEF report) (i) their carbon content (physical content and allocated content) and (ii) that corresponding carbon emissions shall be modelled with '(land use change)' elementary flows.

For **soil carbon stock**: soil carbon emissions shall be included and modelled under this sub-category (e.g. from rice fields). Soil carbon emissions derived from aboveground residues (except from native forest) shall be modelled under sub-category 2, such as the application of non-native forest residues or straw. Soil carbon uptake (accumulation) shall be excluded from the results, e.g. from grasslands or improved land management through tilling techniques or other management actions taken in relation to agricultural land. Soil carbon storage may only be included in the PEF study as additional environmental information and if proof is provided. If legislation has different modelling requirements for the sector, such as the EU Decision on greenhouse gas accounting from 2013 (Decision 529/2013/EU), which indicates carbon stock accounting, it shall be modelled according to the relevant legislation and provided under additional environmental information.

4.4.11 Offsets

The term "offset" is frequently used with reference to third-party greenhouse gas mitigation activities, e.g. regulated schemes in the framework of the Kyoto Protocol (CDM – Clean Development Mechanism, JI – Joint Implementation, ETS - Emissions Trading Schemes), or voluntary schemes. Offsets are discrete greenhouse gas (GHG) reductions used to compensate for (i.e., offset) GHG emissions elsewhere, for example to meet a voluntary or mandatory GHG target or cap. Offsets are calculated relative to a baseline that represents a hypothetical scenario for what emissions would have been in the absence of the mitigation project that generates the offsets. Examples are carbon offsetting by the Clean Development Mechanism, carbon credits, and other system-external offsets.

Offsets shall not be included in the impact assessment of a PEF study, but may be reported separately as additional environmental information.

4.5 Handling multi-functional processes

If a process or facility provides more than one function, i.e. it delivers several goods and/or services ("co-products"), it is "multifunctional". In these situations, all inputs and emissions linked to the process shall be partitioned between the product of interest and the other co-products in a principled manner. Systems involving multi-functionality of processes shall be modelled in accordance with the following decision hierarchy.

Specific allocation requirements in other sections of this method always prevail over the ones available in this section (e.g., section 4.4.2 on electricity, 4.4.3 on transport, 4.4.10 on greenhouse gas emissions, or 4.5.1 on slaughterhouse activities).

Decision hierarchy

1) Subdivision or system expansion

As per ISO 14044, wherever possible, subdivision or system expansion should be used to avoid allocation. Subdivision refers to disaggregating multifunctional processes or facilities to isolate the input flows directly associated with each process or facility output. System expansion refers to expanding the system by including additional functions related to the co-products. It shall be investigated first whether it is possible to subdivide or expand the analysed process. Where subdivision is possible, inventory data should be collected only for those unit processes[51] directly attributable[52] to the goods/services of concern. Or, if the system may be expanded, the additional functions shall be included in the analysis with results communicated for the expanded system as a whole rather than on an individual co-product level.

2) Allocation based on a relevant underlying physical relationship

Where it is not possible to apply subdivision or system expansion, allocation should be applied: the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects relevant underlying physical relationships between them (ISO 14044:2006).

Allocation based on a relevant underlying physical relationship refers to partitioning the input and output flows of a multi-functional process or facility in accordance with a relevant, quantifiable physical relationship between the process inputs and co-product outputs (for example, a physical property of the inputs and outputs that is relevant to the function provided by the co-product of interest). Allocation based on a physical relationship may be modelled using direct substitution, if it is possible to identify a product that is directly substituted[53].

To demonstrate whether the direct substitution effect is robust, the user of the PEF method shall prove that (1) there is a direct, empirically demonstrable substitution effect, AND (2) it is possible to model the substituted product and to subtract the life cycle inventory in a directly representative manner: If both conditions are fulfilled, model the substitution effect.

Or

To allocate input/output based on some other relevant underlying physical relationship that relates the inputs and outputs to the function provided by the system, the user of the PEF method shall demonstrate that it is possible to define a relevant physical relationship by which to allocate the flows attributable to the provision of the defined function of the product system[54]: If this condition is fulfilled, the user of the PEF method may allocate based on this physical relationship.

3) Allocation based on some other relationship

Allocation based on some other relationship may be possible. For example, economic allocation refers to allocating inputs and outputs associated with multi-functional processes to the co-product outputs in proportion to their relative market values. The market price of the co-functions should refer to the specific condition and point at which the co-products are produced. In any case, a clear justification for having discarded 1) and 2) and for having selected a certain allocation rule in step 3) shall be provided, to ensure the physical representativeness of the PEF results as far as possible.

Allocation based on some other relationship may be approached in one of the following alternative ways:

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[51] A unit process is the smallest element considered in the LCI for which input and output data are quantified (based on ISO 14040:2006).
[52] Directly attributable refers to a process, activity or impact occurring within the defined system boundary.
[53] See below for an example of direct substitution.
[54] A product system is the collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product (ISO 14040:2006)

(i) Is it possible to identify an indirect substitution[55] effect and may the substituted product be modelled and the inventory subtracted in a reasonably representative manner? If yes (i.e. both conditions are verified), model the indirect substitution effect.

Or

(ii) Is it possible to allocate the input/output flows between the products and functions on the basis of some other relationship (e.g. the relative economic value of the co-products)? If yes, allocate products and functions on the basis of the identified relationship.

Dealing with multi-functionality of products is particularly challenging when recycling or energy recovery of one (or more) of these products is involved as the systems tend to get rather complex. The Circular Footprint Formula (see section 4.4.8.1) provides the approach that shall be used to estimate the overall emissions associated to a certain process involving recycling and/or energy recovery. These moreover also relate to waste flows generated within the system boundary.

4.5.1 Animal husbandry

This section provides instructions on how to address specific issues related to the modelling of farm, slaughterhouse and rendering for cattle, pig, sheep and goat. In particular, instructions are provided on:

1. Allocation of upstream burdens at farm level among outputs leaving the farm;

2. Allocation of upstream burdens (linked to live animals) at slaughterhouse among outputs leaving the slaughterhouse.

4.5.1.1 Allocation within the farm module

At farm module, subdivision shall be used for processes that are directly attributed to certain outputs (e.g. energy use and emissions related to milking processes). If the processes cannot be subdivided due to the lack of separate data or because it is technically impossible, the upstream burden, e.g. feed production, shall be allocated to farm outputs using a biophysical allocation method. Default values to perform allocation are provided in the following sections for each type of animal. These default values shall be used by PEF studies unless company-specific data are collected. The change of allocation factors is allowed only if company-specific data are collected and used for the farm module. In case secondary data are used for the farm module, no change of allocation factors is allowed.

4.5.1.2 Allocation within the farm module for cattle

The IDF (2015) allocation method between milk, cull cows and surplus calves shall be used. Dead animals and all products coming from dead animals shall be regarded as waste and the Circular Footprint Formula shall be applied. In this case, however, the traceability of the products coming from dead animals shall be guaranteed to enable PEF studies to take this aspect into consideration.

Manure exported to another farm shall be considered as:

- **Residual (default option):** if manure does not have an economic value at the farm gate, it is regarded as residual without allocation of an upstream burden. The emissions related to manure management up to farm gate are allocated to the other outputs of the farm where manure is produced.

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[55] Indirect substitution occurs when a product is substituted but you do not know by which products exactly.

- **Co-product**: when exported manure has an economic value at farm gate, an economic allocation of the upstream burden shall be used for manure by using the relative economic value of manure compared to milk and live animals at the farm gate. Biophysical allocation based on IDF rules shall nevertheless be applied to allocate the remaining emissions between milk and live animals.
- **Manure as waste**: when manure is treated as waste (e.g. landfilled), the Circular Footprint Formula shall be applied.

The allocation factor (AF) for milk shall be calculated using the following equation:

$$AF = 1 - 6.04 * \frac{M_{meat}}{M_{milk}} \quad \text{[Equation 8]}$$

Where M_{meat} is the mass of live weight of all animals sold including bull calves and culled mature animals per year and M_{milk} is the mass of fat and protein corrected milk (FPCM) sold per year (corrected to 4% fat and 3.3% protein). The constant 6.04 describes the causal relationship between the energy content in feed in relation to the milk and live weight of animals produced. The constant is determined based on a study that collected data from 536 US dairy farms (Thoma et al., 2013). Although based on US farms, IDF considers that the approach is applicable to the European farming systems.

The FPCM (corrected to 4% fat and 3.3% protein) shall be calculated by using the following formula:

[Equation 9]

$$FPCM \left(\frac{kg}{yr} \right) = Production \left(\frac{kg}{yr} \right) * (0.1226 * True \ Fat \ \% + 0.0776 * True \ Protein \ \% + 0.2534)$$

In cases where a default value of 0.02 kg_{meat}/kg_{milk} for the ratio of live weight of animals and milk produced in Equation 9 is used, the equation yields default allocation factors of 12% to live weight of animals and 88% to milk (Table 10). These values shall be used as default values for allocating the upstream burdens to milk and live weight of animals for cattle when secondary datasets are used. If company-specific data are collected for the farming stage, the allocation factors shall be changed using the equations included in this section.

Table 10 Default allocation factors for cattle at farming

Co-product	Allocation factor
Animals, live weight	12%
Milk	88%

4.5.1.3 Allocation within the farm module for sheep and goat

A biophysical approach shall be used for the allocation of upstream burdens to the different co-products for sheep and goat. The 2006 IPCC guidelines for national greenhouse gas inventories (IPCC, 2006) contain a model to calculate energy requirements that shall be used for sheep and, as a proxy, for goats. This model is applied in the present document.

Dead animals and all the products coming from dead animals shall be regarded as waste and the Circular Footprint Formula (CFF, Section 4.4.8.1) shall be applied. In this case, however, the traceability of the products coming from dead animals shall be granted in order for this aspect to be taken into consideration in PEF studies.

The use of the default allocation factors included in this document is mandatory whenever secondary datasets are used for the life cycle stage of farming for sheep and goat. If company-specific data are used for this life cycle stage, the calculation of the allocation factors with the company-specific data shall be performed using the equations provided.

The allocation factors shall be calculated as follows[56]:

$$\% \; wool = \frac{[Energy \; for \; wool \; (NE_{wool})]}{[(Energy \; for \; wool \; (NE_{wool}) + \; Energy \; for \; milk \; (NE_l) + \; Energy \; for \; meat \; (NE_g)]} \quad \textit{[Equation 10]}$$

$$\% \; milk = \frac{[Energy \; for \; milk \; (NE_l)]}{[(Energy \; for \; wool \; (NE_{wool}) + \; Energy \; for \; milk \; (NE_l) + \; Energy \; for \; meat \; (NE_g)]} \quad \textit{[Equation 11]}$$

$$\% \; meat = \frac{[Energy \; for \; meat \; (NE_g)]}{[(Energy \; for \; wool \; (NE_{wool}) + \; Energy \; for \; milk \; (NE_l) + \; Energy \; for \; meat \; (NE_g)]} \quad \textit{[Equation 12]}$$

For the calculation of energy for wool (NE_{wool}), energy for milk (NE_l) and energy for meat (NE_g) with company specific data, the equations included in IPPC (2006) and reported below shall be used. In case secondary data are used instead, the default values for the allocation factors provided in this document shall be used.

Energy for wool, NE$_{wool}$

$$NE_{wool} = \frac{(EV_{wool} \cdot Production_{wool})}{365} \quad \textit{[Equation 13]}$$

NE_{wool} = net energy required to produce wool, MJ day^{-1}

EV_{wool} = the energy value of each kg of wool produced (weighed after drying but before scouring), MJ

kg^{-1}. A default value of 157 MJ kg^{-1} (NRC, 2007) shall be used for this estimate[57].

$Production_{wool}$ = annual wool production per sheep, kg yr^{-1}

Default values to be used for the calculation of NE_{wool} and the resulting net energy required are reported in Table 11.

Table 11 Default values to be used for the calculation of NE$_{wool}$ for sheep and goat

Parameter	Value	Source
EV_{wool} - sheep	157 MJ kg^{-1}	NRC, 2007
$Production_{wool}$ - sheep	7.121 kg	Average of the four values provided in Table 1 of "Application of LCA to sheep production systems: investigating co-production of wool and meat using case studies from major global producers", Wiedemann et al, Int J. of LCA 2015.
NE_{wool} - sheep	3.063 MJ/d	Calculated using Eq. 14
NE_{wool} - goat	2.784 MJ/d	Calculated from NE$_{wool}$ – sheep using Eq. 17

Energy for milk, NE$_l$

$$NE_l = Milk \cdot EV_{milk} \quad \textit{[Equation 14]}$$

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[56] The same naming as used in IPCC (2006) is used.

[57] The default value of 24 MJ kg^{-1} originally included in the IPPC document was modified into 157 MJ kg^{-1} following the indication of FAO - Greenhouse gas emissions and fossil energy demand from small ruminant supply chains Guidelines for assessment (2016).

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NE_l = net energy for lactation, MJ day^{-1}

Milk = amount of milk produced, kg of milk day^{-1}

EV_{milk} = the net energy required to produce 1 kg of milk. A default value of 4.6 MJ/kg (AFRC, 1993) shall be used which corresponds to a milk fat content of 7% by weight.

Default values to be used for the calculation of NE_l and the resulting net energy required are provided in Table 12.

Table 12 Default values to be used for the calculation of NE_l for sheep and goat

Parameter	Value	Source
EV_{milk} - sheep	4.6 MJ kg^{-1}	AFRC, 1993
$Milk$ - sheep	2.08 kg/d	Estimated milk production 550 lbs of sheep milk per year (average value), milk production estimated for 120 days in one year.
NE_l - sheep	9.568 MJ/d	Calculated using Eq. 15
NE_l - goat	8.697 MJ/d	Calculated from NE_l – sheep using Eq. 17

Energy for meat, NE$_g$

$$NE_g = WG_{lamb} \cdot \frac{a+0.5b(BW_i+BW_f)}{365}$$

[Equation 15]

NE_g = net energy needed for growth, MJ day^{-1}

WG_{lamb} = the weight gain (BW$_f$ – BW$_i$), kg yr^{-1}

BW_i = the live bodyweight at weaning, kg

BW_f = the live bodyweight at 1-year old or at slaughter (live-weight) if slaughtered prior to 1 year of age, kg

a, b = constants as described in Table 13.

Note that lambs will be weaned over a period of weeks as they supplement a milk diet with pasture feed or supplied feed. The time of weaning should be taken as the time at which they are dependent on milk for half their energy supply. The NE$_g$ equation used for sheep includes two empirical constants (a and b) that vary by animal species/category (Table 13).

Table 13 Constants for use in calculating NEg for sheep[58]

Animal species/category	a (MJ kg^{-1})	b (MJ kg^{-2})
Intact males	2.5	0.35

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[58] This table corresponds to Table 10.6 in IPCC (2006).

Animal species/category	a (MJ kg^{-1})	b (MJ kg^{-2})
Castrates	4.4	0.32
Females	2.1	0.45

In case company-specific data are used for the farming stage, the allocation factors shall be recalculated. In this case, the parameter "a" and "b" shall be calculated as weighted average if more than one animal category is present.

Default values to be used for the calculation of NE$_g$ are reported in Table 14.

Table 14 Default values to be used for the calculation of NEg for sheep and goat

Parameter	Value	Source
WG$_{lamb}$ - sheep	26.2-15=11.2 kg	Calculated
BW$_i$ - sheep	15 kg	It is assumed that the weaning happens at six weeks. Weight at six weeks read from Figure 1 in "A generic model of growth, energy metabolism and body composition for cattle and sheep", Johnson et al, 2015 – Journal of Animal Science.
BW$_f$ - sheep	26.2 kg	Average of the values for weight at slaughter, sheep as provided in Appendix 5, Greenhouse gas emissions and fossil energy demand from small ruminant supply chains, FAO 2016.
a - sheep	3	Average of the three values provided in Table 13.
b - sheep	0.37	Average of the three values provided in Table 13
NE$_g$ - sheep	0.326 MJ/d	Calculated using Eq. 16
NEg - goat	0.296 MJ/d	Calculated from NEg – sheep using Eq. 17

The default allocation factors to be used PEF studies for sheep and goat are provided in Table 14 together with the calculations. The same equations[59] and default values used for the calculation of the energy requirements for sheep are used for the calculation of the energy requirements for goats after application of a correction factor.

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[59] Page 10.24 of IPCC (2006).

$$Net\ energy\ requirement, goat = \left[\frac{goat\ weight}{sheep\ weight}\right]^{0.75} \times Net\ energy\ requirement\ sheep$$

[Equation 16]

Sheep weight: 64.8 kg, average of male and female sheep for different regions in the world, data from Appendix 5, Greenhouse gas emissions and fossil energy demand from small ruminant supply chains, FAO 2016.

Goat weight: 57.05 kg, average of male and female goats for different regions in the world, data from Appendix 5, Greenhouse gas emissions and fossil energy demand from small ruminant supply chains, FAO 2016.

Net energy requirement, goat = [(57.05) / (64.8)]$^{0.75}$ • Net energy requirement, sheep
    [Equation 17]

Table 15 *Default allocation factors to be used PEF studies for sheep at farming stage*

	Sheep	Goat[60]
Allocation factor, meat	$\% \ meat = \frac{[(NE_g)]}{[(NE_{wool})+ (NE_l) + (NE_g)]} =$ 2.52%	2.51 %
Allocation factor, milk	$\% \ milk = \frac{[(NE_l)]}{[(NE_{wool})+ (NE_l) + (NE_g)]} =$ 73.84%	73.85%
Allocation factor, wool	$\% \ wool = \frac{[(NE_{wool})]}{[(NE_{wool})+ (NE_l) + (NE_g)]} =$ 23.64%	23.64%

4.5.1.4 Allocation within the farm module for pig

Allocation at farming stage between piglets and sows shall be made applying economic allocation. The default allocation factors to be used are reported in Table 16.

Table 16 *Allocation at farming stage between piglets and sows*

	Unit	Price	Allocation factors
Piglets	24.8 p	0.95 €/kg live weight	92.63%
Sow to slaughter	84.8 kg	40.80 €/pig	7.37%

4.5.1.5 Allocation within the slaughterhouse

Slaughterhouse and rendering processes produce multiple outputs going to the food and feed chain or to other non-food or feed value chains as the leather industry or chemical or energy recovery chains.

At the slaughterhouse and rendering module, subdivision shall be used for those process flows that are directly attributable to certain outputs. If it is not possible to subdivide the

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[60] Allocation factors for goat are calculated starting from the net energy requirements for goat estimated from the net energy requirements for sheep and considering: sheep weight= 64.8 kg and goat weight= 57.05 kg.

processes, the remaining flows (e.g. excluding those already allocated to milk for milk producing systems or to wool for wool producing systems) shall be allocated to the slaughterhouse and rendering outputs using economic allocation. Default allocation factors are provided in the following sections for cattle, pigs and small ruminants (sheep, goat). These default values shall be used in PEF studies. No change of allocation factors is allowed.

4.5.1.6 Allocation within the slaughterhouse for cattle

At the slaughterhouse, the allocation factors are established for the five product categories described in Table 17. If allocation factors to subdivide the impact of the carcass among the different cuts are desired, they shall be defined and justified in the PEF study.

The by-products from slaughterhouse and rendering are classified in three categories:

- **Category 1**: Risk materials, e.g. infected/ contaminated animals or animal by-products

    o Disposal and use: incineration, co-incineration, landfill, used as biofuel for combustion, manufacture of derived products.

- **Category 2**: Manure and digestive tract content, products of animal origin unfit for human consumption:

    o Disposal and use: incineration, co-incineration, landfill, fertilisers, compost, biofuels, combustion, manufacture of derived products.

- **Category 3**: Carcasses and parts of animals slaughtered and which are fit for human consumption but are not intended for human consumption for commercial reasons, including skins and hides going to the leather industry (note that hides and skins may also belong to other categories depending on the condition and nature that is determined by the accompanying sanitary documentation):

    o Disposal and use: incineration, co-incineration, landfill, feed, pet food, fertilisers, compost, biofuels, combustion, manufacture of derived products (e.g. leather), oleo-chemicals and chemicals.

The upstream burdens to slaughterhouse and rendering outputs shall be allocated as follows:

- **Food grade materials**: product with allocation of upstream burdens.

- **Cat 1 material**: per default no allocation of upstream burdens is performed, as it is seen as animal by-product treated as waste according to the CFF.

- **Cat 2 material**: per default no allocation of upstream burdens is performed as it is seen as animal by-product treated as waste according to the CFF.

- **Cat 3 material having the same fate of cat 1 and cat 2** (for fat – to be burned, or bone and meat meal) **and does not have an economic value at the slaughterhouse gate**: per default no allocation of upstream burdens is performed, as it is treated as waste according to the CFF.

- **Cat 3 skins and hides** (unless they are classified as waste and/or following the same way as cat 1 and cat 2): product with allocation of upstream burdens.

- **Cat 3 materials, not included in previous categories**: product with allocation of upstream burdens.

The default values in Table 17 shall be used in PEF studies. The change of allocation factors is not allowed.

Table 17 Economic allocation ratios for beef [61]

	Mass faction (F)	Price (P)	Economic allocation (EA)	Allocation ratio* (AR)
	%	€/kg	%	
a) Fresh meat and edible offal	49.0	3.00	92.9[62]	1.90
b) Food grade bones	8.0	0.19	1.0	0.12
c) Food grade fat	7.0	0.40	1.8	0.25
d) Cat. 3 slaughter by-products	7.0	0.18	0.8	0.11
e) Hides and skins	7.0	0.80	3.5	0.51
f) Cat 1/2 material and waste	22.0	0.00	0.0	0.00

*Allocation ratios (AR) have been calculated as 'Economic allocation' divided by 'Mass fraction'

Allocation ratios (AR) shall be used to calculate the environmental impact of a unit of product by using the equation below:

$$EI_i = EI_w * AR_i \; [Equation \; 18]$$

Where, EI_i is the environmental impact per mass unit of product i, (i = a slaughterhouse output listed in Table 17), EI_w is the environmental impact of the whole animal divided by live weight mass of the animal and AR_i is the allocation ratio for product i (calculated as economic value of i divided by mass fraction of i).

EI_w shall include upstream impacts, slaughterhouse impacts that are not directly attributable to any specific product and impact from the management of slaughterhouse waste (cat. 1 and 2 material and waste in Table 17). The default values for AR_i as shown in Table 17 shall be used for the EF studies to represent the European average situation.

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[61] Based on the PEF screening study (v 1.0, November 2015) of the meat pilot, available at https://webgate.ec.europa.eu/fpfis/wikis/pages/viewpage.action?pageId=81474527

4.5.1.7 Allocation within the slaughterhouse for pigs

The default values in Table 18 shall be used in PEF studies dealing with allocation within the slaughterhouse for pigs. The change of allocation factors based on company-specific data is not allowed.

Table 18 Economic allocation ratios for pigs[63]

	Mass fraction (F)	Price (P)	Economic allocation (EA)	Allocation ratio* (AR)
	%	€/kg	%	
a) Fresh meat and edible offal	67.0	1.08	98.67	1.54
b) Food grade bones	11.0	0.03	0.47	0.04
c) Food grade fat	3.0	0.02	0.09	0.03
d) Cat. 3 slaughter by-products	19.0	0.03	0.77	0.04
e) Hides and skins (categorized in cat.3 products)	0.0	0.00	0	0
Total	100.0		100.0	

4.5.1.8 Allocation within the slaughterhouse for sheep and goat

The default values in Table 19 shall be used in PEF studies dealing with allocation within the slaughterhouse for sheep and goat. The change of allocation factors based on company-specific data is not allowed. The same allocation factors as for sheep shall be used also for goat.

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[63] Based on the PEF screening study (v 1.0, November 2015) of the meat pilot, available at https://webgate.ec.europa.eu/fpfis/wikis/pages/viewpage.action?pageId=81474527

Table 19 Economic allocation ratios for sheep[64].

	Mass fraction (F)	Price (P)	Economic allocation (EA)	Allocation ratio* (AR)
	%	€/kg	%	
a) Fresh meat and edible offal	44.0	7	97.8[65]	2.22
b) Food grade bones	4.0	0.01	0.0127	0.0032
c) Food grade fat	6.0	0.01	0.0190	0.0032
d) Cat. 3 slaughter by-products	13.0	0.15	0.618	0.05
e) Hides and skins (categorized in cat.3 products)	14.0	0.35	1.6	0.11
f) cat ½ material and waste	19	0	0	0
Total	100		100	

4.6 Data collection requirements and quality requirements

4.6.1 Company-specific data

This section describes company-specific Life Cycle Inventory data, which are data directly measured or collected at a specific facility or set of facilities, and representative of one or more activities or processes in the system boundary.

The data shall include all known inputs and outputs for the processes. Examples for inputs are use of energy, water, land, materials, etc. Outputs are the products, co-products, emissions and waste generated. Emissions are divided into three compartments (emissions to air, to water and to soil).

Company-specific emission data may be collected, measured or calculated using company-specific activity data and related emission factors (e.g. litre of fuel consumption and emission factors for combustion in a vehicle or boiler).

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[64] Based on the PEF screening study (v 1.0, November 2015) of the meat pilot, available at https://webgate.ec.europa.eu/fpfis/wikis/pages/viewpage.action?pageId=81474527

The most representative sources of data for specific processes are measurements directly performed on the process, or obtained from operators via interviews or questionnaires. The data may need scaling, aggregation or other forms of mathematical treatment to bring them in line with the functional unit and reference flow of the process.

Typical specific sources of company-specific data are:

- Process- or plant-level consumption data;

- Bills and stock/ inventory changes of consumables;

- Emission measurements (amounts and concentrations of emissions from flue gas and wastewater);

- Composition of products and waste;

- Procurement and sale department(s)/ unit(s).

All new datasets created when conducting a PEF study shall be EF-compliant (see http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml for further details).

All company-specific data shall be modelled in company-specific datasets.

The bill of material (BoM)[66] is constituted of two parts: the list of materials/ingredients and the quantity used for each of them.

The activity data of the BoM shall be specific to the product in scope and modelled with company-specific data. For companies producing more than one product the activity data used (including the BoM) shall be specific to the product in scope of the study.

The modelling of the manufacturing processes shall be based on company-specific data (e.g. energy needed for the assembly of the materials/ components of the product in scope). For companies producing more than one product the activity data used (including the BoM) shall be specific to the product in scope of the study.

4.6.2 Secondary data

Secondary data refer to data that are not based on direct measurements or calculation of the respective processes in the system boundary. Secondary data is either sector-specific, i.e. specific to the sector being considered for the PEF study, or multi-sector. Examples of secondary data include:

- Data from literature or scientific papers;

- Industry average life cycle data from LCI databases, industry association reports, government statistics, etc.

All secondary data shall be modelled in secondary datasets that shall fulfil the data quality requirements specified in section 4.6.5. The sources of the data used shall be clearly documented and reported in the PEF report.

4.6.3 Which datasets to use?

PEF studies shall use secondary datasets that are EF compliant, when available. In case an EF compliant secondary dataset does not exist, the selection of the datasets to be used shall be done according to the following rules, provided below in hierarchical order:

- Use an EF-compliant proxy (if available); the use of proxy datasets shall be reported in the limitations section of the PEF report.

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[66] In some sectors it is equivalent to the bill of components.

- Use an ILCD entry level (EL) compliant proxy[67]. A maximum of 10% of the total environmental impact may be derived from ILCD-EL compliant datasets (calculated cumulatively from lowest to largest contribution to the total EF profile).

- If no EF-compliant or ILCD-EL compliant proxy is available, then the process shall be excluded from the model. This shall be clearly stated in the in the "limitations" section of the PEF report as a data gap and validated by the verifier.

4.6.4 Cut-off

Any cut-off shall be avoided, unless under the following rules:

Processes and elementary flows may be excluded up to 3.0%, based on material and energy flows and the level of environmental significance (single overall score). The processes subject to cut-off shall be made explicit and justified in the PEF report, in particular with reference to the environmental significance of the cut-off applied.

This cut-off has to be considered additionally to the cut-off already included in the background datasets. This rule is valid for both intermediate and final products.

The processes that in total account less than 3.0% of the material and energy flow and environmental impact for each impact category may be excluded from PEF studies (starting from the less relevant).

A screening study is recommended to identify processes that may be subject to cut-off.

4.6.5 Data quality requirements

This section describes how the data quality of EF compliant datasets shall be assessed. The data quality requirements are presented in Table 20.

- Two minimum requirements: (i) completeness, and (ii) methodological appropriateness and consistency (i.e. full compliance with the PEF method). Once the processes and products are chosen which represent the system analysed, and the LCI of these processes and products are inventoried, the completeness criterion evaluates to what degree the LCI covers all the emissions and resources of the processes and products that are required to calculate all EF impact categories. The completeness criterion is a pre-requisite for EF compliant datasets and thus shall not be rated. Full compliance with the PEF method is required for EF compliant datasets, therefore the criterion methodological appropriateness and consistency is also a pre-requisite and shall not be rated.

- Four quality criteria: technological, geographical, time-related representativeness, and precision. These criteria shall be subject to a scoring procedure.

- Three quality aspects: documentation, nomenclature and review. These criteria are not included within the semi-quantitative assessment of the data quality.

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[67] In case an ILCD-EL compliant proxy is used, for the elementary flows, the nomenclature shall be aligned with the most recent version of the EF reference package available on the EF developer's page at the following link http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml. Details to fulfil this aspect are available at http://eplca.jrc.ec.europa.eu/uploads/MANPROJ-PR-ILCD-Handbook-Nomenclature-and-other-conventions-first-edition-ISBN-fin-v1.0-E.pdf. Furthermore, the EF reference package used for the ILCD-EL proxy, shall be the same one of the EF-compliant datasets used in the PEF study.

This JRC technical report is a working document and does not modify Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations

Table 20 Data quality criteria, documentation, nomenclature and review[68]

Minimum requirements	• Completeness • Methodological appropriateness and consistency[69]
Data quality criteria (scored)	• Technological representativeness[70] (TeR) • Geographical representativeness[71] (GeR) • Time-related representativeness[72] (TiR) • Precision[73] (P)
Documentation	• Compliant with the ILCD format
Nomenclature	• Compliant with the ILCD nomenclature structure (use of EF reference elementary flows for IT compatible inventories; see detailed requirements at section 4.3)
Review	• Review by "Qualified reviewer" • Separate review report

Each data quality criterion to be scored (TeR, GeR, TiR and P) is rated according to the five levels listed in Table 21.

Table 21 *Data Quality Rating (DQR) and data quality levels of each data quality criterion*

Data Quality Rating of Data Quality Criteria (TeR, GeR, TiR, P)	Data Quality Level
1	Excellent
2	Very Good
3	Good
4	Fair
5	Poor

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[68] Detailed requirements regarding documentation and review are provided http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

[69] The term "methodological appropriateness and consistency" used throughout this method is equivalent to "consistency" used in ISO14044.

[70] The term "technological representativeness" used throughout this method is equivalent to "technological coverage" used in ISO14044.

[71] The term "geographical representativeness" used throughout this method is equivalent to "geographical coverage" used in ISO14044.

[72] The term "time-related representativeness" used throughout this method is equivalent to "time-related coverage" used in ISO14044.

[73] The term "parameter uncertainty" used throughout this method is equivalent to "precision" used in ISO14044.

This JRC technical report is a working document and does not modify Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations

4.6.5.1 DQR formula

Within the EF context, the data quality of each new EF compliant dataset and of the total PEF study shall be calculated and reported. The calculation of the DQR shall be based on four data quality criteria:

$$DQR = \frac{TeR + GeR + TiR + P}{4} \quad \text{[Equation 19]}$$

where TeR is the Technological-Representativeness, GeR is the Geographical-Representativeness, TiR is the Time-Representativeness, and P is Precision. The representativeness (technological, geographical and time-related) characterises to what degree the processes and products selected are depicting the system analysed, while the precision indicates the way the data is derived and related level of uncertainty.

Five quality levels (from excellent to poor) can be achieved according to the Data Quality Rating (DQR). They are summarized in Table 222.

Table 22 Overall data quality level of EF-compliant datasets, according to the achieved data quality rating

Overall data quality rating (DQR)	Overall data quality level
DQR ≤ 1.5	"Excellent quality"
1.5 < DQR ≤ 2.0	"Very good quality"
2.0 < DQR ≤ 3.0	"Good quality"
3 < DQR ≤ 4.0	"Fair quality"
DQR >4	"Poor quality"
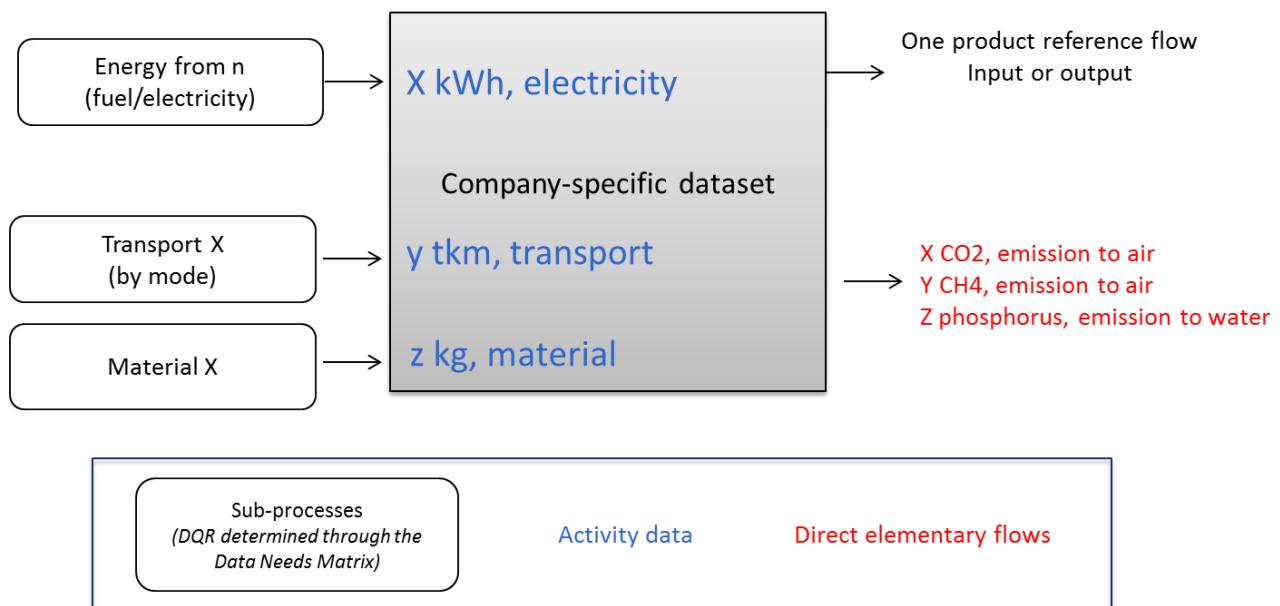
The DQR formula is applicable to:

1. Company-specific datasets: section 4.6.5.2 describes the procedure to calculate the DQR of company-specific datasets;

2. Secondary datasets: when using a secondary EF compliant dataset in a PEF study (procedure described in section 4.6.5.3);

3. PEF study (procedure described in section 4.6.5.8).

4.6.5.2 DQR of company-specific datasets

When creating a company-specific dataset, the data quality of i) the company-specific activity data and ii) the company-specific direct elementary flows (i.e. emission data) shall be assessed separately. The DQR of the sub-processes linked to the activity data (see Figure 9) are evaluated through the requirements provided in the Data Needs Matrix (section 4.6.5.4).

Figure 9 Graphical representation of a company-specific dataset. A company-specific dataset is a partially disaggregated one: the DQR of the activity data and direct elementary flows shall assessed. The DQR of the sub-processes shall be assessed through the Data Needs Matrix.

The DQR of the newly developed dataset shall be calculated as follows:

1) Select the most relevant activity data and direct elementary flows: most relevant activity data are the ones linked to sub-processes (i.e. secondary datasets) that account for at least 80% of the total environmental impact of the company-specific dataset, listing them from the most contributing to the least contributing one. Most relevant direct elementary flows are defined as those direct elementary flows contributing cumulatively at least with 80% to the total impact of the direct elementary flows.

2) Calculate the DQR criteria TeR, TiR, GeR and P for each most relevant activity data and each most relevant direct elementary flow using Table 23.

   a. Each most relevant direct elementary flow consists of the amount and elementary flow naming (e.g. 40 g CO_2). For each most relevant elementary flow, the 4 DQR criteria named Te_{R-EF}, Ti_{R-EF}, G_{R-EF}, P_{EF} shall be evaluated (e.g. the timing of the flow measured, for which technology the flow was measured and in which geographical area).

   b. For each most relevant activity data, the 4 DQR criteria shall be evaluated (named Ti_{R-AD}, P_{AD}, G_{r-AD}, Te_{r-AD}).

   c. Considering that both activity data and direct elementary flows shall be company specific, the score of P cannot be higher than 3 while the score for TiR, TeR, and GeR cannot be higher than 2 (the DQR score shall be ≤1.5).

3) Calculate the environmental contribution of each most-relevant activity data (through linking to the appropriate sub-process) and direct elementary flow to the total sum of the environmental impact of all most relevant activity data and direct elementary flows, in % (weighted, using all EF impact categories). For example, the newly developed dataset has only two most relevant activity data, contributing in total to 80% of the total environmental impact of the dataset:

- Activity data 1 carries 30% of the total dataset environmental impact. The contribution of this process to the total of 80% is 37.5% (the latter is the weight to be used).

- Activity data 2 carries 50% of the total dataset environmental impact. The contribution of this process to the total of 80% is 62.5% (the latter is the weight to be used).

4) Calculate the TeR, TiR, GeR and P criteria of the newly developed dataset as the weighted average of each criteria of the most relevant activity data and direct elementary flows. The weight is the relative contribution (in %) of each most relevant activity data and direct elementary flow calculated in step 3.

5) The user of the PEF method shall calculate the total DQR of the newly developed dataset using the equation below, where $\overline{Te_R}, \overline{G_R}, \overline{Ti_R}, \overline{P}$ are the weighted average calculated as specified in point (4).

$$DQR = \frac{\overline{Te_R} + \overline{Ge_R} + \overline{Ti_R} + \overline{P}}{4} \qquad [Equation\ 20]$$

Table 23 How to assign the values to DQR criteria when using company-specific information. No criteria shall be modified.

Rating	P$_{EF}$ and P$_{AD}$	Ti$_{R-EF}$ and Ti$_{R-AD}$	Te$_{R-EF}$ and Te$_{R-AD}$	G$_{R-EF}$ and G$_{R-AD}$
1	Measured/calculated and externally verified	The data refers to the most recent annual administration period with respect to the EF report publication date	The elementary flows and the activity data exactly the technology of the newly developed dataset	The activity data and elementary flows reflects the exact geography where the process modelled in the newly created dataset takes place
2	Measured/calculated and internally verified, plausibility checked by reviewer	The data refers to maximum 2 annual administration periods with respect to the EF report publication date	The elementary flows and the activity data is a proxy of the technology of the newly developed dataset	The activity data and elementary flows) partly reflects the geography where the process modelled in the newly created dataset takes place
3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer	The data refers to maximum three annual administration periods with respect to the EF report publication date	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable

P$_{EF}$: Precision for elementary flows; P$_{AD}$: Precision for activity data; **Ti$_{R-EF}$**: Time Representativeness for elementary flows; **Ti$_{R-AD}$**: Time representativeness for activity data;; **Te$_{R-EF}$**: Technology representativeness for elementary flows; **Te$_{R-AD}$**: Technology representativeness for activity data; **G$_{R-EF}$**: Geographical representativeness for elementary flows; **G$_{R-AD}$:** Geographical representativeness for activity data.

4.6.5.3 DQR of secondary datasets used in PEF studies

This section describes the procedure to calculate the DQR of secondary datasets used in a PEF study. This means that the DQR of the EF compliant secondary dataset (calculated by the data provider) shall be re-calculated, when they are used in the modelling of most relevant processes (see 4.6.5.4), to allow the user of the PEF method to assess the context-specific DQR criteria (i.e. TeR, TiR and GeR of most relevant processes). The TeR, TiR and GeR criteria shall be re-evaluated based on Table 24. It is not allowed to modify any criteria. The total DQR of the dataset shall be recalculated using equation 19.

Table 24 How to assign the values to DQR criteria when using secondary datasets.

Rating	Ti$_R$	Te$_R$	Ge$_R$
1	The EF report publication date happens within the time validity of the dataset	The technology used in the EF study is exactly the same as the one in scope of the dataset	The process modelled in the EF study takes place in the country the dataset is valid for
2	The EF report publication date happens not later than 2 years beyond the time validity of the dataset	The technologies used in the EF study is included in the mix of technologies in scope of the dataset	The process modelled in the EF study takes place in the geographical region (e.g. Europe) the dataset is valid for
3	The EF report publication date happens not later than 4 years beyond the time validity of the dataset	The technologies used in the EF study are only partly included in the scope of the dataset	The process modelled in the EF study takes place in one of the geographical regions the dataset is valid for
4	The EF report publication date happens not later than 6 years beyond the time validity of the dataset	The technologies used in the EF study are similar to those included in the scope of the dataset	The process modelled in the EF study takes place in a country that is not included in the geographical region(s) the dataset is valid for, but sufficient similarities are estimated based on expert judgement.
5	The EF report publication date happens later than 6 years after the time validity of the dataset, or the time validity is not specified	The technologies used in the EF study are different from those included in the scope of the dataset	The process modelled in the EF study takes place in a different country than the one the dataset is valid for

Ti$_R$: Time representativeness; **Te$_R$**: Technology representativeness; **Ge$_R$:** Geographic representativeness.

4.6.5.4 The data needs matrix (DNM)

The Data Needs Matrix shall be used to evaluate all processes required to model the product in scope on their data requirements (see Table 25). It indicates for which processes company-specific data or secondary data shall or may be used, depending on the level of influence the company has on the process. The following three cases are found in the DNM and explained below:

1. **Situation 1:** the process is run by the company performing the PEF study.

2. **Situation 2:** the process is not run by the company performing the PEF study, but the company has access to (company-)specific information.

3. **Situation 3:** the process is not run by the company performing the PEF study and this company does not have access to (company-)specific information.

The user of the PEF method shall:

1. Determine the level of influence (Situation 1, 2 or 3) the company has for each process in its supply chain. This decision determines which of the options in Table 25 is pertinent for each process;

2. Provide a table in PEF report listing all processes and their situation according to the DNM;

3. Follow the data requirements indicated in Table 25;

4. Calculate/ re-evaluate the DQR values (for each criterion + total) for the datasets of most relevant processes and the new ones created, as indicated in sections 4.6.5.6 – 4.6.5.8.

Table 25 Data Needs Matrix (DNM) – Requirements for a company performing a PEF study. The options indicated for each situation are not listed in hierarchical order

		Data requirements
Situation 1: process run by the company	**Option 1**	Provide company-specific data (both activity data and direct emissions) and create a company-specific dataset (DQR≤1.5). Calculate DQR of the dataset following the rules at section 4.6.5.2.
Situation 2: process not run by the company but with access to company-specific information	**Option 1**	Provide company-specific data and create a company-specific dataset (DQR≤1.5). Calculate DQR of the dataset following the rules at section 4.6.5.2.
	Option 2	Use an EF-compliant secondary dataset and apply company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤3.0). Recalculate DQR of the dataset used (see section 4.6.5.6).
Situation 3: process not run by the company and without access to company-specific information	**Option 1**	Use an EF-compliant secondary data set in aggregated form (DQR≤3.0). Recalculate DQR of the dataset if the process is most relevant (see section 4.6.5.7)

4.6.5.5 DNM, situation 1

For all processes run by the company and where the company performing the PEF study uses company-specific data, the DQR of the newly developed EF compliant dataset shall be evaluated as described in section 4.6.5.2.

4.6.5.6 DNM, situation 2

When a process is in situation 2 (i.e. the company performing the PEF study is not running the process but has access to company-specific data) there are two possible options:

- The user of the PEF method has access to extensive supplier-specific information and wants to create a new EF-compliant dataset (Option 1);
- The company has some supplier-specific information and wants to make some minimum changes (Option 2);

Situation 2/Option 1

For all processes not run by the company and where the company performing the PEF study uses company-specific data, the DQR of the newly developed EF compliant dataset shall be evaluated as described in section 4.6.5.2.

Situation 2/Option 2

A disaggregated secondary EF compliant dataset is used for processes in Situation 2/Option 2. The company performing the PEF study shall:

- Use company-specific activity data for transport;

- Substitute the sub-processes for the electricity mix and transport used in the disaggregated secondary EF compliant dataset with supply chain specific EF compliant datasets.

Supply-chain specific R_1 values may be used. The user of the PEF method shall recalculate the DQR criteria for the processes in Situation 2, Option 2. It shall make the DQR context-specific by re-evaluating TeR and TiR using the table(s) provided in Table 24. The criterion GeR shall be lowered by 30% and the criterion P shall keep the original value.

4.6.5.7 DNM, situation 3

If a process is in situation 3 (i.e. the company performing the PEF study is not running the process and this company does not have access to company-specific data), the company performing the PEF study shall use EF compliant secondary datasets.

If the process is a most relevant one, following the procedure described in section 6.3, the user of the PEF method shall make the DQR criteria context-specific by re-evaluating TeR, TiR and GeR using Table 24. The parameter P shall keep the original value.

For the non-most relevant processes, following the procedure described in section 6.3, the company performing the PEF study shall take the DQR values from the original dataset.

4.6.5.8 DQR of a PEF study

To calculate the DQR of the PEF study, the user of the PEF method shall calculate separately the TeR, TiR, GeR and P. They shall be calculated as the weighted average of the DQR scores of all most relevant processes, based on their relative environmental contribution to the single overall score, using equation 20.

5 Environmental Footprint impact assessment

Once the Life Cycle Inventory (LCI) has been compiled, the EF impact assessment[74] shall be undertaken to calculate the environmental performance of the product, using all the EF impact categories and models. EF impact assessment includes four steps: classification, characterisation, normalisation and weighting. Results of a PEF study shall be calculated and reported in the PEF report as characterised, normalised and weighted results for each EF impact category and as a single overall score based on the weighting factors provided in Section 5.2.2. Results shall be reported for (i) the total life cycle, and (ii) the total life cycle excluding the use stage.

5.1 Classification and characterisation

5.1.1 Classification

Classification requires assigning the material/ energy inputs and outputs inventoried in the LCI to the relevant EF impact category. For example, during the classification phase, all inputs/ outputs that result in greenhouse gas emissions are assigned to the climate change category. Similarly, those that result in emissions of ozone-depleting substances are classified accordingly to the ozone depletion category. In some cases, an input or output may contribute to more than one EF impact category (for example, chlorofluorocarbons (CFCs) contribute to both climate change and ozone depletion).

It is important to express the data in terms of the constituent substances for which characterisation factors (see next section) are available. For example, data for a composite NPK fertiliser shall be disaggregated and classified according to its N, P, and K fractions, because each constituent element will contribute to different EF impact categories. In practice, much of the LCI data may be drawn from existing public or commercial LCI databases, where classification has already been implemented. In such cases, it must be assured, for example by the provider, that the classification and linked EF impact assessment pathways correspond to the requirements of the PEF method.

All inputs and outputs inventoried during the compilation of the LCI shall be assigned to the EF impact categories to which they contribute ("classification") using the classification data available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

As part of the classification of the Life Cycle Inventory, data should be expressed in terms of constituent substances for which characterisation factors are available, as far as possible.

5.1.2 Characterisation

Characterisation refers to the calculation of the magnitude of the contribution of each classified input and output to their respective EF impact categories, and aggregation of the contributions within each category. This is carried out by multiplying the values in the LCI by the relevant characterisation factor for each EF impact category.

The characterisation factors are substance- or resource-specific. They represent the impact intensity of a substance relative to a common reference substance for an EF impact category (impact category indicator). For example, in the case of calculating climate change impacts, all greenhouse gas emissions inventoried in the LCI are weighted in terms of their impact intensity relative to carbon dioxide, which is the reference substance for

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[74] The EF Impact Assessment does not intend to replace other (regulatory) tools that have a different scope and objective such as (Environmental) Risk Assessment ((E)RA), site specific Environmental Impact Assessment (EIA) or Health and Safety regulations at product level or related to safety at the workplace. Especially, the EF Impact Assessment has not the objective to predict if at any specific location at any specific time thresholds are exceeded and actual impacts occur. In contrast, it describes the existing pressures on the environment. Thus, the EF Impact Assessment is complementary to other well-proven tools, adding the life cycle perspective.

this category. This allows for the aggregation of impact potentials and expression in terms of a single equivalent substance (in this case, CO_2 equivalents) for each EF impact category.

All classified inputs and outputs in each EF impact category shall be assigned characterisation factors representing the contribution per unit of input or output to the category, using the provided characterisation factors available online at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml. EF impact assessment results shall subsequently be calculated for each EF impact category by multiplying the amount of each input/ output by its characterisation factor and summing the contributions of all inputs/ outputs within each category to obtain a single measure expressed in the appropriate reference units.

5.2 Normalisation and weighting

Following the steps of classification and characterisation, the EF impact assessment shall be complemented with normalisation and weighting.

5.2.1 Normalisation of Environmental Footprint impact assessment results

Normalisation is the step in which the life cycle impact assessment results are multiplied by normalisation factors to calculate and compare the magnitude of their contributions to the EF impact categories relative to a reference unit. As a result, dimensionless, normalised results are obtained. These reflect the burdens attributable to a product relative to the reference unit. Within the PEF method the normalisation factors are expressed per capita based on a global value. The EF normalisation factors to be used are available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

Normalised environmental footprint results do not, however, indicate the severity or relevance of the respective impacts.

In PEF studies, normalised results shall not be aggregated as this implicitly applies weighting. Characterised results shall be reported alongside the normalised results.

5.2.2 Weighting of Environmental Footprint impact assessment results

Weighting is a mandatory step in PEF studies and it supports the interpretation and communication of the results of the analysis. In this step, normalised results are multiplied by a set of weighting factors (in %) which reflect the perceived relative importance of the life cycle impact categories considered. Weighted results of different impact categories may then be compared to assess their relative importance. They may also be aggregated across life cycle impact categories to obtain a single overall score.

To develop weighting factors, value judgements are required as to the respective importance of the life cycle impact categories considered. The weighting factors[75] that shall be used in PEF studies are provided at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

The results of the EF impact assessment prior to weighting (i.e. characterised and normalised) shall be reported alongside weighted results in the PEF report.

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[75] For more information on existing weighting approaches in PEF, please refer to the reports developed by the JRC available online at http://ec.europa.eu/environment/eussd/smgp/documents/2018_JRC_Weighting_EF.pdf

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6 Interpretation of Product Environmental Footprint results

6.1 Introduction

Interpretation of the results of the PEF study serves two purposes:

- the first is to ensure that the performance of the PEF model corresponds to the goals and quality requirements of the study. In this sense, life cycle interpretation may inform iterative improvements of the PEF model until all goals and requirements are met;

- the second purpose is to derive robust conclusions and recommendations from the analysis, for example in support of environmental improvements.

To meet these objectives, the interpretation phase shall include the steps outlined in this chapter.

6.2 Assessment of the robustness of the Product Environmental Footprint model

The assessment of the robustness of the PEF model evaluates the extent to which methodological choices such as the system boundary, data sources, and allocation choices influence the analytical outcomes.

Tools that should be used to assess the robustness of the PEF model include:

- **Completeness checks**: assess the Life Cycle Inventory data to ensure that it is complete relative to the defined goals, scope, system boundary and quality criteria. This includes completeness of process coverage (i.e. all processes at each supply chain stage considered have been included) and input/ output coverage (i.e. all material or energy inputs and emissions associated with each process have been included).

- **Sensitivity checks**: assess the extent to which the results are determined by specific methodological choices, and the impact of implementing alternative choices where these are identifiable. It is useful to structure sensitivity checks for each phase of the PEF study, including goal and scope definition, the Life Cycle Inventory, and the EF impact assessment.

- **Consistency checks**: assess the extent to which assumptions, methods, and data quality considerations have been applied consistently throughout the PEF study.

Any issues flagged in this evaluation may be used to inform iterative improvements to the PEF study.

6.3 Identification of hotspots: most relevant impact categories, life cycle stages, processes and elementary flows

Once the user of the PEF method ensures that the PEF model is robust and conforms to all aspects defined in the goal and scope definition phases, the main contributing elements to the PEF results shall be identified. This step may also be referred to as "hotspot" analysis. The user of the PEF method shall identify and list in the PEF report (together with the %) the most relevant:

1. Impact categories,
2. Life cycle stages,
3. Processes and
4. Elementary flows.

There is an important operational difference between most relevant impact categories, and life cycle stages on one hand and most relevant processes, and elementary flows on the other. In particular, most relevant impact categories and life cycle stages may be mainly relevant in the context of the "communication" of a PEF study. They might serve the purpose of "warning" an organisation about the area where they should focus their attention.

The identification of the most relevant processes and elementary flows is more important for the engineers and designers to identify actions for improving the overall footprint e.g. by-pass or change a process, further optimise a process, apply anti-pollution technology etc. This is particularly relevant for internal studies, to look deeper on how to improve the environmental performance of the product.

The procedure that shall be followed to identify the most relevant impact categories, life cycle stages, processes and elementary flows is described in the following sections.

6.3.1 Procedure to identify the most relevant impact categories

The identification of the most relevant impact categories shall be based on the normalised and weighted results. The most relevant impact categories shall be identified as all impact categories that cumulatively contribute to at least **80%** to the total environmental impact. This shall start from the largest to the smallest contributions.

At least three relevant impact categories shall be identified as most relevant ones. The user of the PEF method may add more impact categories to the list of the most relevant ones but none shall be deleted.

6.3.2 Procedure to identify the most relevant life cycle stages

The most relevant life cycle stages are the ones that together contribute to at least **80%** to any of the most relevant impact categories identified. This shall start from the largest to the smallest contributions. The user of the PEF method may add more life cycle stages to the list of the most relevant ones but none shall be deleted. As a minimum, the life cycle stages described at section 4.2 shall be considered.

If the use stage accounts for more than 50% of the total impact, the procedure shall be re-run with the exclusion of the use stage. In this case, the list of most relevant life cycle stages shall be those selected through the latter procedure plus the use stage.

6.3.3 Procedure to identify the most relevant processes

Each most relevant impact category shall be further investigated by identifying the most relevant processes used to model the product in scope. The most relevant processes are those that collectively contribute to at least **80%** to any of the most relevant impact categories identified. Identical processes[76] taking place in different life cycle stages (e.g. transportation, electricity use) shall be accounted for separately. Identical processes taking place within the same life cycle stage shall be accounted for together. The list of most relevant processes shall be reported in the PEF report together with the respective life cycle stage (or multiple life cycle stages if relevant) and the contribution in %. The identification of the most relevant processes shall be done according to Table 26.

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[76] Two processes are identical when they have the same UUID.

Table 26 Criteria to select at which life cycle stage level to identify the most relevant processes

— **Contribution of the use stage to the total impact**	— **Most relevant processes identified at the level of**
— ≥ 50%	— Whole life cycle excluding use stage, and — Use stage
— < 50%	— Whole life cycle

This analysis shall be reported separately for each most relevant impact category. The user of the PEF method may add more processes to the list of the most relevant ones but none shall be deleted.

6.3.4 Procedure to identify the most relevant elementary flows

The most relevant elementary flows are defined as those elementary flows contributing cumulatively at least with **80%** to the total impact for each most relevant processes, starting from the most contributing to the less contributing ones. This analysis shall be reported separately for each most relevant impact category.

Elementary flows belonging to the background system of a most relevant process may dominate the total impact, therefore, if disaggregated datasets are available, the user of the PEF method should in addition identify the most relevant direct elementary flows for each most relevant process.

Most relevant direct elementary flows are defined as those direct elementary flows contributing cumulatively at least with **80%** to the total impact of the direct elementary flows of the process, for each most relevant impact category. The analysis shall be limited to the direct emissions of the level-1 disaggregated datasets (see http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml) for description of level-1 disaggregated datasets). This means that the 80% cumulative contribution shall be calculated against the impact caused by the direct emissions only, and not against the total impact of the process.

The user of the PEF method may add more elementary flows to the list of the most relevant ones but none shall be deleted. The list of most relevant elementary flows (or, if applicable, direct elementary flows) per most relevant process shall be reported in the PEF report.

6.3.5 Dealing with negative numbers

When identifying the percentage impact contribution for any process or elementary flow, it is important that absolute values be used. This allows to identify the relevance of any credits (e.g., from recycling). In case of processes or flows with a negative impact score, the following procedure shall be applied:

- consider the absolute values (i.e. impacts of processes or flows to have a plus sign, namely a positive score),
- the total impact score needs to be recalculated including the converted negative scores,
- the total impact score is set to 100%,
- the percentage impact contribution for any process or elementary flow is assessed to this new total.

This procedure does not apply to identify the most relevant life cycle stages.

6.3.6 Summary of requirements

Table 27 summarises the requirements to define most relevant contributions.

Table 27 Summary of requirements to define most relevant contributions

Item	At what level does relevance need to be identified?	Threshold
Most relevant impact categories	Normalised and weighted results	Impact categories cumulatively contributing at least **80%** of the total environmental impact
Most relevant life cycle stages	For each most relevant impact category	All life cycle stages contributing cumulatively more than **80%** to that impact category
Most relevant processes	For each most relevant impact category	All processes contributing cumulatively (along the entire life cycle) more than **80%** to that impact category, considering absolute values.
Most relevant elementary flows	For each most relevant process and most relevant impact categories	All elementary flows contributing cumulatively at least to 80% to the total impact for each most relevant processes.
		If disaggregated data are available: for each most relevant process, all direct elementary flows contributing cumulatively at least to **80%** to that impact category (caused by the direct elementary flows only)

6.3.7 Example

Fictitious examples are provided below, which are not based on any specific PEF study results.

Most relevant impact categories

Table 28 Contribution of different impact categories based on normalised and weighted results – example

Impact category	Contribution to the total impact (%)
Climate change	21.5
Ozone depletion	3.0

Impact category	Contribution to the total impact (%)
Human toxicity, cancer	6.0
Human toxicity, non-cancer	0.1
Particulate matter	14.9
Ionizing radiation, human health	0.5
Photochemical ozone formation, human health	2.4
Acidification	1.5
Eutrophication, terrestrial	1.0
Eutrophication, freshwater	1.0
Eutrophication, marine	0.1
Ecotoxicity, freshwater	0.1
Land use	14.3
Water use	18.6
Resource use, minerals and metals	6.7
Resource use, fossils	8.3
Total most relevant impact categories	**84.3**

Based on the normalised and weighted results, the most relevant impact categories are: climate change, particulate matter, water use, land use, and resource use (minerals and metals and fossils) for a cumulative contribution of 84.3% of the total impact.

Most relevant life cycle stages

Table 29 Contribution of different life cycle stages to the climate change impact category (based on the characterised inventory results) – example

Life cycle stage (LCS)	Contribution (%)
Raw material acquisition and pre-processing	46.3
Production of the main product	21.2
Product distribution and storage	16.5
Use stage	5.9
End of life	10.1
Total most relevant LCS	**88.0**

The three life cycle stages in yellow will be the ones identified as "most relevant" for climate change as they are contributing to more than 80%. Ranking shall start from the highest contributors.

This procedure shall be repeated for all the selected most relevant EF impact categories.

Most relevant processes

Table 30 Contribution of different processes to the climate change impact category (based on the characterised inventory results) - example

Life cycle stage	Unit process	Contribution (%)
Raw material acquisition and pre-processing	Process A	4.9
	Process B	41.4
Production of the main product	Process C	18.4
	Process D	2.8
Product distribution and storage	Process E	16.5
Use stage	Process F	5.9
End of life	Process G	10.1

Life cycle stage	Unit process	Contribution (%)
Total most relevant processes		**86.4**

According to the proposed procedure the processes B, C, E and G shall be selected as "most relevant".

This procedure shall be repeated for all the selected most relevant impact categories.

Dealing with negative numbers and identical processes in different life cycle stages

Table 31 Example on how to deal with negative numbers and identical process in different life cycle stages

Impact Category 1 (Characterised results)

1. Characterised results of a most relevant EF Impact Category

	LC stage 1	LC stage 2	LC stage 3	LC stage 4	LC stage 5	total per process	% per process
Process A	18	23				41	44%
Process B			13			13	14%
Process C	17				-9	8	9%
Process D	5			6		11	12%
Process E	4	4	4	4	4	20	22%
Total of LC						93	100%

2. Convert everything to absolute values

	LC stage 1	LC stage 2	LC stage 3	LC stage 4	LC stage 5	total per process	% per process
Process A	18	23				41	38%
Process B			10			10	9%
Process C	17				9	26	24%
Process D	5			6		11	10%
Process E	4	4	4	4	4	20	19%
Total of LC						108	100%

Most relevant processes

3. Calculate the % per process and life cycle stage

	LC stage 1	LC stage 2	LC stage 3	LC stage 4	LC stage 5	total per process (absolute values)	% per process
Process A	17%	21%				41	38%
Process B			9%			10	9%
Process C	16%				8%	26	24%
Process D	5%			6%		11	10%
Process E	4%	4%	4%	4%	4%	20	19%
Total of LC						108	100%

6.4 Conclusions and recommendations

The final aspect of the EF interpretation phase is to draw conclusions based on the analytical results, answer the questions posed at the outset of the PEF study, and advance

recommendations appropriate to the intended audience and context whilst explicitly taking into account any limitations to the robustness and applicability of the results. The PEF needs to be seen as complementary to other assessments and instruments such as site-specific environmental impact assessments or chemical risk assessments.

Potential improvements should be identified, for example using cleaner technology or production techniques, changes in product design, applying environmental management systems (e.g. Eco-Management and Audit Scheme (EMAS) or ISO 14001), or other systematic approaches.

Conclusions, recommendations and limitations shall be described in accordance with the defined goals and scope of the PEF study. The conclusions should include a summary of identified supply chain "hotspots" and the potential improvements associated with management interventions.

7 Product Environmental Footprint reports

7.1 Introduction

A PEF report complements the PEF study and it provides a relevant, comprehensive, consistent, accurate, and transparent summary of the PEF study. It reflects the best possible information in such a way as to maximise its usefulness to intended current and future users, whilst transparently communicating the limitations. Effective PEF reporting requires that several criteria, both procedural (report quality) and substantive (report content), are met. A PEF report template is available in Annex E. The template includes the minimum information to be reported in a PEF report.

A PEF report consists of at least: a summary, the main report, the aggregated EF compliant dataset and an annex. Confidential and proprietary information may be documented in a fourth element - a complementary confidential report. Review reports are annexed.

7.1.1 Summary

The summary shall be able to stand alone without compromising the results and conclusions/ recommendations (if included). The summary shall fulfil the same criteria about transparency, consistency, etc. as the detailed report. To the extent possible, the summary should be written targeting a non-technical audience.

7.1.2 Main report

The main report[77] shall, as a minimum, include the following components:

- General information,
- Goal of the study,
- Scope of the study,
- Life cycle inventory analysis,
- Life cycle impact assessment results,
- Interpreting PEF results.

7.1.3 Aggregated EF compliant dataset

For each product in scope of the PEF study, the user shall make available an aggregated EF compliant dataset to the European Commission. The details related to the use and intellectual property rights related to this data are available at the link: http://ec.europa.eu/environment/eussd/smgp/pdf/IPR_PEFCR_OEFSR.pdf

If the user of the PEF method or of the PEFCR publishes such an EF compliant dataset, the PEF report on the basis of which the dataset is generated shall also be made public.

7.1.4 Validation statement

See section 8.5.3.

7.1.5 Annexes

The annexes serve to document supporting elements to the main report which are of a more technical nature (e.g detailed calculations for data quality assessment, alternative approach for nitrogen field model when a PEF study has agricultural modelling in scope,

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[77] The main report, as defined here, is insofar as possible in line with ISO 14044 requirements on reporting for studies which do not contain comparative assertions to be disclosed to the public.

results of sensitivity analysis, assessment of the robustness of the PEF model, bibliographic references).

7.1.6 Confidential report

The confidential report is an optional reporting element that shall contain all data (including raw data) and information that are confidential or proprietary and may not be made externally available. The confidential report shall be made available for the verification and validation procedure of the PEF study (see section 8.4.3).

8 Verification and validation of PEF studies, reports, and communication vehicles

In case policies implementing the PEF method define specific requirements regarding verification and validation of PEF studies, reports and communication vehicles, the requirements in said policies shall prevail.

8.1 Defining the scope of the verification

The verification and validation of the PEF study is mandatory whenever the PEF study, or part of the information therein, is used for any type of external communication (i.e. communication to any interested party other than the commissioner or the user of the PEF method of the study).

Verification means the conformity assessment process carried out by an environmental footprint verifier to check whether the PEF study has been carried out in compliance with the most updated version of the Commission PEF method.

Validation means the confirmation by the environmental footprint verifier who carried out the verification, that the information and data included in the PEF study PEF report and the communication vehicles are reliable, credible and correct.

The verification and validation shall cover the following three areas:

1. the PEF study (including, but not limited to the data collected, calculated, and estimated and the underlying model);
2. the PEF report;
3. the technical content of the communication vehicles, if applicable.

The verification of the **PEF study** shall ensure that the PEF study is conducted in compliance with the most recent version of the PEF method or PEFCR.

The validation of information in the PEF study shall ensure that:

- the data and information used for the PEF study are consistent, reliable and traceable;
- the calculations performed do not include significant[78] mistakes.

The verification and validation of the **PEF report** shall ensure that:

- the PEF report is complete, consistent, and compliant with the PEF report template provided in the most recent version of the PEF method;
- the information and data included are consistent, reliable and traceable;
- the mandatory information and sections are included and appropriately filled in;
- all the technical information that could be used for communication purposes, independently from the communication vehicle to be used, are included in the report.

Note: confidential information shall be subject to validation, whilst they may be excluded from the PEF report.

The validation of the technical content of the **communication vehicle** content shall ensure that**:**

- The technical information and data included are reliable and consistent with the information included in the PEF study and in the PEF report;

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[78] Mistakes are significant if they change the final result by more than 5% for any of the impact categories, or the identified most relevant impact categories, life cycle stages and processes.

- That the information is compliant with the requirements of the Unfair Commercial Practices Directive[79];
- That the communication vehicle fulfils the principles of transparency, availability and accessibility, reliability, completeness, comparability and clarity, as described in the Commission Communication on Building the Single Market for Green Products[80].

8.2 Verification procedure

The verification procedure covers the following steps:

1. The commissioner shall select the verifier or verification team following the rules outlined in section 8.3.1;

2. The verification shall be performed following the verification process described in section 8.4;

3. The verifier shall communicate to the commissioner any misstatements, non-conformities and need for clarifications (section 8.3.2), and draft the validation statement (section 8.5.2);

4. The commissioner shall respond to the verifier's comments and introduce necessary corrections and changes (if needed) to ensure the final compliance of the PEF study, PEF report and technical content of PEF communication vehicles. If, in the verifier's judgement, the commissioner does not respond appropriately within a reasonable time period, the verifier shall issue a modified validation statement;

5. The final validation statement is provided, considering (if needed) the corrections and changes introduced by the commissioner;

6. Surveillance that the PEF report is available during the validity of the validation statement (as defined in 8.5.3).

If a matter comes to the verifier's attention that causes the verifier to believe in the existence of fraud or noncompliance with laws or regulations, the verifier shall communicate this immediately to the commissioner of the study.

8.3 Verifier(s)

The verification/ validation may be performed by a single verifier or by a verification team. The independent verifier(s) shall be external to the organisation that conducted the PEF study.

In all cases the independence of the verifiers shall be guaranteed, i.e. they shall fulfil the intentions in the requirements of ISO/IEC 17020:2012 regarding a 3rd party verifier, they shall not have conflicts of interests on concerned products.

In case the PEF study is done based on a PEFCR, verifiers shall not include members of the Technical Secretariat or of the consultants involved in previous parts of the work - screening studies, supporting studies, PEFCR review, etc.

The minimum requirements and score for the verifier(s) as specified below shall be fulfilled. If the verification/ validation is performed by a single verifier, he or she shall satisfy all the minimum requirements and the minimum score (see chapter 8.3.1); if the

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[79] Directive 2005/29/EC of the European Parliament and of the Council of 11 May 2005 concerning unfair business-to-consumer commercial practices in the internal market and amending Council Directive 84/450/EEC, Directives 97/7/EC, 98/27/EC and 2002/65/EC of the European Parliament and of the Council and Regulation (EC) No 2006/2004 of the European Parliament and of the Council ('Unfair Commercial Practices Directive')

[80] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0196

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verification/validation is performed by a team, the team as a whole shall satisfy all the minimum requirements and the minimum score. The documents proving the qualifications of the verifier(s) shall be provided as annex to the verification report or they shall be made available electronically.

In case a verification team is established, one of the members of the verification team shall be appointed as lead verifier.

8.3.1 Minimum requirements for verifier(s)

The assessment of the competences of verifier or verification team is based on a scoring system that takes into account (i) verification and validation experience, (ii) EF/LCA methodology and practice, and (iii) knowledge of relevant technologies, processes or other activities included in the product(s)/organisation(s) in scope of the study. Table 32 presents the scoring system for each relevant competence and experience topic.

Unless otherwise specified in the context of the intended application, the verifier's self-declaration on the scoring system constitutes the minimum requirement. Verifier(s) shall provide a self-declaration of their qualifications (e.g. university diploma, working experience, certifications, etc), stating how many points they achieved for each criterion and the total points achieved. This self-declaration shall form part of the PEF verification report.

A verification of a PEF study shall be conducted as per the requirements of the intended application. Unless otherwise specified, the minimum necessary score to qualify as a verifier or a verification team is six points, including at least one point for each of the three mandatory criteria (i.e. verification and validation practice, PEF/LCA methodology and practice, and knowledge of technologies or other activities relevant to the PEF study).

Table 32 Scoring system for each relevant competence and experience topic for the assessment of the competences of verifier(s)

	Topic	Criteria	Score (points)				
			0	**1**	**2**	**3**	**4**
Mandatory criteria	Verification and validation practice	Years of experience (1)	<2	2 ≤ x < 4	4 ≤ x < 8	8≤ x < 14	≥14
		Number of verifications (2)	≤5	5 < x ≤ 10	11 ≤ x ≤ 20	21 ≤ x ≤ 30	>30
	LCA method-logy and practice	Years of experience (3)	<2	2 ≤ x < 4	4 ≤ x < 8	8≤ x < 14	≥14
		Number of LCA studies or reviews (4)	≤5	5 < x ≤ 10	11 ≤ x ≤ 20	21 ≤ x ≤ 30	>30
	Know-ledge of the specific sector	Years of experience (5)	<1	1 ≤ x < 3	3 ≤ x < 6	6≤ x < 10	≥10
Additional criteria	Review, verifica-tion/ validation practice	Optional scores relating to verification/ validation	— 2 points: Accreditation as third party verifier for EMAS — 1 point: Accreditation as third party reviewer for at least one EPD Scheme, ISO 14001, or other EMS				

(1) Years of experience in the field of environmental verifications and/or review of LCA/PEF/EPD studies.

(2) Number of verifications for EMAS, ISO 14001, International EPD scheme or other EMS.

(3) Years of experience in the field of LCA modelling. Work done during master and bachelor degrees shall be excluded. Work done during a relevant Ph.D./Doctorate course shall be accounted for. Experience in LCA modelling includes, among others:

- LCA modelling in commercial and non-commercial software
- Datasets and database development

(4) Studies compliant with one of the following standards/methods: PEF, OEF, ISO 14040-44, ISO 14067, ISO 14025

(5) Years of experience in a sector related to the studied product(s). The experience in the sector may be gained through LCA studies or through other types of activities. The LCA studies shall be done on behalf of and with access to primary data of the producing/operating industry. The qualification of knowledge about technologies or other activities is assigned according to the classification of NACE codes (*Regulation (EC) No 1893/2006 of the European Parliament and of the Council of 20 December 2006 establishing the statistical classification of economic activities - NACE Revision 2*). Equivalent classifications of other international organisations may also be used. Experience gained with technologies or processes in a whole sector are considered valid for any of its sub-sectors.

8.3.2 Role of the lead verifier in the verification team

The lead verifier is a team member with additional tasks. The lead verifier shall:

- distribute the tasks to be fulfilled between the team members according to the specific competencies of the team members, to get the full coverage of the tasks to be done and to use in the best manner the specific competencies of the team members;
- coordinate the whole verification/validation process and ensure that all team members have a common understanding of the tasks they need to fulfil;
- assemble all comments and ensure they are communicated to the commissioner of the PEF study in a clear and comprehensible way;
- resolve any conflicting statements between team members;
- ensure that the verification report and validation statement are generated and are signed by each member of the verification team.

8.4 Verification / validation requirements

The verifier(s) shall describe all the outcomes related to the verification of the PEF study, PEF report and PEF communication vehicles and give the commissioner of the PEF study the opportunity to improve the work, if necessary. Depending on the nature of the outcomes, additional iterations of comments and responses may be necessary. Any changes made in response to the verification outcomes shall be documented in the verification report.

The verification/validation shall be done by combining documental review and model validation.

- the documental review includes the PEF report, the technical content of any communication vehicle, and the data used in the calculations through requested underlying documents. Verifier(s) may organise the documental review either as an "at desk" or "on site" exercise, or as a mix of the two. The verification of the company-specific data shall always be organised through a visit of the production site(s) the data refer to.
- the validation of the model may take place at the production site of the commissioner of the study or be organised remotely. The verifier(s) shall access the model to verify its structure, the data used, and its consistency with the PEF report. The details about how the verifier(s) accesses the model shall be agreed by the commissioner of the PEF study and the verifier(s).

The verification may take place at the end of the PEF study or in parallel (concurrent) to the study.

The verifier(s) shall ensure that data verification/validation includes:

(a) coverage, precision, completeness, representativeness, consistency, reproducibility, sources and uncertainty;

(b) plausibility, quality and accuracy of the LCA-based data;

(c) quality and accuracy of additional environmental and technical information;

(d) quality and accuracy of the supporting information.

The validation of the PEF report shall be carried out by checking enough information to provide reasonable assurance that the PEF report fulfils all the conditions listed in section 8.4.1.

The verification and validation of the PEF study shall be carried out by following the minimum requirements listed below.

8.4.1 Minimum requirements for the verification and validation of the PEF study

The verifier(s) shall validate the accuracy and reliability of the quantitative information used in the calculation of the study. As this may be highly resource intensive, the following requirements shall be followed:

- the verifier shall check if the correct version of all impact assessment methods was used. For each of the most relevant EF impact categories (ICs), at least 50% of the characterisation shall be verified, while all normalisation and weighting factors of all ICs shall be verified. In particular, the verifier shall check that the characterisation factors correspond to those included in the EF impact assessment method the study declares compliance with[81];

- cut-off applied (if any) fulfils the requirements at section 4.6.4;

- all the newly created datasets shall be checked on their EF compliance (for the meaning of EF compliant datasets refer to http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml). All their underlying data (elementary flows, activity data and sub processes) shall be validated;

- the aggregated EF compliant dataset of the product in scope is made available to the European Commission;

- for at least 70% of the most relevant processes (by number) in situation 2 option 2 of the DNM, 70% of the underlying numbers shall be validated. The 70% data shall include all energy and transport sub-processes for processes in situation 2 option 2;

- for at least 60% of the most relevant processes (by number) in situation 3 of the DNM, 60% of the underlying data shall be validated;

- for at least 50% of the other processes (by number) in situation 1, 2 and 3 of the DNM, 50% of the underlying data shall be validated.

The verifier shall put together in a single list all the most relevant processes coming from all the most relevant impact categories, together with their situation in the DNM.

For all processes to be validated, it shall be checked if the DQR satisfies the minimum DQR as specified in the PEF method (see section 4.6.5.4).

These data checks shall include, but should not be limited to, the activity data used, the selection of secondary sub-processes, the selection of the direct elementary flows and the CFF parameters. For example, if there are 5 processes and each one of them includes 5 activity data, 5 secondary datasets and 10 CFF parameters, then the verifier(s) has to

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[81] Available at: http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml

check at least 4 out of 5 processes (70%) and, for each process, (s)he shall check at least 4 activity data (70% of the total amount of activity data), 4 secondary datasets (70% of the total amount of secondary datasets), and 7 CFF parameters (70% of the total amount of CFF parameters), i.e. the 70% of each of data that could be possible subject of check.

8.4.2 Verification and validation techniques

The verifier shall assess and confirm whether the calculation methodologies applied are of acceptable accuracy, reliable, are appropriate and performed in accordance to the PEF method. The verifier shall confirm the correct application of conversion of measurement units.

The verifier shall check if applied sampling procedures are in accordance with the sampling procedure defined in the PEF method. The data reported shall be checked against the source documentation in order to check their consistency.

The verifiers shall evaluate whether the methods for making estimates are appropriate and have been applied consistently.

The verifier may assess alternatives to estimations or choices made, in the assertion to determine whether a conservative choice has been selected.

The verifier may identify uncertainties that are greater than expected and assess the effect of the identified uncertainty on the final PEF results.

8.4.3 Data confidentiality

Data for validation shall be presented in a systematic and comprehensive way, all the project documentation supporting the validation of a PEF study shall be provided to the verifier(s), including the EF model, the confidential information and data. This data and information shall be treated as confidential and shall be used only during the verification process.

Confidential information may be excluded from the report, provided that:

- the request for non-disclosure only cover input information, not any output information;

- the commissioner of the PEF study provides the verifier with sufficient information of the nature of the data and information, and the reason for the request of excluding the data or information from the study report;

- the verifier accept the non-disclosure and include in the verification report the reasons for doing so;

- the commissioner of the PEF study keep a file of the non-disclosed information for possible future re-evaluation of the decision of non-disclosure.

Business data could be of confidential nature because of competition aspects, intellectual property rights or similar legal restrictions. Therefore, business data identified as confidential and provided during validation process shall be kept confidential. Hence, verifiers shall not disseminate or otherwise retain for use, without the permission of the organisation, any information disclosed to them during the course of the review work. The commissioner of the PEF study may ask to the verifier(s) to sign a non-disclosure agreement (NDA).

8.5 Outputs of the verification/ validation process

8.5.1 Content of the verification and validation report

The verification and validation report[82] shall include all findings of the verification/ validation process, the actions taken by the commissioner to answer the comments of the verifier(s), and the final conclusion. The report is mandatory, but it may be confidential.

The final conclusion may be of different nature:

- "compliant" if the documental or on-site information proves that the requirements of this chapter are fulfilled.

- "not compliant" if the documental or on-site information proves that the requirements of this chapter are not fulfilled.

- "complementary information needed" if the documental or on-site information cannot allow the verifier to conclude on compliance. This may happen if the information is not transparently or sufficiently documented or registered.

8.5.2 Content of the validation statement

The validation statement is mandatory and shall always be provided as an annex to the PEF report. Therefore, from each communication vehicle it shall be possible to have access to the complete PEF report (except any confidential annexes), including the validation statement.

The following elements and aspects shall be included in the validation statement, as a minimum:

- title of the PEF study under verification/validation, together with the exact version of the report to which the validation statement belongs;

- the commissioner of the PEF study;

- the user of the PEF method;

- the verifier(s) or, in the case of a verification team, the team members with the identification of the lead verifier;

- absence of conflicts of interest of the verifier(s) with respect to concerned products and any involvement in previous work (where relevant, PEFCR development, Technical Secretariat membership, consultancy work carried out for the user of the PEF method during the last three years);

- a description of the objective of the verification/ validation;

- a statement of the result of the verification /validation;

- any limitations of the verification/ validation outcomes;

- date in which the validation statement has been issued;

- signature by the verifier(s).

8.5.3 Validity of the verification and validation report and the validation statement

A verification/ validation report and a validation statement shall refer only to one specific PEF report. The verification and validation report and a validation statement shall unambiguously identify the specific PEF study under verification (e.g. by including the title, the commissioner of the PEF study, the user of the PEF method, etc.), together with the

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[82] The two aspects, validation and verification, are included in one report.

explicit version of the final PEF report to which the verification and validation report and a validation statement apply (e.g. by including the report date, the version number, etc.).

Both the verification and validation report and the validation statement shall be completed on the basis of the final PEF report, after the implementation of all the corrective actions requested by the verifier(s). They shall carry the handwritten or electronic signature of the verifier(s).

The maximum validity of the verification and validation report and of the validation statement should not exceed three years starting from their first issue date.

During the validity period of the verification, surveillance (follow-up) shall be agreed between the commissioner of the PEF study and the verifier(s) to evaluate if the content is still consistent with the current situation (the suggested periodicity for this follow up is once per year).

The periodic checks shall focus on the parameters that according to the verifiers might lead to relevant changes in the results of the PEF study. A non-exhaustive list of such parameters is:

- bill of material/ bill of components;
- energy mix used for processes in situation 1 of the Data Needs Matrix;
- change of packaging;
- changes in the suppliers (materials/ geography);
- changes in the logistics;
- relevant technological changes in the processes in situation 1 of the Data Needs Matrix.

At the time of the periodic check the reasons for non-disclosure of information should also be reconsidered. The surveillance verification may be organised as a documental check and/or through on-site inspections.

Regardless of the validity, the PEF study (and consequently the PEF report) shall be updated during the surveillance period if the results of one of the impact categories communicated has worsened by more than 10.0% compared to the verified data, or if the total aggregated score has worsened by more than 5.0% compared to the verified data.

If these changes affect also the communication content, it shall be updated accordingly.

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Annexes

Annex A - REQUIREMENTS TO DEVELOP PEFCRS AND PERFORM PEF STUDIES IN COMPLIANCE WITH AN EXISTING PEFCR

Product Environmental Footprint Category Rules (PEFCRs) provide specific requirements for calculating the products' life cycle potential environmental impacts. This Annex contains all additional requirements for developing PEFCRs and performing PEF studies in compliance with an existing PEFCR.

A PEFCR shall be in line with all requirements of this document, shall include (as text) all requirements of this Annex and shall refer (without copying the corresponding text) to the requirements in the PEF method where relevant. It shall further specify those requirements where the PEF method leaves a choice, and may add new requirements, if relevant and in line with the PEF method. Further specified requirements in a PEFCR always prevail over those included in the PEF method.

The objective is to ensure that PEFCRs (developed according to the PEF method) provide the specifications needed to achieve the increased comparability, reproducibility, consistency, relevance, focus and efficiency of PEF studies for products within the same defined category.

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2013/179/EU on the use of common methods to measure and communicate the life cycle
environmental performance of products and organisations

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Terminology: shall, should may

This Annex uses precise terminology to indicate the requirements, the recommendations and options that could be chosen when developing a PEFCR.

The term "shall" is used to indicate what is required in order for a PEFCR to be in conformance with the PEF method, including all its annexes.

The term "should" is used to indicate a recommendation rather than a requirement. Any deviation from a "should" requirement has to be justified when developing the PEFCR.

The term "may" is used to indicate an option that is permissible. Whenever options are available, the PEFCR shall include adequate argumentation to justify the chosen option.

A.1 INTRODUCTION

Rules analogous to PEFCRs exist in standards for other types of life cycle-based product claims, such as ISO 14025:2006 (type III environmental declarations). PEFCRs were named differently to prevent confusion between other analogous rules and uniquely identify rules under the PEF method.

Based on an analysis carried out by JRC in 2010[83], the Commission came to the conclusion that existing life cycle based standards do not provide sufficient specificity to ensure that the same assumptions, measurements and calculations are made to support comparability of environmental claims across products delivering the same function. PEFCRs aim at increasing comparability, reproducibility, consistency, relevance, focus and efficiency of PEF studies.

A PEFCR shall be developed according to the latest available version of the PEF method. It should be developed and written in a format that persons with technical knowledge (in LCA as well as with regard to the considered product category) can understand and can use to conduct a PEF study.

Each PEFCR shall implement the materiality principle, meaning that a PEF study shall focus on those aspects and parameters that are the most relevant for the environmental performance of a given product. By doing this the time, effort and cost of carrying out the analysis is reduced.

Each PEFCR shall specify the minimum list of processes (mandatory processes) that shall always be modelled with company-specific data. The purpose is to avoid that users of the PEFCR are able to perform a PEF study and communicate its results without having access to the relevant company-specific (primary) data and by using only default data. The PEFCR shall define this mandatory list of processes based on their relevance and the possibility to have access to company-specific data.

A.1.1.   Role of PEFCRs and relation with existing Product Category Rules

The development of a PEFCR should take into account, to the extent possible, already existing technical documents and PCRs from other schemes.

As defined in ISO 14025(2006), Product Category Rules (PCRs)[84] include sets of specific rules, guidelines and requirements to develop "Type III environmental declarations" for any product category (i.e. goods and/or services providing equivalent functions). "Type III environmental declarations" are quantitative, LCA-based claims of the environmental aspects[85] of a certain good or service, e.g. quantitative information regarding potential environmental impacts. Type III environmental declarations may, for instance, be a potential application of a PEF study.

For the development and review of Product Category Rules (PCRs), ISO 14025(2006) describes the procedure and establishes requirements for the comparability of different so-called "Type III environmental declarations".

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[83]   Analysis of Existing Environmental Footprint Methodologies for Products and Organizations: Recommendations, Rationale, and Alignment (2010), available at: http://ec.europa.eu/environment/eussd/smgp/dev_methods.htm

[84]   Product Category Rules (PCR) are a set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories (ISO 14025:2006).

[85]   An environmental aspect is defined as an element of an organisation's activities or products that has or can have an impact on the environment.

The guidelines on how to develop PEFCRs are based on the minimum content of a PCR document as required by ISO 14025. Following ISO 14025 for PCRs this includes, but is not limited to:

- Identification of the product category for which a PCR is to be developed, including a description of, for example, the product's function(s), technical performance and use(s);

- Definition of the goal and scope for the Life Cycle Assessment (LCA) of the product, according to the requirement of the ISO 14040 series in terms of, for example, functional unit, system boundary, data quality requirements;

- Description of the Life Cycle Inventory (LCI) analysis, with special focus on the data collection phase, calculation procedures, and allocation rules;

- Choice of the impact category indicators to be included in the LCA;

- Description of any eventual predetermined parameter for the reporting of LCA data, for example, certain predetermined inventory data categories and/or category indicators;

- If not all life-cycle stages are included in the LCA, information/ justification on which stages are not covered;

- Time validity of the PEFCR being developed.

A.1.2.   How to manage modularity

In case of intermediate products, the PEFCR becomes a "module" to be used when developing PEFCRs for products further down the same supply chain. This is equally applicable if the intermediate product can be used in different supply chains (e.g. metal sheets). The development of "modules" allows for a higher level of consistency among different supply chains that are using the same modules as part of their LCA. Furthermore, the development of "modules" is essential to keep the number of PEFCRs manageable.

The possibility to build such modules should always be considered also for final products, especially for those products that share part of the production chain and then differentiate due to different functions (e.g. detergents).

There are different scenarios that require a modular approach:

(a)   A final product using in its BoM an intermediate product for which there is already an existing PEFCR (e.g. car production with leather upholstery) or a final product that becomes part of the life cycle of another product (e.g. detergent used to wash a T-shirt);

(b)   A final product using a component or product that is already used as a component by another PEFCR (e.g. fittings to be used in piping systems, fertilisers).

For scenario (a), the new PEFCR shall define how to manage the product information based on the environmental relevance of the product and the Data Needs Matrix (see section A.4.4.4.4). This means that if the product is "most relevant" and it is under the company's control, company-specific data shall be requested, following the rules of

the PEFCR having the module in its scope[86]. If it is not under the company's operational control or amongst the "most relevant" processes, the PEFCR user may choose either to provide company-specific data, or to use the EF-compliant secondary dataset[87] provided with the PEFCR that has the module in its scope.

In scenario (b), the TS shall assess the feasibility of implementing the same modelling assumptions and secondary datasets listed in the existing PEFCR. If feasible, the TS shall implement the same modelling assumptions and dataset to be used in its own PEFCR. If not feasible, the TS shall agree on a solution with the Commission.

A.2. THE PROCESS OF DEVELOPING A PEFCR

This section includes the process for developing a PEFCR. The following situations might occur:

(a)   Development of a new PEFCR;

(b)   Full revision of an existing PEFCR;

(c)   Partial revision of an existing PEFCR.

For cases (a) and (b) the procedure described in this section (see figure A-1) shall be followed.

Case (c) is only allowed if the model of the Representative Product (RP, see section A.2.3) is updated with corrected/ new data or datasets, and the results of the RP change with a certain maximum:

(i)   LCIA results change <10% per impact category (characterized results), and

(ii)   LCIA results change <5% on the total impact (weighted single overall score), and

(iii)   the list of most relevant impact categories, life cycle stages, processes, and direct elementary flows don't change.

If results of the RP change > 10% for at least one impact category (characterized results) or > 5% on the total impact (weighted single overall score), case (c) is not applicable and a full revision of the PEFCR is needed.

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[86]   In case the already existing PEFCR used as a module is updated during the validity of the PEFCR relying on it, the old version prevails and stays valid for the duration of the validity of the newly developed PEFCR.

[87]   This is a mandatory deliverable for any representative product developed in a PEFCR.

In case (c) the TS shall provide an updated PEFCR to the panel review and the last three steps of Figure A-1 shall be followed (i.e. panel review, final draft PEFCR, final approval of the PEFCR).
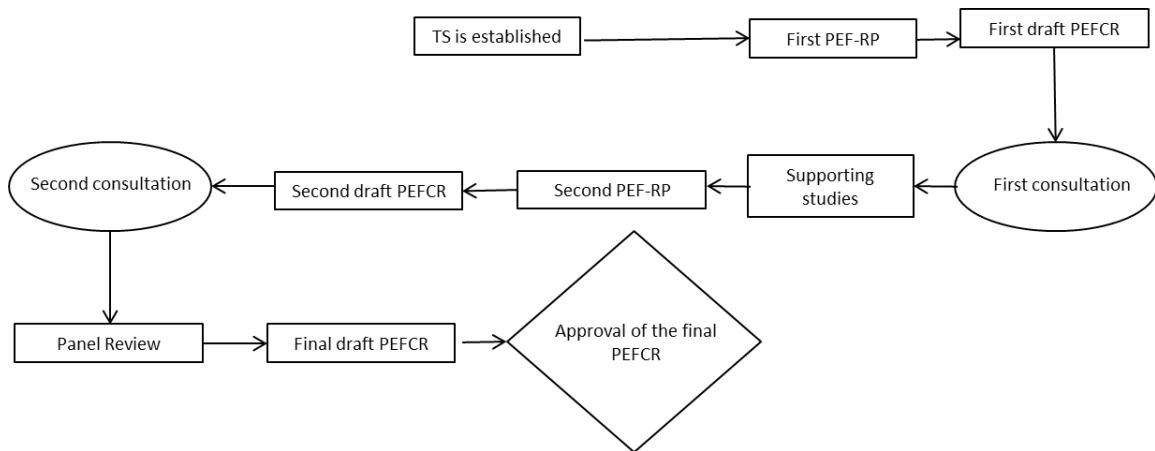
***Figure A-1** – Process flow to create/revise a PEFCR. PEF-RP: PEF study of the Representative Product.*

A.2.1. Who can develop a PEFCR

A Technical Secretariat (TS) shall be set up to develop a PEFCR. The Technical Secretariat shall represent at least 51% of the EU market in terms of turnover in the EU. The TS shall achieve this market coverage directly by companies participating in it and/or indirectly, through the EU market coverage of members represented by a business association. Proof of market coverage shall be provided in the form of a confidential report.

A.2.2. Role of the Technical Secretariat

The Technical Secretariat is responsible for the following activities:

(a) Drafting the PEFCR in compliance with the rules included in the most updated version of the PEF method and this Annex;

(b) Harmonisation with existing PCRs/ PEFCRs;

(c) Organising public consultations on draft versions of the documents, analysis of comments, and providing written feedback;

(d) Co-ordinating the supporting studies;

(e) Managing the public online platform for the respective PEFCR. This activity includes tasks such as the drafting of publicly available explanatory materials related to the PEFCR, online consultations on drafts and publishing of feedback on stakeholder comments;

(f) Ensuring the selection and appointment of competent independent PEFCR review panel members.

A.2.3. Definition of the representative product(s)

The TS shall develop a "model" of the representative product (RP) sold on the EU market. The RP shall reflect the current situation, at the time of developing the PEFCR. This means, for example, that future technologies, future transport scenarios or future end of life treatments shall be excluded.

The RP may be a real or a virtual (non-existing) product. The virtual product should be calculated based on average European market sales-weighted characteristics of all existing technologies/ materials covered by the product category or sub-category. Other weighting sets may be used, if justified, for example weighted average based on mass (ton of material) or weighted average based on product units (pieces).

When identifying the RP there is the risk that different technologies with very different market shares get mixed up and the ones with a relatively small market share might be overlooked. In such cases the TS shall include the missing technologies/ products (if in scope) in the definition of the representative product or provide written justification if this is not technically possible.

The RP is the basis for the PEF study of the representative product (PEF-RP). The RP may be a final product or an intermediate product. For final products only, it is also the basis for identifying the corresponding benchmark. Section A.3.1 explains for which product categories or sub-categories a RP shall be developed.

The TS shall provide information about all the steps taken to define the "model" of the RP and report the information gathered in an Annex to the PEFCR. The TS shall take the most appropriate measures to preserve the confidentiality of data, if applicable.

A.2.4. First PEF study of the representative product(s)

A first PEF study shall be carried out on each representative product (first PEF-RP). The first PEF-RP aims at:

(3)   Identifying the most relevant impact categories;

(4)   Identifying the most relevant life cycle stages, processes and elementary flows;

(5)   Identifying data needs, data collection activities and data quality requirements.

The TS carries out the first PEF-RP on the "model" of the RP(s). Lack of available data and low market shares shall not be an argument for exclusions of technologies or production processes.

The TS shall use EF compliant datasets for the PEF-RP, if available. If an EF compliant dataset does not exist, the following procedure shall be followed in hierarchical order:

- If an EF compliant proxy can be found it shall be used;

- If an ILCD entry level compliant proxy can be found: it shall be used but shall not be included in the list of default datasets of the first draft PEFCR. The proxy shall be listed in the limitations of the first draft PEFCR with the following text: "This dataset is used as a proxy during the first PEF-RP only. However, the company performing the supporting study to test the first draft PEFCR shall apply an EF compliant dataset, if available (following the rules laid out in section A.4.4.2 on which dataset to use). If this is not available, the

company shall use the same proxy as used for the calculation of the first PEF-RP."

- If no EF compliant or ILCD entry level compliant proxy can be found, another dataset may be used. The TS should obtain or develop an EF compliant dataset to carry out the second PEF-RP.

In the first PEF-RP no cut-off of processes, emissions to the environment and resources from the environment is allowed. All the life cycle stages and processes shall be included (incl. capital goods). However, activities like staff commuting, canteens at production sites, consumables not strictly related to production processes, marketing, business trips and R&D activities may be excluded. Cut-offs may only be included in the final PEFCR based on the rules included in the PEF method and this Annex.

A first PEF-RP report shall be provided (following template in Annex E) and shall include the characterised, normalised and weighted results. Being based on secondary data, there should be no confidentiality issues.

The first PEF-RP and its report shall be reviewed by the review panel and a public review report shall be provided as its annex.

A.2.5. First draft PEFCR

Based on the results of the first PEF-RP the TS shall produce a first draft PEFCR, used to carry out the PEFCR supporting studies. It shall be drafted according to the requirements included in this Annex and the template provided in Annex B. It shall include all the requirements needed for the supporting studies, with particular reference to company-specific data collection tables and procedures.

A.2.6. Supporting studies

The goal of the supporting studies is to test the implementability of the first draft PEFCR and, to a lesser extent, provide indications about the suitability of the identified most relevant impact categories, life cycle stages, processes and direct elementary flows.

For each RP at least three PEF supporting studies shall be carried out.

The supporting studies shall be in compliance with all requirements included in the first draft PEFCR and the version of the PEF method it refers to. The following additional rules shall be followed:

- No cut-off is allowed;

- Each study shall implement the hotspot analysis described in section 6.3 of the PEF method and 0 of this Annex. Each study shall be carried out on real products as currently sold in the European market;

- To better analyse the applicability of the first draft PEFCR, the studies shall be carried out on products from (i) companies of different sizes, including at least one SME if present in the sector; (ii) companies characterized by different production processes/ technologies; and (iii) companies with the main production processes (i.e. the ones for which company-specific data are collected) located in different countries.

Each supporting study shall be carried out by a company/consultant neither involved in the drafting of the PEFCR nor part of the review panel. In case one company/consultancy carries out more than one supporting study, then it shall be ensured that each study is carried out by a different person.

The supporting studies shall be reviewed by the review panel. The results of the supporting studies are confidential and shall only be shared with the Commission, together with the review statement. The company performing the supporting study may decide to grant access to other stakeholders.

A.2.7. Second PEF study of the representative product

Conducting the PEF study of the representative product is an iterative process. Based on the information gathered through the first consultation and the supporting studies, the TS shall carry out a second PEF-RP. This second PEF-RP shall include new EF compliant datasets, updated default activity data and all assumptions that are at the basis of the requirements in the second draft PEFCR. Based on the second PEF-RP, the TS shall draft a second PEF-RP report.

The TS shall use EF compliant datasets if available for free[88]. In case EF compliant datasets are not available, the following rules shall be followed in hierarchical order:

- An EF compliant proxy is available for free: it shall be included in the list of default processes of the PEFCR and stated within the limitations chapter of the second draft PEFCR.

- An ILCD-entry level (EL) compliant proxy is available for free: these may be used up to a maximum of 10% of the total environmental impact of the PEF-RP (calculated cumulatively from lowest to largest contribution to the total EF profile).

- If no EF compliant or ILCD-EL compliant proxy is available for free: it shall be excluded from the model. This shall be clearly stated in the second draft PEFCR as a data gap and validated by the PEFCR verifiers.

The second PEF-RP shall determine all the requirements of the final PEFCR including, but not limited to, the final list of most relevant impact categories, life cycle stages, processes, direct elementary flows, cut-offs, etc. For final products, it will also identify the values for the benchmark.

A second PEF-RP report shall be provided (following the template in Annex E) and shall include the characterised, normalised and weighted results. Being based on secondary data, no confidentiality issues are expected.

The second PEF-RP and its report shall be reviewed by the review panel and a public review report shall be provided as its annex.

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[88] All EF compliant datasets used for modeling the RP shall be made available at the same terms and conditions as provided in the "Guide on EF data" (available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml).

A.2.8 The second draft PEFCR

The TS shall draft the second draft PEFCR taking into consideration the results of the supporting studies and of the second PEF-RP. All the sections in the PEFCR template (see annex B to the PEF method) shall be filled in.

The PEFCR shall clarify that all the data gaps included in the PEFCR will remain data gaps for its entire validity as they have a direct impact on the benchmark. Therefore, data gaps are indirectly part of the system boundary of the PEFCR to allow a fair comparison with the benchmark.

A.2.9. The PEFCR review

A.2.9.1. Review panel

The TS shall set up an external independent third-party review panel for the PEFCR review. The review panel will be responsible for the independent review of the following documents:

- First and second PEF-RP, including the RP model and PEF-RP reports (public review report for each);
- Supporting studies (review statement to be provided to the Commission);
- Second draft PEFCR (confidential and public review report).

If the second consultation or the PEFCR review affects the results of the second PEF-RP, the second PEF-RP shall be updated and the results shall be implemented in the final PEFCR. No further consultation is needed, but the review shall take into account the updated results.

The panel shall be composed of minimum three members (a chair and two members). The panel shall include one LCA expert (with a background on the product category or sector under consideration and product-related environmental aspects), one industry expert and, if possible, one representative from NGOs. One member shall be selected as the chair.

The panel shall not have conflict of interests with the company or products involved, and shall not include members from companies that are members of the TS[89] or of the consultants involved in the work of the TS (PEF-RP studies, supporting studies, PEFCR drafting).

The assessment of the competences of the panel review is based on a scoring system that takes into account their experience, EF/LCA methodology and practice, and knowledge of relevant technologies, processes or other activities included in the product(s) in scope of the PEFCR. Table 32 of the PEF method presents the scoring system for each relevant competence and experience topic.

The review panel members shall provide a self-declaration of their qualifications, stating how many points they achieved for each criterion and the total points achieved. This self-declaration shall be included in the PEFCR review report.

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[89] If an industry association is member of a Technical Secretariat, an industry expert of one company belonging to that industry association can be in the review panel. On the contrary, experts on the payroll of the association shall not be members of the review panel.

The minimum necessary score to qualify as a reviewer is six points, including at least one point for each of the three mandatory criteria (i.e. review practice, EF/LCA methodology and practice, and knowledge of technologies or other activities relevant to the EF study).

A.2.9.2 Review procedure

The TS shall agree on the review procedure with the review panel when signing the review contract. In particular, the TS shall agree the period available to the review panel for producing comments after each document is released by the TS and how to manage the comments received.

The panel shall send the review of each document to the TS for their analysis and discussion. The TS shall review the panel's comments and proposals, and it shall develop a response for each.

For the PEF-RPs and PEFCR documents only, the TS shall generate written responses in a review report that may include:

- Acceptance of the proposal: change the document to reflect proposal,
- Acceptance of the proposal: change the document with modification to the original proposal,
- Supporting comments on why the TS did not agree with the proposal,
- Return to the review panel with further questions on the comments/proposals.

A.2.9.3. Review criteria of the PEFCR document

The reviewers shall investigate whether the PEFCR (i) is developed in accordance with the requirements provided in the PEF method and this Annex, and (ii) supports the creation of credible, relevant, and consistent PEF profiles. In addition, the following criteria shall also apply:

- The PEFCR scope and the representative products are adequately defined;
- The functional unit, allocation and calculation rules are adequate for the product category and sub-categories under consideration;
- Datasets used in the PEF-RPs and the supporting studies are relevant, representative, reliable, and in compliance with data quality requirements;
- The model of the RP and corresponding benchmark (if applicable) represent correctly the product category or sub-category;
- The RP model(s), disaggregated in line with the PEFCR and aggregated in ILCD format, are EF compliant following the rules available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml;
- The RP model in its corresponding excel version is compliant with the rules outlined in section A.2.10.1;
- The Data Needs Matrix is correctly implemented;
- The selected additional environmental information is appropriate for the product category and sub-categories under consideration;

- The performance classes (where included) are plausible.

A.2.9.4. Review report/ statement

The review panel shall produce:

- A public review report for each PEF-RP;
- A (public) review statement for each supporting study;
- A confidential and public review report for the final PEFCR.

The public review report shall include a review statement (as provided in the PEFCR template), all relevant information concerning the review process, the comments raised by the reviewers with the replies provided by the TS, and the outcome. The public review reports (i.e. for each PEF-RP and for the final PEFCR) shall be an annex to the final PEFCR.

The **confidential** review report of the PEFCR shall include the comments on all documents produced by the TS during the development of the PEFCR (PEF-RP, supporting studies, and the PEFCR). This report shall include all the comments made by the review panel and the replies provided by the TS. Any other relevant information concerning the review process and outcomes shall also be included.

A.2.10. Final draft PEFCR

Once the drafting work is finalised the Technical Secretariat shall send to the Commission the following documents:

- the final draft PEFCR (including all annexes);
- confidential review report of the PEFCR;
- public review report of the PEFCR;
- second PEF-RP report (including its public review report);
- review statements on the supporting studies;
- all EF compliant datasets used for the modelling (both aggregated and disaggregated at level-1; see details in section A.2.10.2);
- the model(s) of the RP(s) in excel format (see details in section A.2.10.1);
- an EF compliant dataset of each RP (aggregated and disaggregated, see details in section A.2.10.3).

The TS shall release to the Commission the non-exclusive intellectual property rights for all these documents, according to the template that is available at the link http://ec.europa.eu/environment/eussd/smgp/pdf/IPR_PEFCR_OEFSR.pdf.

A.2.10.1. Excel model(s) of the representative product(s)

The "model" of the RP shall be made available in MS Excel format. In case the model of the RP is built on multiple sub-models (e.g. very different technologies), for each of these sub-models a separate excel file shall be provided in addition to the one of the overall model. The excel file shall contain at least the following information:

- Name and scope of the PEFCR and product category or sub-category, a graphical representation of the detailed system boundaries of the life cycle model and list of the life cycle stages included.

- For each life cycle stage and for the full life cycle: (i) all direct elementary flows (using the EF reference package available on the EF developer's page at the following link http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml) with the amount, and (ii) the life cycle inventory datasets used (in aggregated form) together with the corresponding activity data.

  For each dataset the following information shall be provided: the exact full name of the dataset as available in the life cycle data network node (LCDN), the Universal Unique Identifier (UUID) of the aggregated dataset, and a web link to the LCDN where the dataset can be found. The modelling approach for the activity data or elementary flows shall be provided and, if relevant, should be computed by using formulas.

- For each RP: list of all life cycle elementary flows of the aggregated life cycle model (using the EF reference package, including flow name with compartment, unit and amount). This is also called "aggregated dataset" or "LCI results dataset".

- For each RP: EF impact category indicator results (as absolute values): (i) characterised, (ii) the normalized, and (iii) weighted.

A.2.10.2 EF compliant datasets listed in the PEFCR

All EF compliant datasets used in the PEFCR shall be available on a node of the Life Cycle Data Network [90].

The following rights shall be granted to the Commission:

(a)   use for its own purposes:

- making available to the staff of the contracting authority;

- making available to the persons and entities working for the contracting authority or cooperating with it, including contractors, subcontractors whether legal or natural persons, Union institutions, agencies and bodies, Member States' institutions;

- installing, uploading, processing;

- arranging, compiling, combining, retrieving;

(b)   modifications:

- shortening;

- summarizing;

- changing and creating variants of any isolated component or part in any other form, colour or proportion;

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[90]   All EF compliant datasets used for modeling the RP shall be made available at the same terms and conditions as provided in the "Guide on EF data" (available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml).

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- modifying of the content;

- assemble and incorporate, any isolated component or part thereof, in any other work or document, by any means and using any technical or artistic process;

- making technical changes to the content:

  o necessary correction of technical errors;

  o adding new parts or functionalities;

  o changing functionalities;

  o providing third parties with additional information concerning the result with a view of making modifications;

- addition of metadata, for text and data-mining purposes; addition of right-management information; addition of technological protection measures;

- reformatting, extracting or incorporating a part or dividing into parts;

- preparation of a derivate work;

- digitise, modulate, compress, decompress or use all other technical processes of the same type for the purpose of the storage, transfer, IT processing, adaptation and/or use thereof;

- reformat;

- modifying dimensions;

- translating, inserting subtitles, dubbing in all official EU languages.

A.2.10.3. EF compliant datasets representing the representative product(s)

The EF compliant dataset(s) representing the RP(s) shall be provided in aggregated and disaggregated form. The latter shall be disaggregated at the level coherent with the respective PEFCR. Data may be aggregated to protect confidential information.

The list of technical requirements to be fulfilled by the dataset to be EF compliant are available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

The user rights listed in section A.2.10.2 apply.

A.3. DEFINING THE SCOPE OF THE PEFCRs

A.3.1. Product categories and sub-categories

The primary objective of a PEFCR is to fix a consistent set of rules to calculate the Environmental Footprint profile of products belonging to a product category or sub-category.

Products having similar functions and applications should be grouped within the same PEFCR. The scope of the PEFCR shall be selected in a way that it is sufficiently wide to cover different applications and/or technologies. In some cases, to fulfil this requirement, a product category may be split into multiple sub-categories. The TS shall

decide if sub-categories are necessary to achieve the primary objective of the PEFCR and therefore to avoid the risk that the hotspot results from different technologies get mixed up or the results of the ones with a small market share are overlooked[91]. It is important to be as specific as possible when defining the product category and sub-categories to ensure comparability of results.

The PEFCR shall be structured with a section including the "horizontal" rules that are common to all products in scope of the PEFCR, and then a section for each sub-category including the specific "vertical" rules applicable only to that sub-category (Figure A-2).

As a general principle, the horizontal rules prevail over the vertical ones; however, specific derogations from this principle may be allowed if properly justified. This structure will make it easier to widen the scope of an existing PEFCR by adding more product sub-categories.

Each sub-category shall be clearly described in the scope definition of the PEFCR, each sub-category shall have its own RP and benchmark[92] together with its selection of most relevant processes, life cycle stages, direct elementary flows and impact categories.
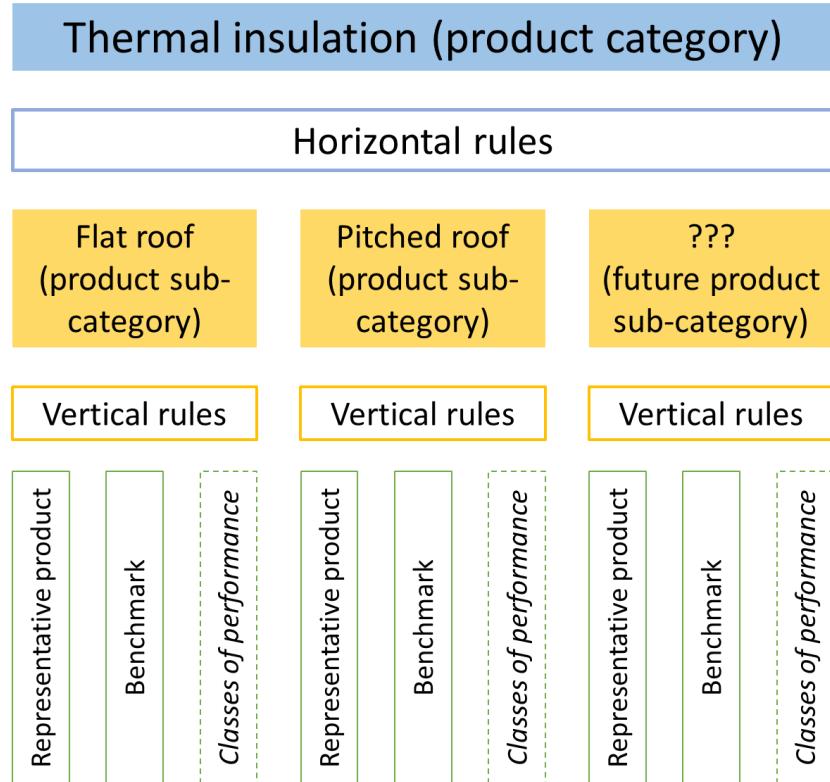
Figure A-2 – Example of a PEFCR structure with product category specific horizontal rules, various product sub-categories, and product sub-category specific vertical rules.

For final products, the PEFCR shall enable the comparison of products belonging to the same product category and/or sub-category (see Table A-1). If sub-categories are

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91   This to ensure that the hotspot analysis reflects all different technologies.
92   A benchmark is only applicable to final products (section A.5.1)

part of the PEFCR scope, a comparison of products belonging to the same sub-category shall always be allowed.

However, the TS may decide, and shall explicitly state in the PEFCR, if a comparison among all products belonging to the overarching product category is allowed. In this case:

- a RP shall be defined also at overarching product category level and it should be modelled based on the European market shares (based on turnover) of the RPs covered by the sub-categories. Other aggregation rules may be used, if justified.

- the TS shall provide the benchmark values of each RP in the PEFCR, both at overarching category and sub-category level.

- for the RP of the overarching category the most relevant impact categories shall be calculated for communication purposes, in addition to the calculation of the most relevant impact categories, life cycle stages processes and direct elementary flows identified for the RP of each sub-category.

The TS may decide, and shall explicitly state in the PEFCR if a cross-comparison of products belonging to two or more different sub-categories is allowed. The definition of a benchmark at the overarching category level is not required.

Table *A-1* *Summary of requirements for PEFCR covering one single product category and for PEFCRs covering sub-categories. Requirements are applicable to final products.*

	Single product category in PEFCR	**Category and sub-categories in PEFCR**	
		Within the category	*Within the sub-category*
Definition of a RP	Shall	May	Shall
Comparative assertion via benchmark for final products	Shall	May. Shall, if a RP is defined at overarching category level.	Shall
Comparative assertion among final products	Shall	May The TS decides in which cases comparison among products in different sub-categories is allowed.	Shall

All requirements in Annex A apply to product categories and sub-categories (if applicable).

A.3.2. Scope of the PEFCR

Meaningful comparisons may only be made if products are fulfilling the same main function (as expressed through the functional unit). Therefore, the scope of a PEFCR

for final products should be defined based on the function, with any deviations to be justified.

The scope should include as many products as possible available in the market that deliver the same main function: this approach also enables to link the product category with the Classification of Products by Activity (CPA) codes and it is line with the definition of a product category by ISO 14025:2006 (i.e. a group of products that can fulfil equivalent functions).

The scope section of the PEFCR shall contain, as a minimum, the following information:

- General description of the scope of the PEFCR:
    - Description of the product category;
    - List and description of sub-categories included in the PEFCR (if any);
    - Description of the product(s) and technical performance;
- Product classification (CPA codes for the products in scope);
- Description of the Representative Product(s) and how it has been derived;
- Functional unit and reference flow;
- System boundary description and diagram;
- List of EF impact categories;
- Additional environmental information and additional technical information;
- Limitations.

A.3.2.1. General description of the scope of the PEFCR

The PEFCR scope definition shall include a general description of the product category, including the granularity of scope, the product sub-categories included (if any), a description of the product(s) in scope and their technical performance. If a product fulfils more than one function and these additional functions are not included in the PEFCR scope and if other products fulfil the same function but they are not included in the scope of the PEFCR, then these omissions shall be explained and documented (see section A.3.2.4).

A.3.2.2. Use of CPA codes

The CPA codes corresponding to the products in scope shall be listed in the PEFCR.

CPA codes relate to activities as defined using NACE codes (i.e. by the Statistical classification of economic activities in the European Community). Each CPA product is assigned to one single NACE activity; hence the CPA structure is parallel to that of NACE at all levels. The International Standard Industrial Classification (ISIC) and NACE have the same code at the highest levels, but NACE is more detailed at the lower levels.

A.3.2.3. Definition of the representative product (RP)

The PEFCR shall include in the scope a short description of the RP(s).

Furthermore, the TS shall provide in an Annex to the PEFCR information about all the steps taken to define the "model" of the RP and report the information gathered. The TS shall take the most appropriate measures to preserve the confidentiality of data, if applicable.

A.3.2.4. Functional unit (FU)

The FU of a PEFCR shall describe qualitatively and quantitatively the function(s) of the product according to the four aspects reported in Table A-2. The table includes additional requirements for food and non-food PEFCRs that shall be adapted in the respective PEFCRs.

In case applicable standards exist, they shall be used and cited in the PEFCR.

For intermediate products, the FU is more difficult to define because they can often fulfil multiple functions and the whole life cycle of the product is not known. Therefore, a material-based approach (or declared unit) may be chosen. For example, mass (kilogram) or volume (cubic meter).

The PEFCR shall explain and document any omission of the functions of the product in the definition of the functional unit.

Table A-2 *Four aspects of the FU with additional requirements for food and non-food PEFCRs*

Elements of the FU	Non-food products	Food products
1. The function(s)/service(s) provided: "what"	PEFCR specific	The FU shall be measured at product consumption level and should exclude inedible parts[93].
2. The extent of the function or service: "how much"	PEFCR specific	PEFCR-specific
3. The expected level of quality: "how well"	PEFCR specific, where possible.	The "How well" element is not always sufficiently taken into account so far.
4. The duration/life time of the product: "how long"	Shall be quantified if technical standards or agreed procedures at sectoral level exist or can be developed.	Shall be quantified if shelf-life (indicated for example as "best before date" or "use by date") is provided on the packaging (e.g. number of months)

The PEFCR shall describe (i) how each aspect of the FU affects the EF of the product, (ii) how to include this effect in the EF calculations and (iii) how an appropriate reference flow[94] shall be calculated. In case calculation parameters are needed, the PEFCR shall provide default values or shall request these parameters in the list of

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[93] The term 'inedible parts' shall be defined by the TS in the PEFCR.
[94] The reference flow is the amount of product needed to fulfil the defined functional unit.

mandatory company-specific information. The PEFCR shall provide a calculation example.

Example

The type of packaging might affect the amount of salad wasted at retail and at the use stage. As a consequence, the type of packaging affects the amount of salad which is needed to fulfil the "how long" and "how much" described in the FU. The PEFCR shall describe the potential effects of packaging on food waste and provide a table with the percentage of salad waste per packaging type used. Finally, the PEFCR shall describe how the percentage of salad waste from the table is integrated into the reference flow and added to the FU of 1kg of salad consumed. All quantitative input and output data collected in the analysis shall be calculated in relation to this reference flow of 1kg plus the percentage of waste.

A.3.2.5. System boundary

The PEFCR shall identify the processes and life cycle stages that are included in the product category/ sub-category. The PEFCR shall provide a short description of the processes and life cycle stages.

The PEFCR shall identify the processes that shall be excluded based on the cut-off rule (see section A.4.3.3), or specify that no cut-off is applicable.

The PEFCR shall provide a system diagram indicating the processes for which mandatory company-specific data are required and the processes excluded from the system boundary.

A.3.2.6. List of EF impact categories

The PEFCR shall list the 16 EF impact categories to be used to calculate the PEF profile, as listed in Table 2 of the PEF method. Out of the 16 impact categories, the PEFCR shall list those that are most relevant for the product category and/or sub-categories in scope (see section A.6.1.1 of this Annex).

The PEFCR shall specify if the user of the PEFCR shall calculate and report separately the sub-indicators for climate change (see section A.4.2.9).

The PEFCR shall specify the version of the EF reference package to be used, available at http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtm.

A.3.2.7. Additional information

A.3.2.7.1. Additional environmental information

The PEFCR shall specify which additional environmental information to report, and whether these are mandatory or recommended additional environmental information. The use of "should" requirements should be avoided. Additional environmental information may be included only if the PEFCR specifies the method that shall be used for its calculation.

Biodiversity

When developing a PEFCR, biodiversity shall be addressed under additional environmental information through the procedure below:

(1) When performing the first and second PEF-RP study, the TS shall make an assessment about the relevance of biodiversity for the product (sub)category(s) in scope of the PEFCR. This assessment may be based on expert judgement, be LCA-based, or be derived through other means already put in place within the sector covering the product group. The assessment shall be clearly explained in a dedicated section of the first and second PEF-RP report.

(2) Based on the above, the PEFCR shall clearly explain whether biodiversity is considered relevant or not. If the TS determines that there are significant impacts on biodiversity, then they shall describe how the user of the PEFCR shall assess and report biodiversity impacts, as additional environmental information.

While the TS may determine how biodiversity shall be assessed and reported in the PEFCR (if relevant), the following suggestions are offered:

- To express the (avoided) impact on biodiversity as the percentage of material that comes from ecosystems that have been managed to maintain or enhance conditions for biodiversity, as demonstrated by regular monitoring and reporting of biodiversity levels and gains or losses (e.g. less than 15% loss of species richness due to disturbance, but the TS may set their own level provided this is well justified). The assessment should refer to materials that end up in the final products and to materials that have been used during the production process. For example, charcoal that is used in steel production processes, or soy that is used to feed cows that produce dairy etc.

- To report additionally the percentage of such materials for which no chain of custody or traceability information can be found.

- To use a certification system as a proxy. The TS shall determine which certification schemes provide sufficient evidence for ensuring biodiversity maintenance and describe the criteria used. A useful overview of standards can be found on http://www.standardsmap.org/.

A.3.2.7.2. Additional technical information

The PEFCR shall list the additional technical information that shall/ should/ may be reported.

If the product in scope is an intermediate product, the PEFCR shall request the following additional technical information:

- The biogenic carbon content at factory gate (physical content) shall be reported in the PEF study. If derived from a native forest, the PEFCR shall require that the corresponding carbon emissions shall be modelled with the elementary flow '(land use change)';

- The recycled content (R1) shall be reported;

- Results with application-specific A-values of the Circular Footprint Formula, if relevant.

A.3.2.8. Assumptions and limitations

The PEFCR shall include the list of limitations a PEF study is subject to, even if carried out in accordance with the PEFCR.

The PEFCR shall include the conditions under which a comparison or comparative assertion may be made.

Furthermore, the PEFCR shall list the ILCD-EL compliant proxy datasets used when modelling the representative product(s) and the data gaps.

A.4. LIFE CYCLE INVENTORY

A.4.1. Life cycle stages

The PEFCR shall list all processes taking place in each life cycle stage: for each process it shall include the default secondary data sets to be used by the user, unless the process is covered by mandatory company-specific data.

The default life cycle stages are listed in section 4.2 of the PEF method and further detailed in sections 4.2.1-4.2.5 of the PEF method.

A.4.2. Modelling requirements

A.4.2.1. Agricultural production

For agricultural activities, the modelling guidelines of chapter 4.4.1 of the PEF method shall be followed for the RPs and included in the PEFCRs. Any exception shall be agreed upon with the Commission before being implemented.

A.4.2.1.1. Fertilisers

For nitrogen-based fertilisers, the Tier 1 emissions factors of table 2-4 of IPCC 2006 should be used, as presented in Table 3 of the PEF method.

The nitrogen field model presented in Table 3 of the PEF method has some limitations and should be improved in the future. Therefore, PEFCRs which have agricultural modelling in scope shall test (as minimum) the following alternative approach within the PEF-RPs:

The N-balance is calculated using the parameters in Table A-3 and the formula below. The total NO_3-N emission to water is considered a variable and its total inventory shall be calculated as:

"Total NO_3-N emission to water" = "NO_3^- base loss" + "additional NO_3-N emissions to water", with

"Additional NO_3-N emissions to water" = "N input with all fertilisers" + "N_2 fixation by crop" – "N-removal with the harvest" – "NH_3 emissions to air" – "N_2O emissions to air" – "N_2 emissions to air" -"NO_3- base loss".

If in certain low-input schemes the value for "additional NO_3-N emissions to water" is negative, the value is to be set to "0". Moreover, in such cases the absolute value of the calculated "additional NO_3-N emissions to water" is to be inventoried as additional

N-fertiliser input into the system, using the same combination of N-fertilisers as employed to the analysed crop. This serves to avoid regarding fertility-depleting schemes by capturing the N-depletion by the analysed crop that is assumed to lead to the need for additional fertiliser later on to keep the same soil fertility level.

Table A-3 *Alternative approach to nitrogen modelling*

Emission	Compartment	Value to be applied
NO_3^- base loss (synthetic fertiliser and manure)	Water	$\text{kg } NO_3^- = \text{kg } N * FracLEACH = 1*0.1*(62/14) = 0.44 \text{ kg } NO_3^-/ \text{kg N applied}$
N_2O (synthetic fertiliser and manure; direct and indirect)	Air	$0.022 \text{ kg } N_2O/ \text{kg N fertilizer applied}$
NH_3 - Urea (synthetic fertiliser)	Air	$\text{kg } NH_3 = \text{kg } N * FracGASF = 1*0.15* (17/14) = 0.18 \text{ kg } NH_3/ \text{kg N fertilizer applied}$
NH_3 - Ammonium nitrate (synthetic fertiliser)	Air	$\text{kg } NH_3 = \text{kg } N * FracGASF = 1*0.1* (17/14) = 0.12 \text{ kg } NH_3/ \text{kg N fertilizer applied}$
NH_3 - others (synthetic fertiliser)	Air	$\text{kg } NH_3 = \text{kg } N * FracGASF = 1*0.02* (17/14) = 0.024 \text{ kg } NH_3/ \text{kg N fertilizer applied}$
NH_3 (manure)	Air	$\text{kg } NH_3 = \text{kg } N * FracGASF = 1*0.2* (17/14) = 0.24 \text{ kg } NH_3/ \text{kg N manure applied}$
N_2-fixation by crop		For crops with symbiotic N_2-fixation: the fixed amount is assumed to be identical to the N-content in the harvested crop
N_2	Air	$0.09 \quad 0.09 \text{ kg } N_2 / \text{kg N applied}$

The TS may decide to include the above approach for N-based modelling in their PEFCR, instead of the one provided in the PEF method. Both approaches shall be tested in the supporting studies, and based on the evidences gathered, the TS shall decide which of the two to apply.

As a second alternative, in case better data is available, a more comprehensive nitrogen field model may be used in the PEFCR, provided (i) it covers at least the emissions requested in Table 3 of the PEF method, (ii) N shall be balanced in inputs and outputs and (iii) it shall be described in a transparent way.

A.4.2.2. Electricity use

The requirements in section 4.4.2 of the PEF method shall be applied, unless the PEFCR covers electricity as main product (e.g., photovoltaic systems).

A.4.2.2.1. Electricity modelling for benchmark calculations

In benchmark calculations the following electricity mix shall be used in hierarchical order:

(i)   Sector specific information on the use of green electricity shall be used if:

    (a)   available, and

    (b)   the set of minimum criteria to ensure the contractual instruments are reliable is met.

    This may be combined with the remaining electricity to be modelled with the residual grid mix.

(ii)   In case no sector specific information is available, the consumption grid mix shall be used.

In case the benchmark is produced in different locations or sold in different countries, the electricity mix shall reflect the ratios of production or ratios of sales between EU countries/regions. To determine the ratio, a physical unit shall be used (e.g. number of pieces or kg of product). Where such data are not available, the average EU consumption mix (EU-28 +EFTA), or region representative consumption mix, shall be used.

A.4.2.3. Transport and logistics

The PEFCR shall provide default transport scenarios to be used, in case these data are not listed as mandatory company-specific information (see section A.4.4.1) and supply-chain specific information is not available. The default transport scenarios shall reflect the European average transport, including all different transport options within the current product category (e.g. including home delivery, if applicable).

In case no PEFCR-specific data[95] is available, the default scenarios and values outlined in section 4.4.3 of the PEF method shall be used. Replacement of the default values provided in section 4.4.3 with PEFCR-specific values shall be clearly mentioned and justified in the PEFCR.

The (final and intermediate) client of the product shall be defined in the PEFCR[96]. The final client may be a consumer (i.e. a person who purchases goods and services for personal use) or a company that uses the product for final use, such as restaurants, professional painters, or a construction site. Re-sellers and importers are intermediate clients and not final clients.

A.4.2.3.1. Allocation of impacts from transport – truck transport

The PEFCR shall specify the utilisation ratio to be used for each truck transport modelled, and it shall clearly indicate whether the utilisation ratio includes empty return trips.

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[95]   Product category specific data, defined by the TS and representing the European average for the products in scope.

[96]   A clear definition of the final client facilitates a correct interpretation of the PEFCR by practitioners which will enhance the comparability of results.

This JRC technical report is a working document and does not modify Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations

- If the load is mass-limited: a default utilisation ratio of 64%[97] shall be used. This utilisation ratio includes empty return trips. Therefore, empty returns shall not be modelled separately. The PEFCR shall list the truck dataset to be used, together with the utilisation factor to be used (64%). The PEFCR shall clearly indicate that the user shall check and adapt the utilisation ratio to the default value provided in the PEFCR.

- If the load is volume-limited and the full volume is used: the PEFCR shall indicate the company-specific utilisation ratio calculated as the kg real load/kg payload of the dataset and indicate how empty returns shall be modelled.

- If the load is delicate (e.g. flowers): it is likely that the full truck volume cannot be used. The PEFCR shall evaluate the most appropriate utilisation ratio to be applied.

- Bulk transport (e.g., gravel transport from mining pit to concrete plant) shall be modelled with a default utilisation ratio of 50% (100% loaded outbound and 0% loaded inbound).

- Reusable products and packaging shall be modelled with PEFCR-specific utilisation ratios. The default value of 64% (including empty return) cannot be used because the return transport is modelled separately for reusable products.

A.4.2.3.2. Allocation of impacts from transport – consumer transport

The PEFCR shall prescribe the default allocation value to be used for consumer transport, if applicable.

A.4.2.3.3. Default scenarios – from supplier to factory

The PEFCR shall specify default transport distances, transport modes (specific dataset) and truck load factors to be used for the transport of products from supplier to factory. If no PEFCR specific data are available, then the default data provided in section 4.4.3.4 of the PEF method shall be prescribed in the PEFCR.

A.4.2.3.4. Default scenarios – from factory to final client

The transport from factory to final client (including consumer transport) shall be described in the distribution stage of the PEFCR. This helps fair comparisons between products delivered through traditional shops as well as delivered at home.

In case no PEFCR-specific transport scenario is available, the default scenario outlined in section 4.4.3.5 of the PEF method shall be used as a basis, together with a number of PEFCR-specific values:

- Ratio between products sold through retail, distribution centre (DC) and directly to the final client;

- For factory to final client: Ratio between local, intracontinental and international supply chains;

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[97] Eurostat 2015 indicates that 21% of the kms truck transport are driven with empty load and 79% are driven loaded (with an unknown load). In Germany only, the average truck load is 64%.

- For factory to retail: distribution between intracontinental and international supply chains.

Note that for reusable products the return transport from retail/DC to factory shall be modelled in addition to the transport needed to go to retail/DC. The same transport distances as from product factory to final client shall be used (see section 4.4.3.5 of the PEF method), however the truck utilisation ratio might be volume-limited depending on the type of product. The PEFCR shall indicate the utilisation ratio that shall be used for the return transport.

A.4.2.4. Capital goods – infrastructure and equipment

During the execution of the PEF-RP studies all processes shall be included in the modelling without applying any cut-off, the modelling assumptions and secondary datasets used shall be clearly documented.

The PEFCR shall identify if, based on the results of the PEF-RP study, capital goods are subject to cut-off or not. If capital goods are included in the PEFCR, clear rules for their calculation shall be provided.

A.4.2.5. Sampling procedure

In some cases, a sampling procedure is needed by the user of a PEFCR to limit the data collection only to a representative sample of plants/ farms etc. Examples of cases when the sampling procedure may be needed are in case multiple production sites are involved in the production of the same SKU; e.g., in case the same raw material/ input material comes from multiple sites or in case the same process is outsourced to more than one subcontractor/ supplier.

There are different procedures to derive a representative sample. For PEFCRs a stratified sample shall be used, i.e. one that ensures that sub-populations (strata) of a given population are each adequately represented within the whole sample of a research study. With this type of sampling, it is guaranteed that subjects from each sub-population are included in the final sample, whereas simple random sampling does not ensure that sub-populations are represented equally or proportionately within the sample.

The TS shall decide if sampling is allowed or not allowed in its PEFCR. The TS may explicitly prohibit the use of sampling procedures in the PEFCR. In this case sampling will not be allowed in PEF studies and the user of the PEFCR shall collect data from all plants or farms. If the TS allows sampling, the PEFCR shall contain the following sentence: "In case sampling is needed, it shall be conducted as specified in this PEFCR. However, sampling is not mandatory and any user of this PEFCR may decide to collect the data from all the plants or farms, without performing any sampling."

In case the PEFCR allows the use of sampling, the PEFCR shall define the requirements for reporting by the user of the PEFCR. The population and the selected sample used for the PEF study shall be clearly described in the PEF report (e.g., the % of the total production or % of number of sites, following the requirements stated in the PEFCR).

A.4.2.5.1. How to define homogeneous sub-populations (stratification)

The PEF method requires aspects to be taken into consideration in the identification of the sub-populations (see section 4.4.6.1 of the PEF method):

- Geographical distribution of sites;

- Technologies/ farming practices involved;

- Production capacity of the companies/ sites taken into consideration.

The PEFCR may list additional aspects to be taken into consideration within a specific product category.

In case additional aspects are taken into account, the number of sub-populations is calculated using the formula (equation 1) provided in section 4.4.6.1 of the PEF method and multiplying the result with the numbers of classes identified for each additional aspect (e.g., those sites which have an environmental management or reporting systems in place).

A.4.2.5.2. How to define sub-sample size at sub-population level

The PEFCR shall specify the approach chosen among the two available in section 4.4.6.2 of the PEF method. The same approach shall be used for all the sub-populations selected.

In case the first approach is chosen the PEFCR shall establish the unit of measure for the production, (if t, m3, m2, value). The PEFCR shall identify the percentage of production to be covered by each sub-population, which shall not be lower than 50%, expressed in the relevant unit. This percentage determines the sample size within the sub-population.

A.4.2.6. Use stage

A.4.2.6.1. Main function approach or delta approach

The PEFCR shall describe which approach shall be applied (main function approach or delta approach, section 4.4.7.1 of the PEF method).

In case the delta approach is used, the PEFCR shall specify a reference consumption to be defined for each associated product (e.g. of energy and materials). The reference consumption refers to the minimum consumption that is essential for providing the function. The consumption above this reference (the delta) will then be allocated to the product. To define the reference situation, the following shall be considered, if available:

- Regulations applicable to the product category;

- Standards or harmonised standards;

- Recommendations from manufacturers or manufacturers' organisations;

- Use agreements established by consensus in sector-specific working groups.

A.4.2.6.2. Modelling the use stage

For all processes belonging to the use stage (both most relevant and the others):

(i)   The PEFCR shall indicate which use stage processes are product dependent and product independent (as described in the PEF method, section 4.4.7).

(ii)   The PEFCR shall identify for which processes default data shall be provided by following the modelling guidelines in Table A-4. In case modelling is optional, the TS shall decide whether this is included in the system boundary of the PEFCR calculation model.

(iii)   Per process to be modelled, the TS shall decide and describe in the PEFCR whether the main function approach or delta approach shall be applied:

    (c)   Main function approach: The default datasets presented in the PEFCR shall reflect as much as possible the reality of market situations.

    (d)   In case of the delta approach, the PEFCR shall provide the reference consumption to be used.

(iv)   The PEFCR shall follow the modelling and reporting guidelines in Table A-4. This table shall be filled in by the TS and included in the first and second PEF-RP reports.

Table A-4 PEFCR guidelines for the use stage

Is the use stage process…		Actions to be taken by the TS	
Product dependent?	**Most relevant?**	**Modelling guidelines**	**Where to report**
Yes	Yes	To be included in the PEFCR system boundary. Provide default data	Mandatory: PEF report, reported separately*
	No	Optional: May be included in the PEFCR system boundary when the uncertainty can be quantified (provide default data)	Optional: PEF report, reported separately*
No	Yes/No	Excluded from the PEFCR system boundary	Optional: qualitative information

*Use stage results for final products shall be reported separately from other life cycle stages and not as additional environmental/technical information.

Annex D provides default data to be used by the TS to model use stage activities that might be cross-cutting for several product groups. It shall be used to fill in the data gaps and ensure consistency among PEFCRs. Better data may be used but shall be justified in the PEFCR.

Example: pasta

This is a simplified example on how the environmental footprint of the use stage can be modelled and reported for the product '1 kg dry pasta' (adapted from the final PEFCR for dry pasta[98]).

Table A-6 presents the processes used for modelling the use stage of 1kg dry pasta (boiling time according to instructions, for instance 10 minutes; amount of water, according to the instructions, for instance 10 litres). Among the four processes, electricity and heat use are the most relevant ones. Within this example, all four processes are product dependent. The amount of water use and cooking time is in general indicated on the packaging. The manufacturer can change the recipe in order to increase or reduce the cooking time, and therefore the energy use. Within the PEFCR, default data is provided on all four processes, as indicated in Table A-6 (activity data + LCI dataset to be used). Following the reporting guidelines, the EF of the total of all four processes is reported as separate information.

Table A-5 Example activity data and secondary datasets used

Materials/fuels	Value	Unit
Tap water; technology mix; at user; per kg water	10	kg
Electricity mix, AC, consumption mix, at consumer, <1kV EU-28+3	0.5	kWh
Heat, from resid. Heating systems from NG, consumption mix, at consumer, temperature of 55C EU-28+3	2.3	kWh
Waste to treatment	Value	Unit
Waste water treatment, domestic waste water according to the Directive 91/271/EEC concerning urban waste water treatment plant EU-28+3	10	kg

Table A-6 Processes of the use stage of dry pasta (adapted from the final PEFCR for dry pasta). The most relevant processes are indicated in the green box

Is the use stage process …?		Pasta processes	Actions taken by the TS:	
(ii) Product dependent?	(iii) Most relevant?		Modelling	Reporting
Yes	Yes	Electricity and Heat	Modelled as main function approach. Default data provided (total energy use).	In the PEF report, reported separately
	No	Tap water Waste water	Modelled as main function approach. Default data provided (total water use).	In the PEF report, reported separately

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[98]   Available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm

Is the use stage process …?		Pasta processes	Actions taken by the TS:	
(ii) Product dependent?	**(iii) Most relevant?**		**Modelling**	**Reporting**
No	Yes/No		Excluded from the EF calculation (impact categories)	Optional: qualitative information

A.4.2.7. End of life modelling

PEFCR shall prescribe the use of the CFF formula and provide all the values for the parameters to be used.

A.4.2.7.1. The A factor

The A values to be used shall be clearly listed in the PEFCR, with a reference to Annex C. When developing a PEFCR the following procedure shall be applied to select the value of A to be included in the PEFCR:

Check in Annex C the availability of an application-specific A value which fits the PEFCR,

If an application specific A value is not available, the material-specific A value in Annex C shall be used,

If a material-specific A value is not available, the A value shall be set equal to 0.5.

If the PEFCR cannot determine specific A values, it shall prescribe the same procedure to be applied by the user of the PEFCR.

A.4.2.7.2. The B factor

In benchmark calculations the B value shall be equal to 0 as default.

A.4.2.7.3. The quality ratios: $Q_{s_{in}}/Q_p$ and $Q_{s_{out}}/Q_p$

The quality ratios shall be determined at the point of substitution and per application or material. The quality ratios are PEFCR-specific, except for packaging materials (see section 4.4.8.5 of the PEF method).

The quantification of the quality ratios shall be based on:

- Economic aspects: i.e. price ratio of secondary compared to primary materials at the point of substitution. In case the price of secondary materials is higher than that of the primary ones, the quality ratios shall be equal to 1.

- If economic aspects are less relevant than physical aspects, the latter may be used.

For packaging, each PEFCR should use the default values provided in Annex C. The TS may decide to change the default values in the PEFCR to product category specific ones. In this case, the justification for the change shall be included in the PEFCR.

A.4.2.7.4. Recycled content (R_1)

The PEFCR shall (i) prescribe the list of R_1 values which shall be used by the user in case no company-specific values are available and (ii) shall make a reference to Annex C. The applied R_1 values shall be subject to the PEFCR review (if applicable) or PEF study verification (if applicable).

The choice for 'default R_1 values' or 'company-specific R_1 values' shall be based on the rules of the DNM (see Table A-7).

This means that supply-chain specific values shall be used when:

- the process is identified in the PEFCR as being most relevant and is run by the company using the PEFCR, or the company is not running the process but has access to company-specific information,

    or

- the process is listed by the PEFCR as mandatory company-specific data.

In all other cases 'default secondary R_1 values' shall be used for example, when R_1 is in situation 2, option 2 of the DNM. In this case company-specific data is not mandatory and default secondary data should be used by the company using the PEFCR. The TS shall provide in the PEFCR default application-specific R1 values and set the R_1 to 0% when no application-specific data is available. Material-specific values based on supply market statistics shall not be used as a proxy.

Table A-7 Requirements regarding R_1 values in relation with the DNM

		Most relevant process	Other process
Situation 1: process run by the company using the PEFCR	**Option 1**	Supply-chain specific R_1 value	
	Option 2		Default (application-specific) R_1 value
Situation 2: process <u>not</u> run by the company using the PEFCR but with access to (company-)specific information	**Option 1**	Supply-chain specific R_1 value	
	Option 2	Default (application-specific) or supply-chain specific R_1 value	
	Option 3		Default (application-specific) or supply-chain specific R_1 value
Situation 3: process <u>not</u> run by the company using the PEFCR and <u>without</u> access to (company)-specific information	**Option 1**	Default (application-specific) R_1 value	
	Option 2		Default (application-specific) R_1 value

A.4.2.7.5. Guidelines on how to deal with pre-consumer scrap

Two options are described in the PEF method (section 4.4.8.8): the PEFCR shall specify which option shall be used when modelling pre-consumer scrap.

A.4.2.7.6. Recycling output rate (R_2)

The PEFCR shall list the default R_2 values (with reference to Annex C) to be used by the user of the PEFCR in case no company-specific values are available. If an R_2 value is not available for a specific application in Annex C, the PEFCR shall list the R_2 values of the material (e.g. materials average).

In case no R_2 values are available in Annex C, the TS has two options: either R_2 shall be equal to 0 or the TS generates new statistics to assign an R_2 value.

The PEFCR shall list the default R_2 values (taken from Annex C) to be applied by the user in case no company-specific values are available. All possible geographic regions shall be provided.

To select the right R_2 value the following procedure shall be followed by the user of the PEFCR and described in the PEFCR:

Company-specific values shall be used if available.

- If no company-specific values are available and the criteria for evaluation of recyclability are fulfilled (see section 4.4.8.9 of the PEF method), application-specific R_2 values shall be used as listed in the PEFCR,

  o If an R_2 value is not available for a specific country, then the European average shall be used.

  o If an R_2 value is not available for a specific application, the R_2 values of the material shall be used (e.g. material's average).

  o In case no R_2 values are available, R_2 shall be 0 or new statistics may be generated to assign an R_2 value in the specific situation.

- The applied R_2 values shall be subject to the PEF study verification.

A.4.2.7.7. $E_{recycled}$ and $E_{recyclingEoL}$

The PEFCR shall list the default datasets that the user of the PEFCR shall apply to model E_{rec} and E_{recEoL}.

A.4.2.7.8. The E^*v

The PEFCR shall list the default datasets that the user of the PEFCR shall apply to model E^*v.

A.4.2.7.9. How to apply the formula to intermediate products (cradle-to-gate PEFCRs)

In cradle-to-gate PEF studies the parameters related to the end-of-life of the product (i.e. recyclability at end-of-life, energy recovery and disposal) shall not be accounted for, unless the PEFCR requires to calculate additional information for the EoL stage.

If the formula is applied in PEF studies for intermediate products (cradle-to-gate studies), the PEFCR shall prescribe:

- The use of the CFF;

- To exclude the end of life by setting the parameters R2, R3, and Ed to 0 for the products in scope;

- The application- or material-specific default A values for the product in scope;

- To use and report the results with two types of A values for the product in scope:

  o Setting A = 1: to be used as default in the PEF profile calculation.

  o Setting A = the application- or material-specific default values as listed in the PEFCR. These results shall be reported as 'additional technical information' and be used when creating EF compliant datasets. This allows a correct A value when the dataset is used in future modelling.

- If the EoL stage shall be calculated as additional information.

When developing the PEFCR, the A value of the product in scope shall be set to 1 for the hotspot analysis in the PEF-RP study to allow to focus the analysis on the actual system. This shall be documented in the PEFCR.

A.4.2.8. Extended product lifetime

In situation 1 described at section 4.4.9 of the PEF method, the PEFCR shall describe how reuse or refurbishment is included in the calculations of the reference flow and full life cycle model, taking into account the "how long" of the FU. Default values for extended lifetime shall be provided in the PEFCR or shall be listed as mandatory company-specific information.

A.4.2.8.1. How to apply "reuse rate" (situation 1)

At point 2) of section 4.4.9.2 of the PEF method, the PEFCR shall further specify and provide one-way transport distances.

A.4.2.8.2. Average reuse rates for company owned pools

The average reuse rates available in section 4.4.9.4 of the PEF method shall be used within the PEF-RP studies and to calculate the benchmark (corresponding to the representative product) for those PEFCRs that have company owned reusable packaging pools in scope, unless data of better quality is available.

If the TS decides to use other values within their PEF-RP study and benchmark calculation, it shall provide a justification and provide the data source. In case a specific packaging type is not present in the list above, sector-specific data shall be used. New values shall be subject to the PEFCR review.

The PEFCR shall prescribe the use of mandatory company-specific reuse rates for company owned packaging pools.

A.4.2.8.3. Average reuse rates for third party operated pools

The average reuse rates available in section 4.4.9.5 of the PEF method shall be used by those PEFCRs that have third party operated reusable packaging pools in scope, unless data of better quality is available.

If the TS decides to use other values within their final PEFCR, it shall clearly justify why and provide the data source. In case a specific packaging type is not present in the list of section 4.4.9.5, sector-specific data shall be collected and included in the PEFCR. New values shall be subject to the PEFCR review.

A.4.2.9. Greenhouse gas emissions and removals

To provide all necessary information for developing the PEFCR, the PEF-RP study shall always calculate the three climate change sub-categories separately. If climate change is identified as a most-relevant impact category, the PEFCR shall (i) always request to report the total climate change as the sum of the three sub-categories, and (ii) shall request the reporting of the sub-categories 'climate change -fossil', 'climate

change – biogenic' and 'climate change - land use and land use change', separately if the PEF-RP study shows a contribution of more than 5%[99] each to the total score.

A.4.2.9.1. Sub-category 2: Climate change – biogenic

The PEFCR shall specify if a simplified modelling approach shall be used when modelling the foreground emissions.

In the case a simplified modelling approach is chosen, the PEFCR shall include the following text: "Only the emission 'methane (biogenic)' is modelled, while no further biogenic emissions and uptakes from the atmosphere are included. When methane emissions can be both fossil or biogenic, the release of biogenic methane shall be modelled first and then the remaining fossil methane."

In the case a simplified modelling approach is not chosen, the PEFCR shall include the following text: "All biogenic carbon emissions and removals shall be modelled separately. However, note that the corresponding characterisation factors for biogenic CO_2 uptakes and emissions within the EF impact assessment method are set to zero".

A.4.4.9.2 Sub-category 3: Climate change – land use and land use change (LULUC)

The TS may decide to include soil carbon storage in the PEFCR as additional environmental information. In case of inclusion, the PEFCR shall specify how this shall be modeled and calculated, and which proof shall be provided. If legislation provides specific modelling requirements for the sector, it shall be modelled according to this legislation.

A.4.2.10. Packaging

European average packaging datasets shall be used in case the PEFCR does not request the use of company-specific data, no supplier-specific information is available or the packaging is not relevant. Although the default secondary datasets shall be listed in the PEFCR, for some multi-material packaging the PEFCR shall provide additional information to allow the user to perform a correct modelling. This is for example the case for beverage cartons and bag-in-box packaging:

- Beverage cartons are made out of LDPE granulates and liquid packaging board, with or without aluminium foil. The amount of LDPE granulates, board and foil (also called the bill of material of beverage cartons) depends on the application of the beverage carton and shall be defined in the PEFCR if applicable (e.g. wine cartons, milk cartons). Beverage cartons shall be modelled by combining the PEFCR prescribed amounts of material datasets with the beverage carton conversion dataset.

- Bag in box is made out of corrugated board and packaging film. If applicable, the PEFCR should define the amount of corrugated board, as well as the amount and type of packaging film. If this is not prescribed by the PEFCR, the user of the PEFCR shall use the default dataset for bag-in-box.

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[99] For example, if 'Climate change - biogenic' contributes with 7% (using absolute values) to the total climate change impact and 'Climate change – land use and land use change' contributes with 3% to the total climate change impact. In that case, the total climate change impact and the 'Climate change – biogenic' shall be reported. It is up to the TS to decide where and how to report the latter ('Climate change – biogenic').

This JRC technical report is a working document and does not modify Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations

A.4.3. Handling multi-functional processes

Systems involving multi-functionality of processes shall be modelled in accordance with the decision hierarchy provided in the PEF method (section 4.5).

The PEFCR shall further specify multi-functionality solutions within the defined system boundary and, where appropriate, for upstream and downstream stages. If applicable, the PEFCR shall further provide specific factors to be used in the case of allocation solutions. All such multi-functionality solutions specified in the PEFCR shall be clearly justified with reference to the PEF multi-functionality solution hierarchy:

Where subdivision is applied, the PEFCR shall specify which processes are to be subdivided and the principles that such subdivision should adhere to.

Where allocation by physical relationship is applied, the PEFCR shall specify the relevant underlying physical relationships that shall be considered and list the specific allocation values that shall be fixed for all studies using the PEFCR.

Where allocation by some other relationship is applied, the PEFCR shall specify this relationship and list the specific allocation values that shall be fixed for all studies using the PEFCR.

A.4.3.1. Animal husbandry

A.4.3.1.1. Allocation within the farm module

Default values for each type of animal shall be provided in the PEFCR and used by PEF studies. The default values available in sections 4.5.1.2-4.5.1.4 of the PEF method should be used, unless more sector-specific data are available.

A.4.3.1.2. Allocation within the slaughterhouse

Default values for prices and mass fractions are provided in the PEF method for cattle, pigs and small ruminants (sheep, goat) and these default values shall be included in relevant PEFCRs and used by PEF studies, PEF supporting studies and PEF-RP studies. No change of allocation factors is allowed in PEF studies.

A.4.3.1.3. Allocation within the slaughterhouse for cattle

If allocation factors to subdivide the impact of the carcass among the different cuts are desired, they shall be defined in the relevant PEFCR.

A.4.4. Data collection requirements and quality requirements

The materiality principle

One of the main features of the PEF method is the "materiality" approach, i.e. focusing where it really matters. In the PEF context, the materiality approach is developed around two main areas:

Impact categories, life cycle stages, processes and direct elementary flows: the PEFCR shall identify the most relevant ones. These are the environmental

contributions on which companies, stakeholders, consumers, and policy makers should focus (see section 6.3 of the PEF method);

Data requirements: as the most relevant processes are those driving the environmental profile of a product, these shall be assessed by using data of higher quality compared to the less relevant processes, independently from where these processes happen in the life cycle of the product.

Once the model(s) for the representative product(s) is developed, the TS shall address the following two questions with the PEF-RP studies:

(1)   Which are the processes for which company-specific information is mandatory?

(2)   Which are the processes that are driving the environmental profile of the product (most relevant processes)?

A.4.4.1. List of mandatory company-specific data

The list of mandatory company-specific data refers to the activity data, direct elementary flows and (unit) processes for which company-specific data shall be collected. This list defines the minimum data requirements to be fulfilled by the users of the PEFCR. The purpose is to avoid that a user without access to the relevant company-specific data is able to perform a PEF study and communicate its results by only applying default data and datasets. The PEFCR shall define the list of mandatory company-specific data.

For the selection of the mandatory company-specific data, the TS shall consider its relevance within the EF profile, the level of effort needed to collect these data (especially for SMEs) and the overall quantity of data / time required to collect all mandatory company-specific data. This decision is very important and has two consequences: (i) companies may perform a PEF study by only searching for these data and using default data for everything outside this list, while (ii) companies that don't have company-specific data for any of the listed data cannot calculate a PEFCR-compliant PEF profile of the product in scope.

For each process for which company-specific data is mandatory the PEFCR shall provide the following information:

(1)   the list of the company-specific activity data to be declared by the user of the PEFCR together with the default secondary datasets to be used. The list of activity data shall be as specific as possible in terms of units of measure and any other characteristics that could help the user in implementing the PEFCR;

(2)   the list of direct (i.e. foreground) elementary flows to be declared by the user of the PEFCR. This is the list of most relevant direct emissions and resources. For each emission and resource, the PEFCR shall specify the frequency of measurements, the measurement methods and any other technical information necessary to ensure that PEF profiles are comparable.

Considering that the data for these processes shall be company-specific, the score of P cannot be higher than 3, the score for TiR, TeR, and GeR cannot be higher than 2, and the DQR score shall be lower than 1.6. To assess the DQR , follow the requirements of Table 23 of the PEF method. The developed datasets shall be EF compliant.

For processes selected to be modelled mandatorily with company-specific data, the PEFCR shall follow the requirements set out in this section. For all other processes, the user of the PEFCR shall apply the Data Needs Matrix as explained in section A.4.4.4.4 of this Annex.

A.4.4.2. Which datasets to use?

When developing the final PEFCR, EF compliant datasets shall be used when available for free[100]. In case EF compliant datasets are not available, the following rules shall be followed in hierarchical order:

- An EF compliant proxy is available for free: it shall be included in the list of default processes of the PEFCR and stated within the limitations chapter of the PEFCR.

- An ILCD entry level (EL) compliant proxy is available for free: These may be used up to a maximum of 10% of the total environmental impact of the final PEF-RP (calculated cumulatively from lowest to largest contribution to the total EF profile).

- If no EF compliant or ILCD-EL compliant proxy is available for free: it shall be excluded from the model. This shall be clearly stated in the PEFCR as a data gap and validated by the PEFCR reviewers.

For the user of the PEFCR, the secondary datasets listed in the PEFCR shall be used. Whenever a dataset needed to calculate the PEF profile is not among those listed, the following rules shall be followed in hierarchical order:

- Use an EF compliant dataset available on one of the nodes of the Life Cycle Data Network http://eplca.jrc.ec.europa.eu/LCDN/;

- Use an EF compliant dataset available in a free or commercial source;

- Use another EF compliant dataset considered to be a good proxy. In this case, this information shall be included in the "limitations" section of the PEF report.

- Use an ILCD-EL compliant dataset. In such cases, these datasets shall be included in the "limitations" section of the PEF report. A maximum of 10% of the total environmental impact may be derived from ILCD-EL compliant datasets (calculated cumulatively from lowest to largest contribution to the total EF profile).

- If no EF compliant or ILCD-EL compliant proxy is available: it shall be excluded from the PEF study. This shall be clearly stated in the PEF report as a data gap and validated by the PEF study and PEF report verifiers.

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[100] The dataset shall be made available at the same terms and conditions as provided on the node where the dataset is available (available at http://eplca.jrc.ec.europa.eu/LCDN/contactListEF.xhtml).

A.4.4.3. Cut-off

Any cut-off shall be avoided in the first PEF-RP study and supporting studies.

Based on the results of the first PEF-RP study and if confirmed by the supporting study results, the second PEF-RP study and PEFCR may exclude processes from the RP system boundaries by applying the following rule:

- In case processes are excluded from the model, this shall be done based on a 3% cut-off for all impact categories based on environmental significance, additionally to the cut-off already included in the background datasets. This rule is valid for both intermediate and final products. To calculate a 3% cut-off, the TS shall order the processes of the first PEF-RP study starting from the least relevant to the most relevant one. The processes that in total account less than 3% of the environmental impact for each impact category may be excluded from the RP (starting from the least relevant). In case the TS decides to apply the cut-off rule, second PEF-RP shall exclude the processes and the PEFCR shall list the processes that shall be excluded based on the cut-off.

- In case the processes identified for cut-off from the first PEF-RP study are not confirmed by the supporting studies, the decision about their exclusion or inclusion shall be left to the review panel and reported explicitly in the review report to be annexed to the PEFCR.

The PEFCR shall list the processes that shall be excluded from the modelling based on the cut-off rule and indicate that no additional cut-offs are allowed by the user of the PEFCR. In case the TS decides that no cut-off is allowed, this requirement shall be explicitly mentioned in the PEFCR.

A.4.4.4. Data quality requirements

A.4.4.4.1. The DQR formula

The PEFCR shall provide tables with the criteria to be used for the semi-quantitative assessment of each data quality criteria. The PEFCR may specify more stringent or specify additional data quality requirements if appropriate for the sector in question.

A.4.4.4.2. The DQR of company-specific datasets

When creating a company-specific dataset, the data quality of i) the company-specific activity data and ii) the company-specific direct elementary flows (i.e. emission data) shall be assessed separately by the user of the PEFCR. To allow the evaluation of the DQR of data sets with company-specific data, the PEFCR shall include at least one table on how to assess the value of the DQR criteria for these processes. The table(s) to be included in the PEFCR shall be based on Table 23 of the PEF method: only the reference years criteria (Ti_{R-EF}, Ti_{R-AD}) may be adapted by the Technical Secretariat.

The DQR of the sub-processes linked to the activity data (see Figure 9 of the PEF method) are evaluated through the requirements provided in the Data Needs Matrix (section A.4.4.4.4).

The DQR of the newly developed dataset shall be calculated as follows:

(1)   Select the most relevant activity data and direct elementary flows: most relevant activity data are the ones linked to sub-processes (i.e. secondary datasets) that account for at least 80% of the total environmental impact of the company-specific dataset, listing them from the most contributing to the least contributing one. Most relevant direct elementary flows are defined as those direct elementary flows contributing cumulatively at least with 80% to the total impact of the direct elementary flows.

(2)   Calculate the DQR criteria TeR, TiR, GeR and P for each most relevant activity data and each most relevant direct elementary flow. The values of each criteria shall be assigned based on the table on how to assess the value of the DQR criteria provided in the PEFCR.

(a)   Each most relevant direct elementary flow consists of the amount and elementary flow naming (e.g. 40 g carbon dioxide). For each most relevant elementary flow, the user of the PEFCR shall evaluate the 4 DQR criteria named Te_{R-EF}, Ti_{R-EF}, G_{R-EF}, P_{EF}. Examples of elements to be evaluated include the timing of the flow measured, the technology for which the flow was measured and in which geographical area the measurement was made.

(b)   For each most relevant activity data, the 4 DQR criteria shall be evaluated (named Ti_{R-AD}, P_{AD}, G_{r-AD}, T_{er-AD}) by the user of the PEFCR.

(c)   Considering that the data for the mandatory processeses shall be company-specific, the score of P cannot be higher than 3 while the score for TiR, TeR, and GeR cannot be higher than 2 (The DQR score shall be ≤1.5).

(3)   Calculate the environmental contribution of each most-relevant activity data (through linking to the appropriate sub-process) and direct elementary flow to the total sum of the environmental impact of all most-relevant activity data and direct elementary flows, in % (weighted, using all EF impact categories). For example, the newly developed dataset has only two most relevant activity data, contributing in total to 80% of the total environmental impact of the dataset:

- Activity data 1 carries 30% of the total dataset environmental impact. The contribution of this process to the total of 80% is 37.5% (the latter is the weight to be used).

- Activity data 2 carries 50% of the total dataset environmental impact. The contribution of this process to the total of 80% is 62.5% (the latter is the weight to be used).

(4)   Calculate the TeR, TiR, GeR and P criteria of the newly developed dataset as the weighted average of each criterion of the most relevant activity data and direct elementary flows. The weight is the relative contribution (in %) of each most relevant activity data and direct elementary flow calculated in step (3).

(5) The user of the PEFCR shall calculate the total DQR of the newly developed dataset using Equation 20 of the PEF method, where $\overline{Te_R}, \overline{Ge_R}, \overline{Ti_R}, \overline{P}$ are the weighted averages calculated as specified in point (4).

A.4.4.4.3. The DQR of secondary datasets used in a PEF study

To allow the user to assess the context-specific DQR criteria TeR, TiR and GeR of most relevant processes, the PEFCR shall include at least one table on how to assess the criteria. The assessment of the TeR, TiR and GeR criteria shall be based on Table 24 of the PEF method. The TS may only adapt the reference years for the criterion TiR. It is not allowed to modify the text for the other criteria.

A.4.4.4.4. The Data Needs Matrix

All processes required to model the product and that are not on the list of mandatory company-specific data shall be evaluated using the Data Needs Matrix (see Table A-8). The next section includes the rules to be followed when developing a PEFCR, while the following section includes the rules for the user of the PEFCR.

Rules to be followed when developing a PEFCR

The PEFCR shall include the following information for all processes that are not on the list of mandatory company-specific data:

(1) provide the list of default secondary datasets to be used within the scope of the PEFCR (dataset name, together with the UUID of the aggregated version[101], the web address of the node, and the data stocks);

(2) report the default DQR values (for each criterion) as provided in their meta data, for all default EF datasets listed;

(3) indicate the most relevant processes;

(4) provide one or more DQR table(s) for the most relevant processes;

(5) indicate the processes expected to be in situation 1;

(6) for those processes expected to be in situation 1, provide the list of activity data and elementary flows to be declared by the user. This list shall be as specific as possible in terms of unit of measurement, averaging data and any other characteristics that could help the user in implementing the PEFCR.

Rules for the user of the PEFCR

The user of the PEFCR shall apply the DNM to evaluate which data is needed. It shall be used within the modelling of its PEF study, depending on the level of influence the user (company) has on the specific process. The following three cases are found in the DNM:

(1) **Situation 1**: the process is run by the company using the PEFCR;

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[101] Each EF compliant dataset tendered by the Commission is available in both an aggregated and disaggregated (at level-1) form.

(2) **Situation 2**: the process is not run by the company using the PEFCR but the company has access to company-specific information;

(3) **Situation 3**: the process is not run by the company using the PEFCR and this company does not have access to company-specific information.

The user of the PEFCR shall:

(1) determine the level of influence (Situation 1, 2 or 3 described below) the company has over each process in its supply chain. This decision determines which of the options in Table A-8 is pertinent for each process;

(2) follow the rules of Table A-8 for the most relevant processes and for the other processes. The DQR value mentioned in brackets is the maximum DQR value allowed.

(3) Calculate or re-evaluate the DQR values (for each criterion + total) for all the datasets used for the most relevant processes and the new ones created. For all remaining 'other processes' the DQR values provided in the PEFCR shall be used.

(4) If one or more processes are not included in the list of default processes in the PEFCR, the user shall identify a suitable dataset according to requirements provided in section A.4.4.2 of this Annex.

Table A-8 Data Needs Matrix (DNM) – Requirements for the user of the PEFCR. The options indicated for each situation are not listed in hierarchical order. See Table A-7 to determine the R_1 value to be used.

		Most relevant process	**Other process**
Situation 1: process run by the company using the PEFCR	Option 1	Provide company-specific data (as requested in the PEFCR) and create a company-specific dataset, in aggregated form (DQR≤1.5)[102] Calculate the DQR values (for each criterion + total)	
	Option 2		Use default secondary dataset in PEFCR, in aggregated form (DQR≤3.0) Use the default DQR values
Situation 2: process not run by the company using the PEFCR but with access to company-specific information	Option 1	Provide company-specific data (as requested in the PEFCR) and create a company-specific dataset, in aggregated form (DQR≤1.5) Calculate the DQR values (for each criterion + total)	
	Option 2	Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤3.0). Re-evaluate the DQR criteria within the product specific context	
	Option 3		Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤4.0) Use the default DQR values.
Situation 3: process not run by the company using the PEFCR and without access to company-specific information	Option 1	Use default secondary data set in aggregated form (DQR≤3.0) Re-evaluate the DQR criteria within the product specific context	
	Option 2		Use default secondary data set in aggregated form (DQR≤4.0) Use the default DQR values

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[102] Company-specific datasets shall be made available to the Commission.

A.4.4.4.5. DNM situation 1

For each process in situation 1 there are two possible options:

- The process is in the list of most relevant processes as specified in the PEFCR or is not in the list of most relevant processes, but still the company wants to provide company-specific data (option 1);

- The process is not in the list of most relevant processes and the company prefers to use a secondary dataset (option 2).

Situation 1/ Option 1

For all processes run by the company and where the company using the PEFCR uses company-specific data, the DQR of the newly developed dataset shall be evaluated as described in 0 while using the PEFCR-specific DQR tables.

Situation 1/ Option 2

For the non-most relevant processes only, if the user decides to model the process without collecting company-specific data, then the user shall apply the secondary dataset listed in the PEFCR together with its default DQR values listed in the PEFCR.

If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the metadata of the original dataset.

A.4.4.4.6. DNM situation 2

If a process is in situation 2 (i.e. the user of the PEFCR is not running the process but has access to company-specific data) there are three possible options:

- The user of the PEFCR has access to extensive supplier-specific information and wants to create a new EF compliant dataset (Option 1);

- The user of the PEFCR has some supplier-specific information and wants to make some minimum changes (Option 2);

- The process is not in the list of most relevant processes, still the company wants to make some minimum changes (Option 3).

Situation 2/ Option 1

For all processes not run by the company and where the user of the PEFCR applies company-specific data. The DQR of the newly developed dataset shall be evaluated as described in section 4.6.5.2 of the PEF method while using the PEFCR-specific DQR tables.

Situation 2/ Option 2

The user of the PEFCR applies company-specific activity data for transport and substitutes the sub-processes used for the electricity mix and transport with supply chain specific EF compliant datasets starting from the default secondary dataset provided in the PEFCR.

Please note that the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required.

For the most relevant processes, the user of the PEFCR shall make the DQR context-specific by re-evaluating TeR and TiR using the table(s) provided in the PEFCR (adapted from Table 24 of the PEF method). The criteria GeR shall be lowered by 30%[103] and the criteria P shall keep the original value.

Situation 2/ Option 3

The user of the PEFCR applies company-specific activity data for transport and substitutes the sub-processes used for the electricity mix and transport with supply chain specific EF compliant datasets starting from the default secondary dataset provided in the PEFCR.

Please note that the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required

In this case, the user of the PEFCR shall aooly the default DQR values. If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the original dataset.

A.4.4.4.7. DNM situation 3

If a process is in situation 3 (i.e. the company using the PEFCR is not running the process and this company does not have access to company-specific data), there are two possible options:

- It is on the list of most relevant processes (situation 3, option 1);
- It is not on the list of most relevant processes (situation 3, option 2).

Situation 3/ Option 1

In this case, the user of the PEFCR shall make the DQR context-specific by re-evaluating TeR, TiR and GeR using the table(s) provided in the PEFCR (adapted from Table 24 of the PEF method). The criterion P shall keep the original value.

Situation 3/ Option 2

The user of the PEFCR shall apply the corresponding secondary dataset listed in the PEFCR together with its DQR values. If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the original dataset.

A.4.4.4.8. DQR of a PEF study

The PEFCR shall require the delivery of an EF compliant dataset of the product in scope (meaning, the PEF study). The DQR of this dataset shall be calculated and the PEF report shall report it. To calculate the DQR of the PEF study, the PEFCR shall specify that the user of the PEFCR shall follow the DQR calculation rules of section 4.6.5.8 of the PEF method.

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[103] In situation 2, option 2 it is proposed to lower the parameter GeR by 30% in order to incentivise the use of company-specific information and reward the efforts of the company in increasing the geographic representativeness of a secondary dataset through the substitution of the electricity mixes and of the distance and means of transportation.

A.5. PEF RESULTS

A.5.1. Benchmark

The benchmark shall be provided for each RP and shall correspond to the PEF profile of the second PEF-RP modelled after the supporting study results are taken into consideration.

The PEFCR shall provide the results of the benchmark for each RP as characterised, normalised and weighted results for each of the EF impact categories (not only the most relevant ones) and as a single overall score based on the weighting factors provided in section 5.2.2 of the PEF method, each in a different table. Results shall be provided for (i) the total life cycle, and (ii) the total life cycle excluding the use stage.

No benchmarking is allowed for intermediate products. The reporting of the characterised, normalised and weighted results calculated for each intermediate RP is optional in the PEFCR, but mandatory in the PEF study and PEF report.

A.5.2. Classes of performance

The identification of classes of performance is not obligatory. Each TS is free to define a method to identify the classes of performance, in case they deem it appropriate and relevant. The procedure described below is provided only as an example.

In this procedure 5 classes of performance are identified, from category A being the best class with lowest environmental impact, up to category E being the worst class with the highest impact. The classes of performance are identified at the level of the single overall score of all 16 EF impact categories (see section 5.2.2 of the PEF method).

First, the single overall score of the representative product (BM, calculated from the second PEF-RP) represents the midpoint of class C.

Second, the upper limit and lower limit of the lowest category A and highest category E are identified through a sensitivity analysis on the model of the RP (on each representative product if there are multiple). The sensitivity analysis will identify the most relevant parameters contributing to the single overall score. Once these parameters are identified, based on industry data provided by the TS members, the theoretical best product (calculated by assigning the best technically feasible value for each parameter) and the theoretical worst product (calculated by assigning the worst technically value for each parameter) are identified. They help to define the upper limit of category A (OS-BP) and lower limit of category E (OS-WP).

Once the two extremes and the midpoint of class C are identified, the remaining limits of the different categories are identified according to the table below:

This JRC technical report is a working document and does not modify Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations

Category	Class of performance boundaries
A	OS $\leq$ BP+(BM-BP)*0.30
B	BP+(BM-BP)*0.30 $\leq$ OS $\leq$ BP+(BM-BP)*0.85
C	BP+(BM-BP)*0.85 $\leq$ OS $\leq$ WP+(BM-WP)*0.85
D	WP+(BM-WP)*0.85 $\leq$ OS $\leq$ WP+(BM-WP)*0.30
E	OS $\geq$ WP+(BM-WP)*0.30

where OS-**BP** is the single overall score of the best product, OS-**WP** is the single overall score of the worst product, **BM** is the single overall score of the representative product (benchmark value), **OS** is the single overall score of a specific product calculated based on a PEF study carried out in compliance with the PEFCR.
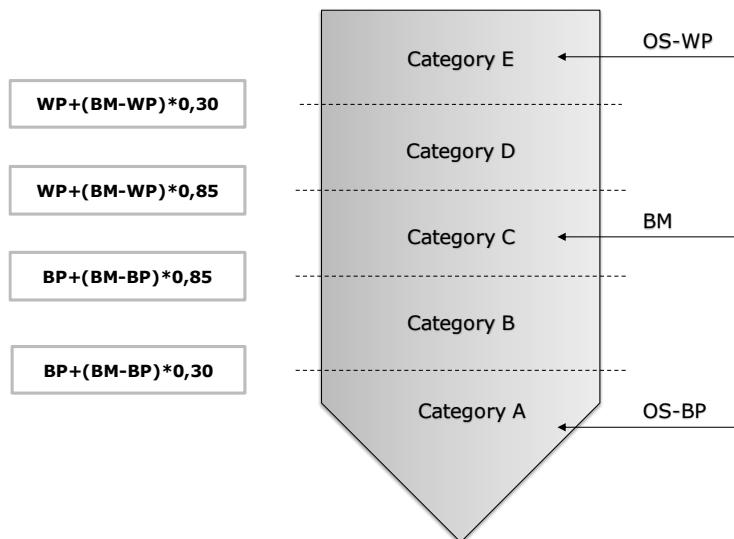
Figure A-3 – PEF Classes of performance

A.6. INTERPRETATION OF PRODUCT ENVIRONMENTAL FOOTPRINT RESULTS

A.6.1. Identification of hotspots

The identification of most relevant impact categories, life cycle stages, processes, direct elementary flows, benchmark and classes of performance shall be based on the first and second PEF-RP study. The second PEF-RP study determines the identification that will be required in the PEFCR. The identification of the most relevant processes and direct elementary flows has a key role in the process to identify data-related requirements (see previous sections on data quality requirements for further information).

A.6.1.1. Procedure to identify the most relevant impact categories

The identification of the most relevant impact categories shall follow the requirements at section 6.3.1 of the PEF method. The PEFCR may add more impact categories to the list of the most relevant ones but none shall be deleted.

A.6.1.2. Procedure to identify the most relevant life cycle stages

The identification of the most relevant impact categories shall follow the requirements in section 6.3.2 of the PEF method. The TS may decide to split or add additional life cycle stages if there are good reasons for it. This shall be justified in the PEFCR. E.g., the life cycle stage 'Raw material acquisition and pre-processing' may be split into 'Raw material acquisition', 'pre-processing', and 'raw materials supplier transport'.

A.6.1.3. Procedure to identify the most relevant processes

The identification of the most relevant processes shall follow the requirements in section 6.3.3 of the PEF method. The PEFCR may add more processes to the list of the most relevant ones but none shall be deleted.

In most cases, vertically aggregated datasets may be identified as representing relevant processes. In such cases, it may not be obvious which process is responsible for contributing to an impact category. The TS may decide whether to seek further disaggregated data or to treat the aggregated dataset as a process for the purposes of identifying relevance.

A.6.1.4. Procedure to identify the most relevant direct elementary flows

The identification of the most relevant direct elementary flows shall follow the requirements at section 6.3.4 of the PEF method. The TS may add more elementary flows to the list of the most relevant ones but none shall be deleted. For each most relevant process, the identification of the most relevant direct elementary flows is important to define which direct emissions or resource use should be requested as company-specific data (i.e. the foreground elementary flows within the processes listed in the PEFCR as mandatory company-specific data).

A.7. PRODUCT ENVIRONMENTAL FOOTPRINT REPORTS

General requirements regarding PEF reports are available in the PEF method (section 7). Any PEF study (including PEF-RP studies and supporting studies) shall include a PEF report. A PEF report provides a relevant, comprehensive, consistent, accurate, and transparent account of the study and of the calculated environmental impacts associated with the product.

A PEF report template is available in Annex E. The template includes the detailed information to be provided in a PEF report. The TS may decide to require further information to be provided in the PEF report, in addition to the ones listed in Annex E.

A.8. Verification and validation of PEF studies, reports, and communication vehicles

A.8.1. Defining the scope of the verification

The verification of the PEF study shall ensure that the PEF study is conducted in compliance with the PEFCR it refers to.

A.8.2. Verifier(s)

The independence of the verifiers shall be guaranteed (i.e. they shall fulfil the intentions in the requirements of ISO/IEC 17020:2012 regarding a 3rd party verifier, they shall not have conflicts of interests on concerned products and cannot include members of the Technical Secretariat or of the consultants involved in previous part of the work - PEF-RP studies, supporting studies, PEFCR review, etc.).

A.8.3. Verification/Validation requirements: requirements for the verification/validation when a PEFCR is available

The verifier(s) shall verify that the PEF report, PEF communication (if any) and PEF study is in compliance with the following documents:

(a)   most recent version of the PEFCR applicable for the specific product in scope;

(b)   conformance with the latest official version of the PEF method.

The verification and validation of the PEF study shall be carried out following the minimum requirements listed in sections 8.4.1 of the PEF method and 0 of Annex A and the additional PEFCR-specific requirements specified by the TS and documented in the PEFCR section "Verification".

A.8.3.1 Minimum requirements for the verification and validation of the PEF study

In addition to the requirements specified in the PEF method, for all processes used in the PEF study that are to be validated, the verifier(s) shall check if the DQR satisfies the minimum DQR as specified in the PEFCR.

The PEFCR may specify additional requirements for the validation that shall be added to the minimum requirements stated in this document. The verifier(s) shall check that all the minimum and additional requirements are satisfied during the verification process.

A.8.3.2. Verification and validation techniques

In addition to the requirements specified in the PEF method, the verifier shall check if the applied sampling procedures are in accordance with the sampling procedure defined in the PEFCR. The data reported shall be checked against the source documentation to check their consistency.

A.8.3.3. Content of the validation statement

In addition to the requirements specified in the PEF method, the following elements and aspects shall be included in the validation statement:

- absence of conflict of interest of the verifier(s) with respect to concerned products and any involvement in previous work (PEFCR development, PEF-RP studies, supporting studies, Technical Secretariat membership and consultancy work carried out for the user of the PEFCR during the last three years).

ANNEX B PEFCR TEMPLATE

> **Note**: the text included in *italics* in each section shall not be modified when drafting the PEFCR, except for references to tables, figures and equations. References shall be revised and linked correctly. Further text may be added if relevant.
>
> In case of conflicting requirements between the ones in this Annex and the main text of the PEF method and Annex A, the latter prevail over the ones in Annex B.
>
> The text included in [] are instructions for the PEFCR developers.
>
> **The order of sections and their titles shall not be modified**.

[The first page shall include at least the following information:

- The product category for which the PEFCR is valid

- Version number

- Date of publication

- Time validity]

Table of contents

Acronyms

[List in this section all the acronyms used in the PEFCR. Those already included in the latest version of the PEF method or the Annex A shall be copied in their original form. The acronyms shall be provided in alphabetical order.]

Definitions

[List in this section all the definitions that are relevant for the PEFCR. Those already included in the latest version of the PEF method or the Annex A shall be copied in their original form. The definitions shall be provided in alphabetical order.]

B.1. INTRODUCTION

The Product Environmental Footprint (PEF) method provides detailed and comprehensive technical rules on how to conduct PEF studies that are more reproducible, consistent, robust, verifiable and comparable. Results of PEF studies are the basis for the provision of EF information and they may be used in a diverse number of potential fields of applications, including in-house management and participation in voluntary or mandatory programmes.

For all requirements not specified in this PEFCR the user of the PEFCR shall refer to the documents this PEFCR is in conformance with (see chapter 0).

The compliance with the present PEFCR is optional for PEF in-house applications, whilst it is mandatory whenever the results of a PEF study or any of its content is intended to be communicated.

Terminology: shall, should and may

This PEFCR uses precise terminology to indicate the requirements, the recommendations and options that could be chosen when a PEF study is conducted.

- The term "shall" is used to indicate what is required in order for a PEF study to be in conformance with this PEFCR.

- The term "should" is used to indicate a recommendation rather than a requirement. Any deviation from a "should" requirement has to be justified when developing the PEF study and made transparent.

-

  - The term "may" is used to indicate an option that is permissible. Whenever options are available, the PEF study shall include adequate argumentation to justify the chosen option.

B.2. GENERAL INFORMATION ABOUT THE PEFCR

B.2.1. Technical Secretariat

[The list of the organizations in the Technical Secretariat (TS) at the time of approval of the final PEFCR shall be provided. For each one, the type of organization shall be reported (industry, academia, NGO, consultant, etc.), as well as the starting date of participation. The TS may decide to include also the names of the members of the persons involved for each organization]

Name of the organisation	Type of organisation	Name of the members (not mandatory)

B.2.2. Consultations and stakeholders

[For each public consultation the following information shall be provided:

- Opening and closing date of the public consultation
- Number of comments received
- Names of organizations that have provided comments
- Link to the online platform]

B.2.3. Review panel and review requirements of the PEFCR

[This section shall include the names and affiliations of the members of the review panel. The member that is chairing the review panel shall be identified.]

Name of the member	Affiliation	Role

The reviewers have verified that the following requirements are fulfilled:

- The PEFCR has been developed in accordance with the requirements provided in the PEF method and Annex A of the PEF method;
- The PEFCR supports the creation of credible, relevant and consistent PEF profiles;
- The PEFCR scope and the representative products are adequately defined;
- The functional unit, allocation and calculation rules are adequate for the product category under consideration;
- Datasets used in the PEF-RPs and the supporting studies are relevant, representative, reliable, and in compliance with data quality requirements;
- The selected additional environmental and technical information are appropriate for the product category under consideration and the selection is done in accordance with the requirements stated in the PEF method,
- The model of the RP and corresponding benchmark (if applicable) represent correctly the product category or sub-category;
- The RP model, disaggregated in line with the PEFCR and aggregated in ILCD format, are EF compliant following the rules available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml;
- The RP model in its corresponding excel version is compliant with the rules outlined in section A.2.3 of Annex A;
- The Data Needs Matrix is correctly implemented;
- The classes of performance, if identified, are appropriate for the product category.

[The TS may add additional review criteria as appropriate]

The public review reports are provided in Annex 3 of this PEFCR.

[The review panel shall produce: i) a public review report for each PEF-RP, ii) a public review report for the final PEFCR].

B.2.4. Review statement

This PEFCR was developed in compliance with the PEF Method adopted by the Commission on [indicate the date of approval of the latest version available].

The representative product(s) correctly describe the average product(s) sold in Europe for the product category/sub-category in scope of this PEFCR.

PEF studies carried out in compliance with this PEFCR would reasonably lead to reproducible results and the information included therein may be used to make comparisons and comparative assertions under the prescribed conditions (see chapter on limitations). [the last part of this statement shall be deleted in case the PEFCR is for intermediate product(s)].

[The review statement shall be completed by the reviewer.]

B.2.5. Geographic validity

This PEFCR is valid for products in scope sold or consumed in the European Union + EFTA.

Each PEF study shall identify its geographical validity listing all the countries where the product object of the PEF study is consumed/sold with the relative market share. In case the information on the market for the specific product object of the study is not available, Europe +EFTA shall be considered as the default market, with an equal market share for each country.

B.2.6. Language

The PEFCR is written in English. The original in English supersedes translated versions in case of conflicts.

B.2.7. Conformance to other documents

This PEFCR has been prepared in conformance with the following documents (in prevailing order):

Product Environmental Footprint (PEF) method

....

[The PEFCR shall list additional documents, if any, with which the PEFCR is in conformance with.]

B.3. PEFCR SCOPE

[This section shall i) include a description of the scope of the PEFCR, ii) list and describe the sub-categories included in the PEFCR (if any), describe the product(s) in scope and the technical performance]

B.3.1. Product classification

The CPA codes for the products included in this PEFCR are:

[Based on the product category/sub-category, provide the corresponding Classification of Products by Activity (CPA) (based on the latest CPA list version available). Where multiple production routes for similar products are defined using alternative CPAs, the PEFCR shall accommodate all such CPAs. Identify the sub-categories not covered by the CPA, if any.]

B.3.2. Representative product(s)

[The PEFCR shall include a description of the representative product(s) and how it has been derived. The TS shall provide in an Annex to the PEFCR information about all the steps taken to define the "model" of the RP(s) and report the information gathered].

The PEF study of the representative product(s) (PEF-RP) is available upon request to the TS coordinator that has the responsibility of distributing it with an adequate disclaimer about its limitations.

B.3.3. Functional unit and reference flow

The functional unit (FU) is … [to be filled in].

Table B. 1 defines the key aspects used to define the FU.

Table B. 1. *Key aspects of the FU*

What?	[to be filled in. Note that in case the PEFCR uses the term 'inedible parts' a definition shall be provided by the TS]
How much?	[to be filled in]
How well?	[to be filled in]
How long?	[to be filled in]

The reference flow is the amount of product needed to fulfil the defined function and shall be measured in … [fill in the units]. *All quantitative input and output data collected in the study shall be calculated in relation to this reference flow.*

[The PEFCR shall describe (i) how each aspect of the functional unit affects the environmental footprint of the product, (ii) how to include this effect in the EF calculations and (iii) how an appropriate reference flow[104] shall be calculated. In case calculation parameters are needed, the PEFCR shall provide default values or shall request these parameters in the list of mandatory company-specific information. A calculation example shall be provided].

B.3.4. System boundary

[This section shall include a system diagram clearly indicating the processes and life cycle stages that are included in the product category/sub-category. A short description of the processes and life cycle stages shall be provided. The diagram shall include an indication of the processes for which company-specific data are required and the processes excluded from the system boundary.]

The following life cycle stages and processes shall be included in the system boundary:

Table B. 2. Life cycle stages

Life cycle stage	*Short description of the processes included*

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[104] The reference flow is the amount of product needed to fulfil the defined functional unit.

According to this PEFCR, the following processes may be excluded based on the cut-off rule: [include the list of processes that shall be excluded based on the cut off rule]. *No additional cut-off is allowed.* OR *According to this PEFCR, no cut-off is applicable.*

Each PEF study done in accordance with this PEFCR shall provide in the PEF study a diagram indicating the activities falling in situation 1, 2 or 3 of the data needs matrix.

B.3.5. List of EF impact categories

Each PEF study carried out in compliance with this PEFCR shall calculate the PEF-profile including all EF impact categories listed in the Table below. [The TS shall indicate in the table if the sub-categories for climate change shall be calculated separately. In case one or both sub-categories are not reported on, the TS shall include a footnote explaining the reasons, e.g.: "The sub-indicators 'Climate change – biogenic' and 'Climate change - land use and land transformation' shall not be reported separately because their contribution to the total climate change impact, based on the benchmark results, is less than 5% each."]

Table B. 3. List of the impact categories to be used to calculate the PEF profile

EF impact category	Impact category indicator	Unit	Characterization model
Climate change *- Climate change-biogenic* [strikethrough if not to be reported upon] *- Climate change – land use and land use change* [strikethrough if not to be reported upon]	*Radiative forcing as Global Warming Potential (GWP100)*	*kg CO$_{2\,eq}$*	*Baseline model of 100 years of the IPCC (based on IPCC 2013)*
Ozone depletion	*Ozone Depletion Potential (ODP)*	*kg CFC-11 $_{eq}$*	*Steady-state ODPs as in (WMO 2014 + integrations)*
Human toxicity, cancer	*Comparative Toxic Unit for humans (CTU$_h$)*	*CTUh*	*USEtox model 2.1 (Fankte et al, 2017)*
Human toxicity, non-cancer	*Comparative Toxic Unit for humans (CTU$_h$)*	*CTUh*	*USEtox model 2.1 (Fankte et al, 2017)*
Particulate matter	*Impact on human health*	*disease incidence*	*PM method recomended by UNEP (UNEP 2016)*

EF impact category	Impact category indicator	Unit	Characterization model
Ionising radiation, human health	*Human exposure efficiency relative to U^{235}*	*kBq U^{235}_{eq}*	*Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)*
Photochemical ozone formation, human health	*Tropospheric ozone concentration increase*	*kg NMVOC $_{eq}$*	*LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe 2008*
Acidification	*Accumulated Exceedance (AE)*	*mol H+ $_{eq}$*	*Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)*
Eutrophication, terrestrial	*Accumulated Exceedance (AE)*	*mol N $_{eq}$*	*Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)*
Eutrophication, freshwater	*Fraction of nutrients reaching freshwater end compartment (P)*	*kg P $_{eq}$*	*EUTREND model (Struijs et al, 2009) as implemented in ReCiPe*
Eutrophication, marine	*Fraction of nutrients reaching marine end compartment (N)*	*kg N $_{eq}$*	*EUTREND model (Struijs et al, 2009) as implemented in ReCiPe*
Ecotoxicity, freshwater	*Comparative Toxic Unit for ecosystems (CTU_e)*	*CTUe*	*USEtox model 2.1 (Fankte et al, 2017)*
Land use	• *Soil quality index105* • *Biotic production* • *Erosion resistance* • *Mechanical filtration* • *Groundwater replenishment*	• *Dimensionless (pt)* • *kg biotic production* • *kg soil* • *m3 water* • *m3 groundwater*	*Soil quality index based on LANCA (Beck et al. 2010 and Bos et al. 2016)*
Water use	*User deprivation potential (deprivation-weighted water consumption)*	*m^3 world $_{eq}$*	*Available WAter REmaining (AWARE) as recommended by UNEP, 2016*
Resource use[106], minerals and metals	*Abiotic resource depletion (ADP ultimate reserves)*	*kg Sb $_{eq}$*	*CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.*
Resource use, fossils	*Abiotic resource depletion – fossil fuels (ADP-fossil)*	*MJ*	*CML 2002 (Guinée et al., 2002) and van Oers et al. 2002*

The full list of normalization factors and weighting factors are available in Annex 1 - List of EF normalisation factors and weighting factors.

The full list of characterization factors is available at this link http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml. [The TS shall specify the EF reference package that shall be used.]

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[105] This index is the result of the aggregation, performed by JRC, of the 4 indicators provided by LANCA model as indicators for land use.

[106] The results of this impact category shall be interpreted with caution, because the results of ADP after normalization may be overestimated. The European Commission intends to develop a new method moving from depletion to dissipation model to better quantify the potential for conservation of resources

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B.3.6. Additional technical information

[The TS shall list the additional technical information to be reported]:

- …

[For intermediate products:]

- *The biogenic carbon content at factory gate (physical content) shall be reported. If derived from a native forest, it shall report that the corresponding carbon emissions shall be modelled with the elementary flow '(land use change)'.*

- *The recycled content (R_1) shall be reported.*

- *Results with application-specific A-values shall be reported, if relevant.*

B.3.7. Additional environmental information

[Specify which additional environmental information shall/should be reported (provide units). Avoid if possible the use of should. Reference all methods used to report additional information.]

Biodiversity is considered as relevant for this PEFCR.

OR

Biodiversity is not considered as relevant for this PEFCR.

[If biodiversity is relevant, the PEFCR shall describe how biodiversity impacts shall be assessed by the user of the PEFCR.]

B.3.8. Limitations

[This section shall include the list of limitations a PEF study will have, even if carried out in accordance with this PEFCR.]

B.3.8.1. Comparisons and comparative assertions
[This section shall include the conditions under which a comparison or comparative assertion may be made.]

B.3.8.2. Data gaps and proxies
[This section shall include:

- The list of data gaps on the company-specific data to be collected that most frequently are encountered by companies in the specific sectors and how these data gaps may be solved in the context of the PEF study;
- The list of processes excluded from the PEFCR due to missing datasets that shall not be filled in by the user of the PEFCR;
- The list of processes for which the user of the PEFCR shall apply ILCD-EL compliant proxies.

The TS may decide to indicate in the LCI excel file (see section B.5) for which processes no datasets are available and therefore are considered data gaps and for which processes proxies shall be used.]

B.4. MOST RELEVANT IMPACT CATEGORIES, LIFE CYCLE STAGES, PROCESSES AND ELEMENTARY FLOWS

B.4.1. Most relevant EF impact categories

[In case the PEFCR has no sub-categories] *The most relevant impact categories for the product category in scope of this PEFCR are the following:*

- [list the most relevant impact categories per category].

[In case the PEFCR has sub-categories] *The most relevant impact categories for the sub-category [name] in scope of this PEFCR are the following:*

- [list the most relevant impact categories per each sub-category].

B.4.2. Most relevant life cycle stages

[In case the PEFCR has no sub-categories] *The most relevant life cycle stages for the product category in scope of this PEFCR are the following:*

- [list the most relevant life cycle stages per sub-category]

[In case the PEFCR has sub-categories] *The most relevant life cycle stages for the sub-category [name] in scope of this PEFCR are the following:*

- [list the most relevant life cycle stages per each sub-category]

B.4.3. Most relevant processes

The most relevant processes for the product category in scope of this PEFCR are the following [this table shall be filled in based on the final results of the PEF studies of the representative product(s). Provide one table per sub-category, if appropriate.]

Table B. 4. List of the most relevant processes

Impact category	*Processes*
Most relevant impact category 1	Process A (from life cycle stage X)
	Process B (from life cycle stage Y)
Most relevant impact category 2	Process A (from life cycle stage X)

Impact category	Processes
	Process B (from life cycle stage X)
Most relevant impact category n	Process A (from life cycle stage X)
	Process B (from life cycle stage X)

B.4.4. Most relevant direct elementary flows

The most relevant direct elementary flows for the product category in scope of this PEFCR are the following [the list shall be provided based on the final results of the PEF studies of the representative product(s). Provide one list per sub-category, if appropriate.]

B.5. LIFE CYCLE INVENTORY

All newly created datasets shall be EF compliant.

[The PEFCR shall indicate if sampling is allowed. If the TS allows sampling, the PEFCR shall describe the sampling procedure as described in the PEF method and contain the following sentence:] *In case sampling is needed, it shall be conducted as specified in this PEFCR. However, sampling is not mandatory and any user of this PEFCR may decide to collect the data from all the plants or farms, without performing any sampling.*

B.5.1. List of mandatory company-specific data

[The TS shall here list the processes to be modelled with mandatory company-specific data (i.e. activity data and direct elementary flows).]

Process a

[Provide a short description of process "a". List all the activity data and direct elementary flows that shall be collected and the default datasets of the sub-processes linked to the activity data within process "a". Use the table below to introduce minimum one example in the PEFCR. In case not all processes are introduced here, the full list of all processes shall be include in an excel file.]

Table B. 5. Data collection requirements for mandatory process A

Requirements for data collection purposes			Requirements for modelling purposes								Re-marks
Activity data to be collected	*Specific requirements (e.g. frequency, measurement standard,*	*Unit of measure*	*Default dataset to be used*	*Dataset source (i.e. node)*	*UUID*	*TiR*	*TeR*	*GeR*	*P*	*DQR*	

	etc.)										
Inputs:											
[E.g.: yearly electri-city use]	[E.g.: 3 year average]	[E.g. kWh/year]	[E.g.: Electricity grid mix 1kV-60kV/EU28+3]	[Link to appropriate node of the Life Cycle Data Network. The "data stock" shall also be specified]	[E.g.: 0af0a6a8-aebc-4eeb-99f8-5ccf2304b99d]	[E.g 1.6]					
Outputs:											
…	…	…	…	…	…	…					

[List all the emissions and resources that shall be modelled with company-specific information (most relevant foreground elementary flows) within process "a".]

Table B. 6. Direct elementary flow collection requirements for mandatory process A

Emissions/resources	Elementary flow	UUID	Frequency of measurement	Default measurement method[107]	Remarks

See excel file named "[Name PEFCR_version number] - *Life cycle inventory" for the list of all company-specific data to be collected.*

B.5.2. List of processes expected to be run by the company

[The processes listed in this chapter shall be additional to the ones listed as mandatory company-specific data. No repetition of processes or data is allowed. In case there are no further processes expected to be run by the company, please state *"There are no further processes expected to be run by the company in addition to those listed as mandatory company-specific data."*]

The following processes are expected to be run by the user of the PEFCR:

- Process X
- Process Y

---

[107] Unless specific measurement methods are foreseen in a country-specific legislation

- …

Process X:

[Provide a short description of process "x". List all the activity data and direct elementary flows that shall be collected and the datasets of the sub-processes linked to the activity data within process "x". Use the table below to introduce minimum one example in the PEFCR. In case not all processes are introduced here, the full list of all processes shall be include in an excel file.]

Table B. 7. Data collection requirements for process X

Requirements for data collection purposes			Requirements for modelling purposes								Re-marks
Activity data to be collected	*Specific requirements (e.g. frequency, measurement standard, etc.)*	*Unit of measure*	*Default dataset to be used*	*Dataset source (i.e. node and data stock)*	*UUID*	*TiR*	*TeR*	*GeR*	*P*	*DQR*	
Inputs:											
[E.g.: yearly electricity use]	[E.g.: 3 year average]	[E.g. kWh/ year]	[E.g.: Electricity grid mix 1kV-60kV/EU28+3]	[Link to appropriate node of the Life Cycle Data Network. The "data stock" shall also be specified]	[E.g.: 0af0a6a8-aebc-4eeb-99f8-5ccf2304b99d]	[E.g 1.6]					

Requirements for data collection purposes			Requirements for modelling purposes								Re-marks
Outputs:											
…	…	…	…	…	…	…					

Table B. 8. Direct elementary flow collection requirements for process X

Emissions/resources	Elementary flow	UUID	Frequency of measurement	Default measurement method[108]	Remarks

See excel file named "[Name PEFCR_version number] - Life cycle inventory" for the list of all processes expected to be in situation 1.

B.5.3. Data quality requirements

The data quality of each dataset and the total PEF study shall be calculated and reported. The calculation of the DQR shall be based on the following formula with four criteria:

$$DQR = \frac{TeR + GeR + TiR + P}{4}$$ *[Equation B.1]*

where TeR is technological representativeness, GeR is geographical representativeness, TiR is time representativeness, and P is precision. The representativeness (technological, geographical and time-related) characterises to what degree the processes and products selected are depicting the system analysed, while the precision indicates the way the data is derived and related level of uncertainty.

The next chapters provide tables with the criteria to be used for the semi-quantitative assessment of each criterion.

[The PEFCR may specify more stringent data quality requirements and specify additional criteria for the assessment of data quality. The PEFCR shall report the formulas to be used for assessing the DQR of i) company-specific data (equation 20 of the PEF method), ii) secondary datasets (equation 19 of the PEF method, iii) PEF study (equation 20 of the PEF method).]

B.5.3.1. Company-specific datasets
The DQR shall be calculated at the level-1 disaggregation, before any aggregation of sub-processes or elementary flows is performed. The DQR of company-specific datasets shall be calculated as following:

1) *Select the most relevant activity data and direct elementary flows: most relevant activity data are the ones linked to sub-processes (i.e. secondary datasets) that account for at least 80% of the total environmental impact of the company-specific dataset, listing them from the most contributing to the least contributing one. Most relevant direct elementary flows are defined as those direct elementary flows contributing cumulatively at least with 80% to the total impact of the direct elementary flows.*

2) *Calculate the DQR criteria TeR, TiR, GeR and P for each most relevant activity data and each most relevant direct elementary flow. The values of each criterion shall be assigned based on Table B.9.*

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[108]   Unless specific measurement methods are foreseen in a country-specific legislation

a. *Each most relevant direct elementary flow consists of the amount and elementary flow naming (e.g. 40 g carbon dioxide). For each most relevant elementary flow, the user of the PEFCR shall evaluate the 4 DQR criteria named Te_{R-EF}, Ti_{R-EF}, G_{R-EF}, P_{EF}. For example, the user of the PEFCR shall evaluate the timing of the flow measured, for which technology the flow was measured and in which geographical area.*

b. *For each most relevant activity data, the 4 DQR criteria shall be evaluated (named Ti_{R-AD}, P_{AD}, G_{r-AD}, T_{er-AD}) by the user of the PEFCR.*

c. *Considering that the data for the mandatory processes shall be company-specific, the score of P cannot be higher than 3, while the score for TiR, TeR, and GR cannot be higher than 2 (The DQR score shall be ≤1.5).*

3) *Calculate the environmental contribution of each most relevant activity data (through linking to the appropriate sub-process) and direct elementary flow to the total sum of the environmental impact of all most-relevant activity data and direct elementary flows, in % (weighted, using all EF impact categories). For example, the newly developed dataset has only two most relevant activity data, contributing in total to 80% of the total environmental impact of the dataset:*

- Activity data 1 carries 30% of the total dataset environmental impact. The contribution of this process to the total of 80% is 37.5% (the latter is the weight to be used).
- Activity data 2 carries 50% of the total dataset environmental impact. The contribution of this process to the total of 80% is 62.5% (the latter is the weight to be used).

4) *Calculate the TeR, TiR, GeR and P criteria of the newly developed dataset as the weighted average of each criteria of the most relevant activity data and direct elementary flows. The weight is the relative contribution (in %) of each most relevant activity data and direct elementary flow calculated in step 3.*

5) *The user of the PEFCR shall calculate the total DQR of the newly developed dataset using Equation B.2, where $\overline{Te_R}, \overline{Ge_R}, \overline{Ti_R}, \overline{P}$ are the weighted average calculated as specified in point (4).*

$$DQR = \frac{\overline{Te_R} + \overline{Ge_R} + \overline{Ti_R} + \overline{P}}{4} \qquad \text{[Equation B.2]}$$

Table B. 9. How to assess the value of the DQR criteria for datasets with company-specific information [Note that the reference years for criterion TiR may be adapted by the TS; more than one table may be included in the PEFCR].

Rating	P_{EF} and P_{AD}	Ti_{R-EF} and Ti_{R-AD}	Te_{R-EF} and Te_{R-AD}	G_{R-EF} and G_{R-AD}
1	Measured/calculated <u>and</u> externally verified	The data refers to the most recent annual administration period with respect to the EF report publication date	The elementary flows and the activity data exactly the technology of the newly developed dataset	The activity data and elementary flows reflects the exact geography where the process modelled in the newly created

Rating	P_{EF} and P_{AD}	T_{iR-EF} and T_{iR-AD}	T_{eR-EF} and T_{eR-AD}	G_{R-EF} and G_{R-AD}
				dataset takes place
2	Measured/calculated and internally verified, plausibility checked by reviewer	The data refers to maximum 2 annual administration periods with respect to the EF report publication date	The elementary flows and the activity data is a proxy of the technology of the newly developed dataset	The activity data and elementary flows) partly reflects the geography where the process modelled in the newly created dataset takes place
3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer	The data refers to maximum three annual administration periods with respect to the EF report publication date	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable

P_{EF}: Precision for elementary flows; P_{AD}: Precision for activity data; T_{iR-EF}: Time Representativeness for elementary flows; T_{iR-AD}: Time representativeness for activity data;; T_{eR-EF}: Technology representativeness for elementary flows; T_{eR-AD}: Technology representativeness for activity data; G_{R-EF}: Geographical representativeness for elementary flows; G_{R-AD}: Geographical representativeness for activity data.

B.5.4. Data needs matrix (DNM)

All processes required to model the product and outside the list of mandatory company-specific data (listed in section B.5.1) shall be evaluated using the Data Needs Matrix (see Table B.10). The user of the PEFCR shall apply the DNM to evaluate which data is needed and shall be used within the modelling of its PEF, depending on the level of influence the user of the PEFCR (company) has on the specific process. The following three cases are found in the DNM and are explained below:

1. **Situation 1:** *the process is run by the company applying the PEFCR;*

2. **Situation 2:** *the process is not run by the company applying the PEFCR but the company has access to (company-)specific information;*

3. **Situation 3:** *the process is not run by the company applying the PEFCR and this company does not have access to (company-)specific information.*

Table B. 10. Data Needs Matrix (DNM)[109]. *Disaggregated datasets shall be used.

	Most relevant process	Other process

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[109] The options described in the DNM are not listed in order of preference

Situation	Option		
Situation 1: process run by the company using the PEFCR	Option 1	Provide company-specific data (as requested in the PEFCR) and create a company-specific dataset, in aggregated form (DQR≤1.5)[110] Calculate the DQR values (for each criterion + total)	
	Option 2		Use default secondary dataset in PEFCR, in aggregated form (DQR≤3.0) Use the default DQR values
Situation 2: process <u>not</u> run by the company using the PEFCR but with access to company-specific information	Option 1	Provide company-specific data (as requested in the PEFCR) and create a company-specific dataset, in aggregated form (DQR≤1.5) Calculate the DQR values (for each criterion + total)	
	Option 2	Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤3.0)* Re-evaluate the DQR criteria within the product specific context	
	Option 3		Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤4.0)* Use the default DQR values.
Situation 3: process <u>not</u> run by the company using the PEFCR and without access to company-specific information	Option 1	Use default secondary data set in aggregated form (DQR≤3.0) Re-evaluate the DQR criteria within the product specific context	
	Option 2		Use default secondary data set in aggregated form (DQR≤4.0) Use the default DQR values

B.5.4.1. Processes in situation 1

For each process in situation 1 there are two possible options:

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[110] Company-specific datasets shall be made available to the EC.

- The process is in the list of most relevant processes as specified in the PEFCR or is not in the list of most relevant process, but still the company wants to provide company-specific data (option 1);
- The process is not in the list of most relevant processes and the company prefers to use a secondary dataset (option 2).

Situation 1/Option 1

For all processes run by the company and where the user of the PEFCR applies company-specific data. The DQR of the newly developed dataset shall be evaluated as described in section B.5.3.1.

Situation 1/Option 2

For the non-most relevant processes only, if the user of the PEFCR decides to model the process without collecting company-specific data, then the user shall use the secondary dataset listed in the PEFCR together with its default DQR values listed here.

If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the metadata of the original dataset.

B.5.4.2. Processes in situation 2

When a process is not run by the user of the PEFCR, but there is access to company-specific data, then there are three possible options:

- The user of the PEFCR has access to extensive supplier-specific information and wants to create a new EF compliant dataset (Option 1);
- The company has some supplier-specific information and want to make some minimum changes (Option 2);
- The process is not in the list of most relevant processes and the company wants to make some minimum changes (option 3).

Situation 2/Option 1

For all processes not run by the company and where the user of the PEFCR applies company-specific data, the DQR of the newly developed dataset shall be evaluated as described in section B.5.3.1

Situation 2/Option 2

The user of the PEFCR shall use company-specific activity data for transport and shall substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets, starting from the default secondary dataset provided in the PEFCR.

Please note that the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required.

The user of the PEFCR shall make the DQR context-specific by re-evaluating TeR and TiR using the table(s) B.11. The criteria GeR shall be lowered by 30%[111] and the criteria P shall keep the original value.

Situation 2/Option 3

The user of the PEFCR shall apply company-specific activity data for transport and shall substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets, starting from the default secondary dataset provided in the PEFCR.

Please note that the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required.

In this case, the user of the PEFCR shall use the default DQR values. If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the original dataset.

Table B. 11. How to assess the value of the DQR criteria when secondary datasets are used. [More than one table may be included in the PEFCR and entered in the section on life cycle stages]

	TiR	*TeR*	*GeR*
1	*The EF report publication date happens within the time validity of the dataset*	*The technology used in the EF study is exactly the same as the one in scope of the dataset*	*The process modelled in the EF study takes place in the country the dataset is valid for*
2	*The EF report publication date happens not later than 2 years beyond the time validity of the dataset*	*The technologies used in the EF study is included in the mix of technologies in scope of the dataset*	*The process modelled in the EF study takes place in the geographical region (e.g. Europe) the dataset is valid for*
3	*The EF report publication date happens not later than 4 years beyond the time validity of the dataset*	*The technologies used in the EF study are only partly included in the scope of the dataset*	*The process modelled in the EF study takes place in one of the geographical regions the dataset is valid for*

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[111] In situation 2, option 2 it is proposed to lower the parameter GeR by 30% in order to incentivise the use of company-specific information and reward the efforts of the company in increasing the geographic representativeness of a secondary dataset through the substitution of the electricity mixes and of the distance and means of transportation.

	TiR	TeR	GeR
4	The EF report publication date happens not later than 6 years beyond the time validity of the dataset	The technologies used in the EF study are similar to those included in the scope of the dataset	The process modelled in the EF study takes place in a country that is not included in the geographical region(s) the dataset is valid for, but sufficient similarities are estimated based on expert judgement.
5	The EF report publication date happens later than 6 years after the time validity of the dataset	The technologies used in the EF study are different from those included in the scope of the dataset	The process modelled in the EF study takes place in a different country than the one the dataset is valid for

B.5.4.3. Processes in situation 3

If a process is not run by the company using the PEFCR and the company does not have access to company-specific data, there are two possible options:

It is in the list of most relevant processes (situation 3, option 1);

It is not in the list of most relevant processes (situation 3, option 2).

Situation 3/Option 1

In this case, the user of the PEFCR shall make the DQR values of the dataset used context-specific by re-evaluating TeR, TiR and GeR, using the table(s) provided. The criteria P shall keep the original value.

Situation 3/Option 2

For the non-most relevant processes, the user of the PEFCR shall apply the corresponding secondary dataset listed in the PEFCR together with its DQR values.

If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the original dataset.

B.5.5. Which datasets to use?

This PEFCR lists the secondary datasets to be applied by the user of the PEFCR. Whenever a dataset needed to calculate the PEF profile is not among those listed in this PEFCR, then the user shall choose between the following options (in hierarchical order):

- Use an EF compliant dataset available on one of the nodes of the Life Cycle Data Network http://eplca.jrc.ec.europa.eu/LCDN/;

- Use an EF compliant dataset available in a free or commercial source;

- Use another EF compliant dataset considered to be a good proxy. In such case this information shall be included in the "limitations" section of the PEF report.

- Use an ILCD entry level (EL) compliant dataset. These datasets shall be included in the "limitations" section of the PEF report. A maximum of 10% of the total environmental impact may be derived from ILCD-EL compliant datasets (calculated cumulatively from lowest to largest contribution to the total EF profile).

- If no EF compliant or ILCD-EL compliant proxy is available, it shall be excluded from the PEF study. This shall be clearly stated in the PEF report as a data gap and validated by the PEF study and PEF report verifiers.

B.5.6. How to calculate the average DQR of the study

To calculate the average DQR of the PEF study, the user of the PEFCR shall calculate separately the TeR, TiR, GeR and P for the PEF study as the weighted average of all most relevant processes, based on their relative environmental contribution to the total single overall score. The calculation rules explained in section 4.6.5.8 of the PEF method shall be used.

B.5.7. Allocation rules

[The PEFCR shall define which allocation rules shall be applied by the user of the PEFCR and how the modelling/ calculations shall be made. In case economic allocation is used, the calculation method on how to derive the allocation factors shall be fixed and prescribed in the PEFCR. The following template shall be used:]

Table B. 12. Allocation rules

Process	Allocation rule	Modelling instructions	Allocation factor
[Example: Process A]	[Example: Physical allocation]	[Example: The mass of the different outputs shall be used.]	[Example: 0.2]
...	...		

B.5.8. Electricity modelling

The following electricity mix shall be used in hierarchical order:

(c)   Supplier-specific electricity product shall be used if for a country there is a 100% tracking system in place, or if :

   (i)   available, and

   (ii)   the set of minimum criteria to ensure the contractual instruments are reliable is met.

(d)   The supplier-specific total electricity mix shall be used if:

      (i)   *available, and*

      (ii)   *the set of minimum criteria to ensure the contractual instruments are reliable is met.*

(e)   *The 'country-specific residual grid mix, consumption mix' shall be used. Country-specific means the country in which the life cycle stage or activity occurs. This may be an EU country or non-EU country. The residual grid mix prevents double counting with the use of supplier-specific electricity mixes in (a) and (b).*

(f)   *As a last option, the average EU residual grid mix, consumption mix (EU-28 +EFTA), or region representative residual grid mix, consumption mix, shall be used.*

Note: for the use stage, the consumption grid mix shall be used.

The environmental integrity of the use of supplier-specific electricity mix depends on ensuring that contractual instruments (for tracking) **reliably and uniquely convey claims to consumers***. Without this, the PEF lacks the accuracy and consistency necessary to drive product/ corporate electricity procurement decisions and accurate consumer (buyer of electricity) claims. Therefore, a set of* **minimum criteria** *that relate to the integrity of the contractual instruments as reliable conveyers of environmental footprint information has been identified. They represent the minimum features necessary to use supplier-specific mix within PEF studies.*

Set of minimum criteria to ensure contractual instruments from suppliers

A supplier-specific electricity product/ mix may only be used if the user of the PEF method ensures that the contractual instrument meets the criteria specified below. If contractual instruments do not meet the criteria, then country-specific residual electricity consumption-mix shall be used in the modelling.

The list of criteria below is based on the criteria of the GHG Protocol Scope 2 Guidance – An amendment to the GHG Protocol Corporate Standard – Mary Sotos – World Resource Institute. A contractual instrument used for electricity modelling shall:

Criterion 1 – Convey attributes

- Convey the energy type mix associated with the unit of electricity produced.
- The energy type mix shall be calculated based on delivered electricity, incorporating certificates sourced and retired (obtained or acquired or withdrawn) on behalf of its customers. Electricity from facilities for which the attributes have been sold off (via contracts or certificates) shall be characterized as having the environmental attributes of the country residual consumption mix where the facility is located.

Criterion 2 – Be a unique claim

- Be the only instruments that carry the environmental attribute claim associated with that quantity of electricity generated.
- Be tracked and redeemed, retired, or cancelled by or on behalf of the company (e.g. by an audit of contracts, third party certification, or may be handled automatically through other disclosure registries, systems, or mechanisms).

Criterion 3 – Be as close as possible to the period to which the contractual instrument is applied

[The TS may provide more information following the PEF method]

Modelling 'country-specific residual grid mix, consumption mix':

Datasets for residual grid mix, consumption mix, per energy type, per country and per voltage are made available by data providers.

If no suitable dataset is available, the following approach should be used:

Determine the country consumption mix (e.g. X% of MWh produced with hydro energy, Y% of MWh produced with coal power plant) and combine them with LCI datasets per energy type and country/region (e.g. LCI dataset for the production of 1MWh hydro energy in Switzerland):

- Activity data related to non-EU country consumption mix per detailed energy type shall be determined based on:
- Domestic production mix per production technologies;
- Import quantity and from which neighbouring countries;
- Transmission losses;
- Distribution losses;
- Type of fuel supply (share of resources used, by import and / or domestic supply).

These data may be found in the publications of the International Energy Agency (IEA (www.iea.org).

- Available LCI datasets per fuel technologies. The LCI datasets available are generally specific to a country or a region in terms of:
- fuel supply (share of resources used, by import and/ or domestic supply);
- energy carrier properties (e.g. element and energy contents);
- technology standards of power plants regarding efficiency, firing technology, flue-gas desulphurisation, NOx removal and de-dusting.

Allocation rules:

[The PEFCR shall define which physical relationship shall be used by PEF studies: (i) to subdivide the electricity consumption among multiple products for each process (e.g. mass, number of pieces, volume…) and (ii) to reflect the ratios of production/ratios of sales between EU countries/regions when a product is produced in different locations or sold in different countries. Where such data are not available, the average EU mix (EU-28 +EFTA), or region representative mix, shall be used. The following template shall be used:]

Table B. 13. Allocation rules for electricity

Process	*Physical relationship*	*Modelling instructions*
Process A	*Mass*	
Process B	*N of pieces*	

...	...	

If the consumed electricity comes from more than one electricity mix, each mix source shall be used in terms of its proportion in the total kWh consumed. For example, if a fraction of this total kWh consumed is coming from a specific supplier a supplier-specific electricity mix shall be used for this part. See below for on-site electricity use.

A specific electricity type may be allocated to one specific product in the following conditions:

(g)   If the production (and related electricity consumption) of a product occurs in a separate site (building), the energy type physical related to this separated site may be used.

(h)   If the production (and related electricity consumption) of a product occurs in a shared space with specific energy metering or purchase records or electricity bills, the product-specific information (measure, record, bill) may be used.

(i)   If all the products produced in the specific plant are supplied with a publically available PEF study, the company wanting to make the claim shall make all PEF studies available. The allocation rule applied shall be described in the PEF study, consistently applied in all PEF studies connected to the site and verified. An example is the 100% allocation of a greener electricity mix to a specific product.

On-site electricity generation:

If on-site electricity production is equal to the site own consumption, two situations apply:

No contractual instruments have been sold to a third party: the own electricity mix (combined with LCI datasets) shall be modelled..

Contractual instruments have been sold to a third party: the 'country-specific residual grid mix, consumption mix' (combined with LCI datasets) shall be used.

If electricity is produced in excess of the amount consumed on-site within the defined system boundary and is sold to, for example, the electricity grid, this system may be seen as a multifunctional situation. The system will provide two functions (e.g. product + electricity) and the following rules shall be followed:

If possible, apply subdivision. Subdivision applies both to separate electricity productions or to a common electricity production where you may allocate based on electricity amounts the upstream and direct emissions to your own consumption and to the share you sell out of your company (e.g. if a company has a windmill on its production site and exports 30% of the produced electricity, emissions related to 70% of produced electricity should be accounted in the PEF study).

If not possible, direct substitution shall be used. The country-specific residual consumption electricity mix shall be used as substitution[112].

Subdivision is considered as not possible when upstream impacts or direct emissions are closely related to the product itself.

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[112]   For some countries, this option is a best case rather than a worst case.

B.5.9. Climate change modelling

The impact category 'climate change' shall be modelled considering three sub-categories:

1. ***Climate change – fossil:*** *This sub-category includes emissions from peat and calcination/carbonation of limestone. The emission flows ending with '(fossil)' (e.g., 'carbon dioxide (fossil)' and 'methane (fossil)') shall be used, if available.*

2. ***Climate change – biogenic:*** *This sub-category covers carbon emissions to air (CO2, CO and CH4) originating from the oxidation and/or reduction of biomass by means of its transformation or degradation (e.g. combustion, digestion, composting, landfilling) and CO_2 uptake from the atmosphere through photosynthesis during biomass growth – i.e. corresponding to the carbon content of products, biofuels or aboveground plant residues, such as litter and dead wood. Carbon exchanges from native forests[113] shall be modelled under sub-category 3 (incl. connected soil emissions, derived products, residues). The emission flows ending with '(biogenic)' shall be used.*

   [Choose the right statement]

   A simplified modelling approach shall be used when modelling foreground emissions.

   [OR]

   A simplified modelling approach shall not be used when modelling foreground emissions.

   [If a simplified modelling approach is used, include in the text: "*Only the emission 'methane (biogenic)' is modelled, while no further biogenic emissions and uptakes from atmosphere are included. If methane emissions can be both fossil or biogenic, the release of biogenic methane shall be modelled first and then the remaining fossil methane.*"]

   [If no simplified modelling is used, include the text: "*All biogenic carbon emissions and removals shall be modelled separately.*"]

   [For intermediate products only:]

   The biogenic carbon content at factory gate (physical content and allocated content) shall be reported as 'additional technical information'.

3. ***Climate change – land use and land use change***: *This sub-category accounts for carbon uptakes and emissions (CO2, CO and CH4) originating from carbon stock changes caused by land use change and land use. This sub-category includes biogenic carbon exchanges from deforestation, road construction or other soil activities (including soil carbon emissions). For native forests, all related CO_2 emissions are included and modelled under this sub-category (including connected soil emissions, products derived from native forest[114] and residues), while their CO_2 uptake is excluded. The emission flows ending with '(land use change)' shall be used.*

   For land use change, all carbon emissions and removals shall be modelled following the modelling guidelines of PAS 2050:2011 (BSI 2011) and the supplementary

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[113] Native forests – represents native or long-term, non-degraded forests. Definition adapted from table 8 in Annex V C(2010)3751 to Directive 2009/28/EC.
[114] Following the instantaneous oxidation approach in IPCC 2013 (Chapter 2).

document PAS2050-1:2012 (BSI 2012) for horticultural products. PAS 2050:2011 (BSI 2011): "Large emissions of GHGs can result as a consequence of land use change. Removals as a direct result of land use change (and not as a result of long-term management practices) do not usually occur, although it is recognized that this could happen in specific circumstances. Examples of direct land use change are the conversion of land used for growing crops to industrial use or conversion from forestland to cropland. All forms of land use change that result in emissions or removals are to be included. Indirect land use change refers to such conversions of land use as a consequence of changes in land use elsewhere. While GHG emissions also arise from indirect land use change, the methods and data requirements for calculating these emissions are not fully developed. Therefore, the assessment of emissions arising from indirect land use change is not included.

The GHG emissions and removals arising from direct land use change shall be assessed for any input to the life cycle of a product originating from that land and shall be included in the assessment of GHG emissions. The emissions arising from the product shall be assessed on the basis of the default land use change values provided in PAS 2050:2011 Annex C, unless better data is available. For countries and land use changes not included in this annex, the emissions arising from the product shall be assessed using the included GHG emissions and removals occurring as a result of direct land use change in accordance with the relevant sections of the IPCC (2006). The assessment of the impact of land use change shall include all direct land use change occurring not more than 20 years, or a single harvest period, prior to undertaking the assessment (whichever is the longer). The total GHG emissions and removals arising from direct land use change over the period shall be included in the quantification of GHG emissions of products arising from this land on the basis of equal allocation to each year of the period[115].

1. *Where it can be demonstrated that the land use change occurred more than 20 years prior to the assessment being carried out, no emissions from land use change should be included in the assessment.*

2. *Where the timing of land use change cannot be demonstrated to be more than 20 years, or a single harvest period, prior to making the assessment (whichever is the longer), it shall be assumed that the land use change occurred on 1 January of either:*

- the earliest year in which it can be demonstrated that the land use change had occurred; or
- on 1 January of the year in which the assessment of GHG emissions and removals is being carried out.

The following hierarchy shall apply when determining the GHG emissions and removals arising from land use change occurring not more than 20 years or a single harvest period, prior to making the assessment (whichever is the longer):

1. *where the country of production is known and the previous land use is known, the GHG emissions and removals arising from land use change shall be those resulting from the change in land use from the previous land use to the current land use in*

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[115] In case of variability of production over the years, a mass allocation should be applied.

that country (additional guidelines on the calculations can be found in PAS 2050-1:2012);

2. *where the country of production is known, but the former land use is not known, the GHG emissions arising from land use change shall be the estimate of average emissions from the land use change for that crop in that country (additional guidelines on the calculations can be found in PAS 2050-1:2012);*

3. *where neither the country of production nor the former land use is known, the GHG emissions arising from land use change shall be the weighted average of the average land use change emissions of that commodity in the countries in which it is grown.*

Knowledge of the prior land use can be demonstrated using a number of sources of information, such as satellite imagery and land survey data. Where records are not available, local knowledge of prior land use can be used. Countries in which a crop is grown can be determined from import statistics, and a cut-off threshold of not less than 90% of the weight of imports may be applied. Data sources, location and timing of land use change associated with inputs to products shall be reported." [end of quote from PAS 2050:2011]

[Choose the right statement]

Soil carbon storage shall be modelled, calculated and reported as additional environmental information.

[OR]

Soil carbon storage shall not be modelled, calculated and reported as additional environmental information.

[If it shall be modelled, the PEFCR shall specify which proof needs to be provided and include the modelling rules.]

The sum of the three sub-categories shall be reported.

[If climate change is selected as a relevant impact category, the PEFCR shall (i) always request to report the total climate change as the sum of the three sub-indicators, and (ii) for the sub-indicators 'Climate change – fossil', 'Climate change – biogenic' and 'Climate change - land use and land use change', request separate reporting for those contributing more than 5% each to the total score.]

[Choose the right statement]

The sub-category 'Climate change-biogenic' shall be reported separately.

[OR]

The sub-category 'Climate change-biogenic' shall not be reported separately.

The sub-category 'Climate change-land use and land transformation' shall be reported separately.

[OR]

The sub-category 'Climate change-land use and land transformation' shall not be reported separately.

B.5.10. Modelling of end of life and recycled content

The end of life of products used during the manufacturing, distribution, retail, the use stage or after use shall be included in the overall modelling of the life cycle of the organisation. Overall, this should be modelled and reported at the life cycle stage where the waste occurs. This section provides rules on how to model the end of life of products as well as the recycled content.

The Circular Footprint Formula (CFF) is used to model the end of life of products as well as the recycled content and is a combination of "material + energy + disposal", i.e.:

Material

$$(1 - R_1)E_V + R_1 \times \left(AE_{recycled} + (1 - A)E_V \times \frac{Q_{Sin}}{Q_p} \right) + (1 - A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P} \right)$$

Energy $(1 - B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$

Disposal $(1 - R_2 - R_3) \times E_D$

With the following parameters

A: allocation factor of burdens and credits between supplier and user of recycled materials.

B: allocation factor of energy recovery processes. It applies both to burdens and credits. It shall be set to zero for all PEF studies.

Qs_{in}: quality of the ingoing secondary material, i.e. the quality of the recycled material at the point of substitution.

Qs_{out}: quality of the outgoing secondary material, i.e. the quality of the recyclable material at the point of substitution.

Q_p: quality of the primary material, i.e. quality of the virgin material.

R_1: it is the proportion of material in the input to the production that has been recycled from a previous system.

R_2: it is the proportion of the material in the product that will be recycled (or reused) in a subsequent system. R2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R2 shall be measured at the output of the recycling plant.

R_3: it is the proportion of the material in the product that is used for energy recovery at EoL.

$E_{recycled}$ (E_{rec}): specific emissions and resources consumed (per functional unit) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.

$E_{recyclingEoL}$ (E_{recEoL}): specific emissions and resources consumed (per functional unit) arising from the recycling process at EoL, including collection, sorting and transportation process.

E_v: specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material.

$E*_v$: specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials.

E_{ER}: specific emissions and resources consumed (per functional unit) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, etc.).

$E_{SE,heat}$ and $E_{SE,elec}$: specific emissions and resources consumed (per functional unit) that would have arisen from the specific substituted energy source, heat and electricity respectively.

E_D: specific emissions and resources consumed (per functional unit) arising from disposal of waste material at the EoL of the analysed product, without energy recovery.

$X_{ER,heat}$ and $X_{ER,elec}$: the efficiency of the energy recovery process for both heat and electricity.

LHV: lower heating value of the material in the product that is used for energy recovery.

[Within the respective chapters, the following parameters shall be provided in the PEFCR:

- All A values to be used shall be listed in the PEFCR, together with a reference to the PEF method and Annex C. In case specific A values cannot be determined by the PEFCR, the PEFCR shall prescribe the following procedure for its users:
  - *Check in Annex C the availability of an application-specific A value which fits the PEFCR,*
  - *If an application-specific A value is not available, the material-specific A value in Annex C shall be used,*
  - *If a material-specific A value is not available, the A value shall be set equal to 0.5.*
- All quality ratios (Qs_{in}, Qs_{out}/Q_p) to be used.
- Default R_1 values for all default material datasets (in case no company-specific values are available), together with a reference to the PEF method and Annex C. They shall be set to 0% when no application-specific data is available.
- Default R_2 values to be used in case no company-specific values are available, together with a reference to the PEF method and Annex C.
- All datasets to be used for E_{rec}, E_{recEoL}, E_v, $E*_v$, E_{ER}, $E_{SE,heat}$ and $E_{SE,elec}$, E_D]

[Default values for all parameters shall be listed in a table in the section of the appropriate life cycle stage.]

Modelling recycled content (if applicable)

[If applicable the following text shall be included:]

The following part of the Circular Footprint Formula is used to model the recycled content:

$$(1 - R_1)E_V + R_1 \times \left(AE_{recycled} + (1 - A)E_V \times \frac{Q_{Sin}}{Q_p} \right)$$

The R_1 values applied shall be supply-chain specific or default as provided in the table above [TS to provide a table]*, in relation with the DNM. Material-specific values based on supply*

market statistics are not accepted as a proxy and therefore shall not be used. The applied R_1 values shall be subject to PEF study verification.

When using supply-chain specific R_1 values other than 0, traceability throughout the supply chain is necessary. The following guidelines shall be followed when using supply-chain specific R_1 values:

- *The supplier information (through e.g., statement of conformity or delivery note) shall be maintained during all stages of production and delivery at the converter;*
- *Once the material is delivered to the converter for production of the end products, the converter shall handle information through their regular administrative procedures;*
- *The converter for production of the end products claiming recycled content shall demonstrate through its management system the [%] of recycled input material into the respective end product(s).*
- *The latter demonstration shall be transferred upon request to the user of the end product. In case a PEF profile is calculated and reported, this shall be stated as additional technical information of the PEF profile.*
- *Company-owned traceability systems may be applied as long as they cover the general guidelines outlined above.*

[Industry systems may be applied as long as they cover the general guidelines outlined above. In that case, the text above may be replaced by those industry specific rules. If not, they shall be supplemented with the general guidelines above.]

[For intermediate products only:]

The PEF profile shall be calculated and reported using A equal to 1 for the product in scope.

Under additional technical information the results shall be reported for different applications/materials with the following A values:

Application/material	A value to be used

B.6. LIFE CYCLE STAGES

B.6.1. Raw material acquisition and pre-processing

[The PEFCR shall list all technical requirements and assumptions to be applied by the user of the PEFCR. Furthermore, it shall list all processes taking place in this life cycle stage (according to the model of the RP), following the table provided below (transport in separate table). The table may be adapted by the TS as appropriate (e.g. by including relevant parameters of the Circular Footprint Formula).]

Table B. 14. Raw material acquisition and pre-processing (capitals indicate those processes expected to be run by the company)

Process name*	Unit of measurement (output)	Default				UUID	Default DQR				Most relevant process [Y/N]
		R_1	Amount per FU	Dataset	Dataset source (Node and data stock)		P	TiR	GeR	TeR	

[Please write in CAPITAL LETTERS the name of those processes expected to be run by the company]

The user of the PEFCR shall report the DQR values (for each criterion + total) for all the datasets used.

[Packaging shall be modelled as part of the raw material acquisition stage of the life cycle.]

[PEFCRs that include the use of beverage cartons or bag-in-box packaging shall provide information on the amounts of input materials (also called the bill of material) and state that the packaging shall be modelled by combining the prescribed amounts of the material datasets with the prescribed conversion dataset.]

[PEFCRs that include reusable packaging from third party operated pools shall provide default reuse rates. PEFCRs with company-owned packaging pools shall specify that the reuse rate shall be calculated using supply-chain-specific data only. The two different modelling approaches as presented in the PEF method shall be used and copied in the PEFCR. The PEFCR shall include the following: *"The raw material consumption of reusable packaging shall be calculated by dividing the actual weight of the packaging by the reuse rate."*]

[For the different ingredients transported from supplier to factory, the user of the PEFCR needs data on (i) transport mode, (ii) distance per transport mode, (iii) utilisation ratios for truck transport and (iv) empty return modelling for truck transport. The PEFCR shall provide default data for these or request these data in the list of mandatory company-specific information. The default values provided in the PEF method shall be applied unless PEFCR-specific data is available.]

Table B. 15. Transport (capitals indicate those processes expected to be run by the company)

Process name*	Unit of measure-ment (output)	Default (per FU)			De-fault data-set	Data-set source	UUID	Default DQR				Most relevant [Y/N]
		Distance	Utilisa-tion ratio*	Empty return				P	TiR	GeR	TeR	

The user of the PEFCR shall always check the utilisation ratio applied in the default dataset and adapt it accordingly.

[Please write in CAPITAL LETTERS the name of processes expected to be run by the company.]

[PEFCRs that include reusable packaging shall include the following: *"The reuse rate affects the quantity of transport needed per FU. The transport impact shall be calculated by dividing the one-way trip impact by the number of times this packaging is reused."*]

B.6.2. Agricultural modelling [to be included only if applicable]

[In case agricultural production is part of the scope of the PEFCR the following text shall be included. Sections that are not relevant may be removed.]

Handling multi-functional processes: The rules described in the LEAP guidelines shall be followed: 'Environmental performance of animal feeds supply chains (pages 36-43), FAO 2015, available at http://www.fao.org/partnerships/leap/publications/en/'.

Use of crop type specific and country-, region- or climate-specific data for yield, water and land use, land use change, fertiliser (artificial and organic) amount (N, P amount) and pesticide amount (per active ingredient), per hectare per year, if available.

Cultivation data shall be collected over a period of time sufficient to provide an average assessment of the life cycle inventory associated with the inputs and outputs of cultivation that will offset fluctuations due to seasonal differences:

- *For annual crops, an assessment period of at least three years shall be used (to level out differences in crop yields related to fluctuations in growing conditions over the years such as climate, pests and diseases, etc.). Where data covering a three-year period is not available i.e. due to starting up a new production system (e.g. new greenhouse, newly cleared land, shift to another crop), the assessment may be conducted over a shorter period, but shall be not less than 1 year. Crops/plants grown in greenhouses shall be considered as annual crops/plants, unless the cultivation cycle is significantly shorter than a year and another crop is cultivated consecutively within that year. Tomatoes, peppers and other crops which are cultivated and harvested over a longer period through the year are considered as annual crops.*
- *For perennial plants (including entire plants and edible portions of perennial plants) a steady state situation (i.e. where all development stages are proportionally represented in the studied time period) shall be assumed and a three-year period shall be used to estimate the inputs and outputs[116].*

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[116] The underlying assumption in the cradle-to-gate life cycle inventory assessment of horticultural products is that the inputs and outputs of the cultivation are in a 'steady state', which means that all development stages of perennial crops (with different quantities of inputs and outputs) shall be proportionally represented in the time period of cultivation that is studied. This approach gives the advantage that inputs and outputs of a relatively short period can be used for the calculation of the cradle-to-gate life cycle inventory from the

- *Where the different stages in the cultivation cycle are known to be disproportional, a correction shall be made by adjusting the crop areas allocated to different development stages in proportion to the crop areas expected in a theoretical steady state. The application of such correction shall be justified and recorded. The life cycle inventory of perennial plants and crops shall not be undertaken until the production system actually yields output.*
- *For crops that are grown and harvested in less than one year (e.g. lettuce produced in 2 to 4 months) data shall be gathered in relation to the specific time period for production of a single crop, from at least three recent consecutive cycles. Averaging over three years may best be done by first gathering annual data and calculating the life cycle inventory per year and then determining the three years average.*

Pesticide emissions shall be modelled as specific active ingredients. As a default approach, pesticides applied on the field shall be modelled as 90% emitted to the agricultural soil compartment, 9% emitted to air and 1% emitted to water.

Fertiliser (and manure) emissions shall be differentiated per fertilizer type and cover as a minimum:

- *NH_3, to air (from N-fertiliser application)*
- *N_2O, to air (direct and indirect) (from N-fertiliser application)*
- *CO_2, to air (from lime, urea and urea-compounds application)*
- *NO_3, to water unspecified (leaching from N-fertiliser application)*
- *PO_4, to water unspecified or freshwater (leaching and run-off of soluble phosphate from P-fertiliser application)*
- *P, to water unspecified or freshwater (soil particles containing phosphorous, from P-fertiliser application).*

The LCI for P emissions should be modelled as the amount of P emitted to water after run-off and the emission compartment 'water' shall be used. When this amount is not available, the LCI may be modelled as the amount of P applied on the agricultural field (through manure or fertilisers) and the emission compartment 'soil' shall be used. In this case, the run-off from soil to water is part of the impact assessment method.

The LCI for N emissions shall be modelled as the amount of emissions after it leaves the field (soil) and ending up in the different air and water compartments per amount of fertilisers applied. N emissions to soil shall not be modelled. The nitrogen emissions shall be calculated from nitrogen applications of the farmer on the field and excluding external sources (e.g. rain deposition).

[For nitrogen based fertilisers, the PEFCR shall describe the LCI model to be used. The Tier 1 emission factors of IPCC 2006 should be used. A more comprehensive nitrogen field model may be used by the PEFCR provided (i) it covers at least the emissions requested above, (ii) N is balanced in inputs and outputs and (iii) it is described in a transparent way.]

Table B. 16. Parameters to be used when modelling nitrogen emission in soil

perennial crop product. Studying all development stages of a horticultural perennial crop can have a lifespan of 30 years and more (e.g. in case of fruit and nut trees).

Emission	Compartment	Value to be applied
N_2O (synthetic fertiliser and manure; direct and indirect)	Air	0.022 kg N_2O/ kg N fertilizer applied
NH_3 (synthetic fertiliser)	Air	kg NH_3= kg N * FracGASF= 1*0.1* (17/14)= 0.12 kg NH_3/ kg N fertilizer applied
NH_3 (manure)	Air	kg NH_3= kg N*FracGASF= 1*0.2* (17/14)= 0.24 kg NH_3/ kg N manure applied
NO_3^- (synthetic fertiliser and manure)	Water	kg NO_3^-= kg N*FracLEACH = 1*0.3*(62/14) = 1.33 kg NO_3^-/ kg N applied
P based fertilisers	Water	0.05 kg P/ kg P applied

FracGASF: fraction of synthetic fertiliser N applied to soils that volatilises as NH_3 and NO_x. FracLEACH: fraction of synthetic fertiliser and manure lost to leaching and runoff as NO3-.

Heavy metal emissions from field inputs shall be modelled as emission to soil and/or leaching or erosion to water. The inventory to water shall specify the oxidation state of the metal (e.g., Cr^{+3}, Cr^{+6}). As crops assimilate part of the heavy metal emissions during their cultivation, clarification is needed on how to model crops that act as a sink. The following modelling approach shall be used:

[The TS shall select one of the two modelling approaches to be used]

- *The final fate of the heavy metals elementary flows are not further considered within the system boundary: the inventory does not account for the final emissions of the heavy metals and therefore shall not account for the uptake of heavy metals by the crop. For example, heavy metals in agricultural crops cultivated for human consumption end up in the plant. Within the EF context human consumption is not modelled, the final fate is not further modelled and the plant acts as a heavy metal sink. Therefore, the uptake of heavy metals by the crop shall not be modelled.*
- *The final fate (emission compartment) of the heavy metal elementary flows is considered within the system boundary: the inventory does account for the final emissions (release) of the heavy metals in the environment and therefore shall also account for the uptake of heavy metals by the crop. For example, heavy metals in agricultural crops cultivated for feed will mainly end up in the animal digestion and used as manure back on the field where the metals are released in the environment and their impacts are captured by the impact assessment methods. Therefore, the inventory of the agricultural stage shall account for the uptake of heavy metals by the crop. A limited amount ends up in the animal, which may be neglected for simplification.*

Methane emissions from rice cultivation shall be included on basis of IPCC 2006 calculation rules.

Drained peat soils shall include carbon dioxide emissions on the basis of a model that relates the drainage levels to annual carbon oxidation.

The following activities shall be included [The TS shall select what shall be included]:

- *Input of seed material (kg/ha)*
- *Input of peat to soil (kg/ha + C/N ratio)*
- *Input of lime (kg CaCO₃/ha, type)*
- *Machine use (hours, type) (to be included if there is high level of mechanisation)*
- *Input N from crop residues that stay on the field or are burned (kg residue + N content/ha)*
- *Crop yield (kg/ha)*
- *Drying and storage of products*
- *Field operations through …[to be filled in]*

B.6.3. Manufacturing

[The PEFCR shall list all technical requirements and assumptions to applied by the user of the PEFCR. Furthermore, it shall list all processes taking place in this life cycle stage, according to the table provided below. The table may be adapted by the TS as appropriate (e.g. by including relevant parameters of the Circular Footprint Formula).]

Table B. 17. Manufacturing (capitals indicate those processes expected to be run by the company)

Name of the process	Unit of measurement (output)	Default amount per FU	Default dataset to be used	Dataset source (Node and data stock)	UUID	Default DQR				Most relevant process [Y/N]
						P	TiR	GeR	TeR	

[Please write in CAPITAL LETTERS the name of those processes expected to be run by the company]

The user of the PEFCR shall report the DQR values (for each criterion + total) for all the datasets used.

[PEFCRs that include reusable packaging shall account for the additional energy and resource used for cleaning, repairing or refilling.]

The waste of products used during the manufacturing shall be included in the modelling. [Default loss rates per type of product and how these shall be included in the reference flow shall be described.]

B.6.4. Distribution stage [to be included if applicable]

Transport from factory to final client (including consumer transport) shall be modelled within this life cycle stage. The final client is defined as … [to be filled in].

In case supply-chain-specific information is available for one or several transport parameters, they may be applied following the Data Needs Matrix.

[A default transport scenario shall be provided by the TS in the PEFCR. In case no PEFCR-specific transport scenario is available, the transport scenario provided in the PEF method shall be used as a basis together with (i) a number of PEFCR-specific ratios, (ii) PEFCR-specific utilisation ratios for truck transport, and (iii) PEFCR-specific allocation factor for consumer transport. For reusable products, the return transport from retail/DC to factory shall be added in the transport scenario. For cooled or frozen products, the default truck/van transport processes should be changed. The PEFCR shall list all processes taking place in scenario (according to the model of the RP) using the table below. The table may be adapted by the TS as appropriate]

Table B. 18. Distribution (capitals indicate those processes expected to be run by the company)

Process name*	Unit of measurement (output)	Default (per FU)			Default dataset	Dataset source	UUID	Default DQR				Most relevant [Y/N]
		Distance	Utilisation ratio	Empty return				P	TiR	GeR	TeR	

[Please write in CAPITAL LETTERS the name of those processes expected to be run by the company.]

The user of the PEFCR shall report the DQR values (for each criterion + total) for all the datasets used.

The waste of products during distribution and retail shall be included in the modelling. [Default loss rates per type of product and how these shall be included in the reference flow shall be described. The PEFCR shall follow the PEF method Annex F in case no PEFCR-specific information is available.]

B.6.5. Use stage [to be included if applicable]

[The PEFCR shall provide a clear description of the use stage and list all processes taking place therein (according to the model of the RP) according to the table provided below. The table may be adapted by the TS as appropriate.]

Table B. 19. Use stage (capitals indicate those processes expected to be run by the company)

Name of the process*	Unit of measurement (output)	Default amount per FU	Default dataset to be used	Dataset source	UUID	Default DQR				Most relevant process [Y/N]
						P	TiR	TeR	GeR	

[Please write in CAPITAL LETTERS the name of those processes expected to be run by the company.]

The user of the PEFCR shall report the DQR values (for each criterion + total) for all the datasets used.

[In this section the PEFCR shall also list all technical requirements and assumptions that the user of the PEFCR shall apply. The PEFCR shall state if a delta approach is used for certain processes. In case the delta approach is used, the PEFCR shall state the minimum consumption (reference) to be used when calculating the additional consumption allocated to the product.]

For the use stage the consumption grid mix shall be used. The electricity mix shall reflect the ratios of sales between EU countries/ regions. To determine the ratio a physical unit shall be used (e.g. number of pieces or kg of product [to be chosen by the TS]). *Where such data are not available, the average EU consumption mix (EU-28 +EFTA), or region-representative consumption mix, shall be used.*

The waste of products during the use stage shall be included in the modelling. [Default loss rates per type of product and how these shall be included in the reference flow shall be described. The PEFCR shall follow the PEF method's Annex F in case no PEFCR-specific information is available.]

B.6.6. End of life [to be included if applicable]

The end of life stage begins when the product in scope and its packaging is discarded by the user and ends when the product is returned to nature as a waste product or enters another product's life cycle (i.e. as a recycled input). In general, it includes the waste of the product in scope, such as the food waste, and primary packaging.

Other waste (different from the product in scope) generated during the manufacturing, distribution, retail, use stage or after use shall be included in the life cycle of the product and modelled at the life cycle stage where it occurs.

[The PEFCR shall list all technical requirements and assumptions that the user of the PEFCR shall apply. Furthermore, it shall list all processes taking place in this life cycle stage (according to the model of the RP) according to the table provided below. The table may be adapted by the TS as appropriate (e.g. by including relevant parameters of the Circular Footprint Formula). Please note that the transport from collection place to EoL treatment may be included in the landfill, incineration and recycling datasets: the TS shall check if it is included in the default datasets provided. However, there might be some cases, where additional default transport data is needed and thus shall be included here. The PEF method provides default values to be used in case no better data is available.]

Table B. 20. End of life (capitals indicate those processes expected to be run by the company)

Name of the process*	*Unit of measurement (output)*	*Default amount per FU*	*Default dataset to be used*	*Dataset source*	*UUID*	*Default DQR*				*Most relevant process [Y/N]*
						P	*TiR*	*Ter*	*GeR*	

[Please write in CAPITAL LETTERS the name of those processes expected to be run by the company.]

The user of the PEFCR shall report the DQR values (for each criterion + total) for all the datasets used.

The end of life shall be modelled using the Circular Footprint Formula and rules provided in chapter 'End of life modelling' of this PEFCR and in the PEF method, together with the default parameters listed in the table [Table number].

Before selecting the appropriate R_2 value, the user of the PEFCR shall carry out an evaluation for recyclability of the material. The PEF study shall include a statement on the recyclability of the materials/ products. The statement on recyclability shall be provided together with an evaluation for recyclability that includes evidence for the following three criteria (as described by ISO 14021:1999, section 7.7.4 'Evaluation methodology'):

1. *The collection, sorting and delivery systems to transfer the materials from the source to the recycling facility are conveniently available to a reasonable proportion of the purchasers, potential purchasers and users of the product;*

2. *The recycling facilities are available to accommodate the collected materials;*

3. *Evidence is available that the product for which recyclability is claimed is being collected and recycled.*

Point 1 and 3 can be proven by recycling statistics (country specific) derived from industry associations or national bodies. Approximation to evidence at point 3 can be provided by

applying for example the design for recyclability evaluation outlined in EN 13430 Material recycling (Annexes A and B) or other sector-specific recyclability guidelines if available[117].

Following the evaluation for recyclability, the appropriate R_2 values (supply-chain specific or default) shall be used. If one criterion is not fulfilled or the sector-specific recyclability guidelines indicate limited recyclability, an R_2 value of 0% shall be applied.

Company-specific R_2 values (measured at the output of the recycling plant) shall be used, if available. If no company-specific values are available and the criteria for the evaluation of recyclability are fulfilled (see below), application-specific R_2 values shall be used as listed in the table below.

- *If an R_2 value is not available for a specific country, the European average shall be used.*
- *If an R_2 value is not available for a specific application, the R_2 values of the material shall be used (e.g. materials average).*
- *In case no R_2 values are available, R_2 shall be set equal to 0 or new statistics may be generated in order to assign an R_2 value in the specific situation.*

The applied R_2 values shall be subject to the PEF study verification.

[The PEFCR shall list in a table all the parameters to be used by the user to implement the CFF, distinguishing between those that have a fixed value (to be provided in the same Table; from the PEF method or PEFCR-specific) and those that are PEF study-specific (e.g. R_2, etc.). Furthermore, the PEFCR shall include additional modelling rules derived from the PEF method, if applicable. Within this table, the B value shall be equal to 0 as default.]

[PEFCRs that include reusable packaging shall include the following: *"The reuse rate determines the quantity of packaging material (per product sold) to be treated at the end of life. The amount of packaging treated at the end of life shall be calculated by dividing the actual weight of the packaging by the number of times this packaging was reused."*]

B.7. PEF RESULTS

B.7.1. Benchmark values

[Here the TS shall report the results of the benchmark for each representative product. The results shall be provided characterised, normalised, and weighted (as absolute values), each in a different table, according to the template provided below. Results shall also be provided as a single overall score, based on the weighting factors provided in Section 5.2.2 of the PEF method.]

Table B. 21. Characterised benchmark values for [introduce name of the representative product]

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[117] E.g. the EPBP design guidelines (http://www.epbp.org/design-methodlines), or Recyclability by design (http://www.recoup.org/)

Impact category	Unit	Life cycle excl. use stage	Total life cycle
Climate change, total	kg CO_2 eq		
Climate change - fossil			
Climate change - biogenic			
Climate change – land use and land use change			
Ozone depletion	kg CFC-11 eq		
Particulate matter	disease incidence		
Ionising radiation, human health	kBq U^{235} eq		
Photochemical ozone formation, human health	kg NMVOC eq		
Acidification	mol H+ eq		
Eutrophication, terrestrial	mol N eq		
Eutrophication, freshwater	kg P eq		
Eutrophication, marine	kg N eq		
Human toxicity, cancer	CTUh		
Human toxicity, non-cancer	CTUh		
Ecotoxicity	CTUe		
Land use	Dimensionless (pt)		
Water use	m^3 world eq		
Resource use, minerals and metals	kg Sb eq		
Resource use, fossils	MJ		

Table B. 22. Normalised benchmark values for **[introduce name of the representative product]**

Impact category	Life cycle excl. use stage	Total life cycle
Climate change (total)		
Climate change - fossil		
Climate change - biogenic		
Climate change – land use and land use change		

Impact category	Life cycle excl. use stage	Total life cycle
Ozone depletion		
Particulate matter		
Ionising radiation, human health		
Photochemical ozone formation, human health		
Acidification		
Eutrophication, terrestrial		
Eutrophication, freshwater		
Eutrophication, marine		
Human toxicity, cancer		
Human toxicity, non-cancer		
Ecotoxicity		
Land use		
Water use		
Resource use, minerals and metals		
Resource use, fossils		

Table B. 23 Weighted benchmark values for [introduce name of the representative product]

Impact category	Life cycle excl. use stage	Total life cycle
Climate change (total)		
Climate change - fossil		
Climate change - biogenic		
Climate change – land use and land use change		
Ozone depletion		
Particulate matter		

This JRC technical report is a working document and does not modify Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations

Impact category	Life cycle excl. use stage	Total life cycle
Ionising radiation, human health		
Photochemical ozone formation, human health		
Acidification		
Eutrophication, terrestrial		
Eutrophication, freshwater		
Eutrophication, marine		
Human toxicity, cancer		
Human toxicity, non-cancer		
Ecotoxicity		
Land use		
Water use		
Resource use, minerals and metals		
Resource use, fossils		

B.7.2. PEF profile

The user of the PEFCR shall calculate the PEF profile of its product in compliance with all requirements included in this PEFCR. The following information shall be included in the PEF report:

- *full life cycle inventory;*
- *characterised results in absolute values, for all impact categories (as a table);*
- *normalised results in absolute values, for all impact categories (as a table);*
- *weighted result in absolute values, for all impact categories (as a table);*
- *the aggregated single overall score in absolute values.*

Together with the PEF report, the user of the PEFCR shall develop an aggregated EF compliant dataset of its product in scope. This dataset shall be made available to the European Commission. The disaggregated version may remain confidential.

B.7.3. Classes of performance

[The identification of classes of performance is not obligatory. Each TS is free to define a method to identify the classes of performance, in case they deem it appropriate and relevant. In case classes of performance are identified, they shall be described and provided in this section. Please refer to 0 for further guidance.]

B.8. VERIFICATION

The verification of an EF study/ report carried out in compliance with this PEFCR shall be done according to all the general requirements included in Section 8 of the PEF method, including Annex A and the requirements listed below.

The verifier(s) shall verify that the PEF study is conducted in compliance with this PEFCR.

In case policies implementing the PEF method define specific requirements regarding verification and validation of PEF studies, reports and communication vehicles, the requirements in said policies shall prevail.

The verifier(s) shall validate the accuracy and reliability of the quantitative information used in the calculation of the study. As this can be highly resource intensive, the following requirements shall be followed:

- *The verifier shall check if the correct version of all impact assessment methods was used. For each of the most relevant impact categories, at least 50% of the characterisation factors (for each of the most relevant EF impact categories) shall be verified, while all normalisation and weighting factors of all impact categories shall be verified. In particular, the verifier shall check that the characterisation factors correspond to those included in the EF impact assessment method the study declares compliance with[118];*
- *The cut-off applied (if any) fulfils the requirements of this PEFCR and the PEF method;*
- *All the newly created datasets shall be checked on their EF compliance (for the meaning of EF compliant datasets refer http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml). All their underlying data (elementary flows, activity data and sub processes) shall be validated;*
- *The aggregated EF compliant dataset of the product in scope (meaning, the EF study) is made available to the European Commission.*
- *For at least 70% of the most relevant processes (by number) in situation 2 option 2 of the DNM, 70% of the underlying data shall be validated. The 70% of data shall include all energy and transport sub-processes for processes in situation 2 option 2;*
- *For at least 60% of the most relevant processes (by number) in situation 3 of the DNM, 60% of the underlying data shall be validated;*
- *For at least 50% of the other processes (by number) in situation 1, 2 and 3 of the DNM, 50% of the underlying data shall be validated.*

In particular, verifier(s) shall verify if the DQR of the process satisfies the minimum DQR as specified in the DNM for the selected processes.

These data checks shall include, but should not be limited to, the activity data used, the selection of secondary sub-processes, the selection of the direct elementary flows and the CFF parameters. For example, if there are 5 processes and each one of them includes 5 activity data, 5 secondary datasets and 10 CFF parameters, then the verifier(s) has to check at least 4 out of 5 processes (70%) and, for each process, (s)he shall check at least 4 activity data (70% of the total amount of activity data), 4 secondary datasets (70% of the total amount of secondary datasets), and 7 CFF parameters (70% of the total amount of CFF parameters), i.e. the 70% of each of data that could be subject to a check.

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[118]   Available at: http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml

The verification of the PEF report shall be carried out by randomly checking enough information to provide reasonable assurance that the PEF report fulfils all the conditions listed in section 8 of the PEF method, including Annex A.

[The PEFCR may specify additional requirements for the verification that should be added to the minimum requirements stated in this document].

References

[List the references used in the PEFCR.]

Annexes

ANNEX B1 – List of EF normalisation and weighting factors

Global normalisation factors are applied within the EF. The normalisation factors as the global impact per person are used in the EF calculations.

[The TS shall provide the list of normalisation and weighting factors that the user of the PEFCR shall apply. Normalisation and weighting factors are available at: http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml]

ANNEX B2 – PEF study template

[The PEFCR shall provide as an annex a checklist listing all the items that shall be included in PEF studies, using the PEF study template available as Annex E of the PEF method. The items already included are mandatory for every PEFCR. In addition, each TS may decide to add additional points to the template.]

ANNEX B3 – Review reports of the PEFCR and PEF-RP(s)

[Insert here the critical review panel reports of the PEFCR and PEF-RP(s), including all findings of the review process and the actions taken from TS to answer the comments of the reviewers.]

ANNEX B4 – Other annexes

[The TS may decide to add other Annexes that are considered important].

ANNEX C LIST OF DEFAULT CFF PARAMETERS

Annex C is available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

The list of values in Annex C is periodically reviewed and updated by the European Commission; users of the PEF method are invited to check and use the most updated values provided in the Annex.

ANNEX D DEFAULT DATA FOR MODELLING THE USE STAGE

The following tables shall be used in PEF studies and when developing PEFCRs unless better data is available. The data provided is based on assumptions, except if specified otherwise.

Product	Use stage assumptions per product category
Meat, fish, eggs	*Chilled storage. Cooking: 10 minutes in frying pan (75% on gas and 25% electricity), 5 gram sunflower oil (incl. its life cycle) per kg product. Dishwashing of frying pan.*
Milk	*Chilled storage, drunk cold in 200 ml glass (i.e., 5 glasses per L milk), incl. glass life cycle and dishwashing.*
Pasta	*Per kg pasta cooked in pot with 10 kg water, 10 min boiling (75% on gas and 25% electricity). Boiling phase: 0.18 kWh per kg of water, Cooking phase: 0.05 kWh per minute of cooking.*
Frozen dishes	*Frozen storage. Cooked in oven 15 minutes at 200°C (incl. a fraction of a stove, a fraction of a baking sheet). Baking sheet rinsing: 5 L water.*
Roast and ground coffee	*7 g roast and ground coffee per cup* *Filter coffee preparation in a filter coffee machine: machine production and end-of-life (1.2 kg, 4380 uses, with 2 cups/use), paper filter (2 g/use), electricity consumption (33 Wh/cup) and water consumption (120 ml/cup).* *Machine rinsing/washing: 1 L cold water per use, 2 L hot water per 7 uses, decanter dishwashing (every 7 uses)* *Cup (mug) production and end-of-life and dishwashing* *Source: based on PEFCR Coffee (draft as of Feb 1, 2015[119])*
Beer	*Cooling, drunk in 33 cl glass (i.e., 3 glasses per L beer), glass production, end-of-life and dishwashing. See also PEFCR of beer[120].*
Bottled water	*Chilled storage. Storage duration: 1 day. 2.7 glasses per L water drunk, 260 gram glass production, end-of-life and dishwashing.*
Pet food	*Pet food dish production, end-of-life and dishwashing*
Goldfish	*Electricity and water use and treatment for the aquarium (43 kWh and 468 L per year). Goldfish feed production (1 g/day, assumed 50% fish meal, 50% soybean meal). Lifetime of the goldfish assumed to be 7.5 years.*
T-shirt	*Washing machine, tumble dryer use and ironing. 52 washing at 41 degree, 5.2 tumble drying (10%) and 30 times ironing per T-shirt.* *Washing machine: 70 kg, 50% steel, 35% plastic, 5% glass, 5% aluminium, 4% copper, 1% electronics, 1560 cycles (=loads) within its*

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[119] https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/PEFCR+Pilot%3A+Coffee
[120] http://ec.europa.eu/environment/eussd/smgp/pdf/Beer%20PEFCR%20June%202018%20final.pdf

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Product	Use stage assumptions per product category
	lifetime. 179 kWh and 8700 L water for 220 cycles at 8 kg load (based on http://www.bosch-home.com/ch/fr/produits/laver-et-s%C3%A9cher/lave-linge/WAQ28320FF.html?source=browse) being 0.81 kWh and 39.5 L/cycle, as well as 70 ml laundry detergent/cycle. Tumble dryer: 56 kg, same composition share and lifetime as for washing machine assumed. 2.07 kWh/cycle for 8 kg clothes load.
Paint	Paint brush production, sand paper, ... (see PEFCR of decorative paints[121]).
Cell phone	2 kWh/year for the charge, 2 years lifetime.
Laundry detergent	Use of a washing machine (see T-shirt data for washing machine model). 70 ml laundry detergent assumed per cycle, i.e., 14 cycles per kg detergent.
Automotive oil	10% losses during use assessed as hydrocarbons emissions to water.

Default assumptions for storage (always based on assumptions, except if specified otherwise).

Product	Assumptions common to several product categories
Ambient storage (at home)	Ambient storage at home is considered, for the sake of simplification, as having no impact.
Chilled storage (in a fridge, at home)	Storage time: product dependent. As default 7 days storage in fridge (ANIA and ADEME 2012[122]). Storage volume: assumed to be 3x the actual product volume Energy consumption: 0.0037 kWh/L (i.e., "the storage volume") - day (ANIA and ADEME 2012). Fridge production and end-of-life considered (assuming 15 years of lifetime).
Chilled storage (at the pub/restaurant)	The fridge at the pub is assumed to consume 1400 kWh/ yr (Heineken green cooling expert, 2015). 100% of this energy consumption is assumed to be for the cooling of beer. The throughput of the fridge is assumed to be 40hl/ yr. This means 0.035 kWh/ l for pub / supermarket cooling for the full storage time. Fridge production and end-of-life considered (assuming 15 years of lifetime).

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[121] http://ec.europa.eu/environment/eussd/smgp/documents/PEFCR_decorative_paints.pdf
[122] ANIA and ADEME. (2012). Projet de référentiel transversal d'évaluation de l'impact environnemental des produits alimentaires (mainly annexe 4) (« GT1 »), 23/04/12.

Product	Assumptions common to several product categories
Frozen storage (in a freezer, at home)	*Storage time: 30 days in freezer (based on ANIA and ADEME 2012).* *Storage volume: assumed to be 2x the actual product volume.* *Energy consumption: 0.0049 kWh/L (i.e., "the storage volume") - day (ANIA and ADEME 2012).* *Freezer production and end-of-life considered (assuming 15 years of lifetime): assumed similar to fridge.*
Cooking (at home)	*Cooking: 1 kWh/h use (derived from consumptions for induction stove (0.588 kWh/h), ceramic stove (0.999 kWh/h) and electric stove (1.161 kWh/h) all from (ANIA and ADEME 2012).* *Backing in oven: electricity considered: 1.23 kWh/h (ANIA and ADEME 2012).*
Dishwashing (at home)	*Dishwasher use: 15 L water, 10 g soap and 1.2 kWh per washing cycle (Kaenzig and Jolliet 2006).* *Dishwasher production and end-of-life considered (assuming 1500 cycle per lifetime).* *When dishwashing is done by hand, one assumes an equivalent of 0.5 L of water and 1 g of soap for the value above of 2.5% (with a scaling in terms of water use and soap, using the % above). The water is assumed to be warmed by natural gas, considering a delta T of 40 °C and an efficiency of energy from natural gas heating to water heat of 1/1.25 (meaning that to heat the 0.5 L of water one needs to use 1.25 * 0.5 * 4186 * 40 = 0.1 MJ of "Heat, natural gas, at boiler").*

ANNEX E PEF REPORT TEMPLATE

This Annex presents the PEF report template that shall be applied for all types of PEF studies (e.g., including PEF-RPs or supporting studies of PEFCRs). The template presents the mandatory report structure to be followed and the information to be reported as a non-exhaustive list. All items required to be reported by the PEF method shall be included, even if they are not explicitly mentioned in this template.

Product Environmental Footprint Report

[Insert product name here]

Table of contents

Acronyms

[List in this section all the acronyms used in the PEF study. Those already included in the latest version of the PEF method shall be copied in their original form. The acronyms shall be provided in alphabetical order.]

Definitions

[List in this section all the definitions that are relevant for the PEF study. Those already included in the latest version of the PEF method shall be copied in their original form. The definitions shall be provided in alphabetical order.]

E.1 SUMMARY

[The summary shall include as a minimum the following elements:

- The goal and scope of the study, including relevant limitations and assumptions;
- A short description of the system boundary;
- Relevant statements about data quality,
- The main results of the LCIA: these shall be presented showing the results of all EF impact categories (characterized, normalized, weighted);
- A description of what has been achieved by the study, any recommendation made and conclusions drawn;

To the extent possible, the summary should be written with a non-technical audience in mind and should not be longer than 3-4 pages.]

E.2. GENERAL

[The information below should ideally be placed on the front-page of the study:

- Name of the product (including a photo),
- Product identification (e.g. model number),
- Product classification (CPA) based on the latest CPA list version available,
- Company presentation (name, geographic location),
- Date of publication of the PEF study (the date shall be written in extended format, e.g. 25 June 2015, to avoid confusion over the date format),
- Geographic validity of the PEF study (countries where the product is consumed/sold),
- Compliance with the PEF method,

- Conformance to other documents, additional to the PEF method,
- Name and affiliation of the verifier(s)]

E.3. GOAL OF THE STUDY

[Mandatory reporting elements include, as a minimum:

- Intended application(s);
- Methodological limitations;
- Reasons for carrying out the study;
- Target audience;
- Commissioner of the study;
- Identification of the verifier]

E.4. SCOPE OF THE STUDY

[The scope of the study shall identify the analysed system in detail and address the overall approach used to establish: i) functional unit and reference flow, ii) system boundary, iii) list of EF impact categories, iv) additional information (environmental and technical) iv) assumptions and limitations.]

E.4.1. Functional/declared unit and reference flow

[Provide the functional unit, defining the four aspects:

- The function(s)/service(s) provided: "**what**";
- The extent of the function or service: "**how much**";
- The expected level of quality: "**how well**";
- The duration/life time of the product: "**how long**";

Provide the declared unit, in case the functional unit cannot be defined (e.g. if the product in scope is an intermediate product)

Provide reference flow]

E.4.2. System boundary

[This section shall include as a minimum:

- All life-cycle stages that are part of the product system. In case the naming of the default life cycle stages has changed, the user shall specify to which default life cycle stage it corresponds. Document and justify if life cycle stages were split and/or new ones were added.
- The main processes covered in each life cycle stage (details are in the LCI section A.5). The co-products, by-products and waste streams of at least the foreground system shall be clearly identified.
- The reason for and potential significance of any exclusion.
- A system boundary diagram with the processes that are included and those excluded, highlight those activities which falls respectively under situation 1, 2, and 3 of the Data Needs Matrix, and highlight where company-specific data are used.]

E.4.3. Environmental Footprint impact categories

[Provide a table with the list of EF impact categories, units, and EF reference package used (see http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml for further details).

For climate change, specify if the results of the three sub-indicators are reported separately in the results section.]

E.4.4. Additional information

[Describe any additional environmental information and additional technical information included in the PEF study. Provide references and exact calculations rules adopted.

Explain if biodiversity is relevant/not relevant for the product in scope.

When the product in scope is an intermediate product, additional technical information shall include:

(a) The biogenic carbon content at factory gate (physical content and allocated content).
(b) Recycled content (R_1).
(c) Results with application-specific A-values of the Circular Footprint Formula, if relevant.]

E.4.5. Assumptions and limitations

[Describe all limitations and assumptions. Provide list of data gaps, if any, and the way in which these gaps were filled. Provide list of proxy datasets used.]

E.5. LIFE CYCLE INVENTORY ANALYSIS

[This section shall describe the compilation of the Life Cycle Inventory (LCI) and include:

- Screening step, if performed,
- List and description of life cycle stages,
- Description of modelling choices,
- Description of allocation approaches applied,
- Description and documentation of data used and sources,
- Data quality requirements and rating]

E.5.1. Screening step [if applicable]

[Provide a description of the screening step, including relevant information regarding data collection, data used (e.g. list of secondary data sets, activity data, direct elementary flows), cut-off, and results of the life cycle impact assessment phase.

Document main findings and any refinement of the initial scope settings (if any).]

E.5.2. Modelling choices

[Describe all modelling choices for the applicable aspects listed below (more can be added, when relevant):

- Agricultural production (PEF studies which have agricultural modelling in scope and have tested the alternative approach described in section 4.4.1.5 and Table 4 of the PEF method, shall report the results in an Annex of the PEF report);
- Transport and logistics: all data used shall be provided in the report (e.g. transportation distance, payload, re-use rate for packaging, etc.). If default scenarios were not used in the modelling, provide documentation of all specific data used;
- Capital goods: if capital goods are included, the PEF report shall include a clear and extensive explanation, reporting all assumptions made;
- Storage and retail;
- Use stage: Product dependent processes shall be included in the system boundary of the PEF study. Product independent processes shall be excluded from the system boundary and qualitative information may be provided, see section 4.4.7 of the PEF method. Describe the approach taken to model the use stage (main function approach or delta approach);
- End of life modelling, including values of parameters of the Circular Footprint Formula (A, B, R_1, R_2, Q_s/Q_p, R_3, LHV, $X_{ER,heat}$, $X_{ER,elec}$), list of processes and datasets used (E_v, E_{rec}, E_{recEoL}, E^*_v, E_d, E_{Er}, $E_{SE,heat}$, $E_{SE,elec}$) with referenct to Annex C of the PEF method;
- Extended product lifetime;
- Electricity use;
- Sampling procedure (report if a sampling procedure was applied and indicate the approach taken);
- Greenhouse gas emissions and removals (report if a simplified approach was not used to model biogenic carbon flows);
- Offsets (if reported as additional environmental information).]

E.5.3. Handling multi-functional processes

[Describe the allocation rules used in the PEF study and how the modelling/calculations were made. Provide the list of all allocation factors used for each process and the detailed list of processes and datasets used, in case substitution is applied.]

E.5.4. Data collection

[This section shall include as a minimum:

- Description and documentation of all company-specific data collected:
    o list of processes covered by company-specific data indicating to which life cycle stage they belong;
    o list of resource use and emissions (i.e. direct elementary flows);
    o list of activity data used;
    o link to detailed bill of materials and/or ingredients, including substance names, units and quantities, including information on grades/ purities and other technically and/or environmentally relevant characterisation of these;
    o company-specific data collection/estimation/calculation procedures;
- List of all secondary datasets used (process name, UUID, dataset source (node on Life Cycle Data Network, data stock) and compliance with the EF reference package);
- Modelling parameters;
- Cut-off applied, if any;

- Sources of published literature;
- Validation of data, including documentation;
- If a sensitivity analysis has been conducted, this shall be reported.]

E.5.5. Data quality requirements and rating

[Provide a table listing all processes and their situation according to the Data Needs Matrix (DNM).

Provide the DQR of the PEF study.]

E.6. IMPACT ASSESSMENT RESULTS [CONFIDENTIAL, IF RELEVANT]

E.6.1. PEF results

[This section shall include as a minimum:

- Characterised results of all EF impact categories shall be calculated and reported as absolute values in the PEF report. The sub-categories 'climate change –fossil', 'climate change – biogenic' and 'climate change - land use and land use change', shall be reported separately if they show a contribution of more than 5% each to the total score of climate change);
- Normalised and weighted results as absolute values;
- Weighted results as single score;
- Results of the use stage for final products shall be reported separately.]

E.6.2. Additional information

[This section shall include:

- Results of the additional environmental information;
- Results of the additional technical information.]

E.7. INTERPRETING PEF RESULTS

[This section shall include as a minimum:

- Assessment of the robustness of the PEF study;
- List of most relevant impact categories, life cycle stages, processes and elementary flows (see tables below);
- Limitations and relationship of the EF results relative to the defined goal and scope of the PEF study,
- Conclusions, recommendations, limitations and improvement potentials)].

Item	At what level does relevance need to be identified?	Threshold
Most relevant impact categories	Normalised and weighted results	Impact categories cumulatively contributing at least **80%** of the total environmental impact
Most relevant life cycle stages	For each most relevant impact category	All life cycle stages contributing cumulatively more than **80%** to that impact category
Most relevant processes	For each most relevant impact category	All processes contributing cumulatively (along the entire life cycle) more than **80%** to that impact category, considering absolute values.
Most relevant elementary flows	For each most relevant process	All elementary flows contributing cumulatively at least to 80% to the total impact for each most relevant processes. If disaggregated data are available: for each most relevant process, all direct elementary flows contributing cumulatively at least to **80%** to that impact category (caused by the direct elementary flows only)

Example:

Most relevant impact category	[%]	Most relevant life cycle stages	[%]	Most relevant processes	[%]	Most relevant elementary flows	[%]
IC 1		End of life		Process 1		el. flow 1	
						el. flow 2	
				Process 2		el. flow 2	
		Raw material acquisition and p.p.		Process 4		el. flow 1	
IC 2		Manufacturing		Process 1		el. flow 2	
						el. flow 3	
IC 3		Manufacturing		Process 1		el. flow 2	
						el. flow 3	

E.8. VALIDATION STATEMENT

[The validation statement is mandatory and shall always be provided as public annex of the public PEF report.

The following elements and aspects shall be included in the validation statement, as a minimum:

- title of the PEF study under verification/validation, together with the exact version of the report to which the validation statement belongs;
- the commissioner of the PEF study;
- the user of the PEF method;
- the verifier(s) or, in the case of a verification team, the team members with the identification of the lead verifier;
- absence of conflicts of interest of the verifier(s) with respect to concerned products and any involvement in previous work (where relevant, PEFCR development, Technical Secretariat membership, consultancy work carried out for the user of the PEF method or of the PEFCR during the last three years);
- a description of the objective of the verification/validation;
- a statement of the result of the verification/validation;
- any limitations of the verification/validation outcomes;
- date in which the validation statement has been issued;
- signature by the verifier(s).]

ANNEX I

[The Annex serves to document supporting elements to the main report which are of a more technical nature. It could include:

- Bibliographic references;
- Detailed life cycle inventory analysis (optional if considered sensitive and communicated separately in the confidential annex, see below)
- Detailed assessment of data quality: Provide i) Data Quality Rating per process in accordance with the PEF Method and ii) Data Quality Rating for the newly created EF-compliant datasets. In case information is confidential, it shall be included in Annex II.]

ANNEX II – CONFIDENTIAL REPORT

[The Confidential annex is an optional chapter that shall contain all those data (including raw data) and information that are confidential or proprietary and cannot be made externally available.]

ANNEX III – EF COMPLIANT DATASET

[The aggregated EF-compliant dataset of the product in scope shall be made available to the European Commission.]

ANNEX F DEFAULT LOSS RATES PER TYPE OF PRODUCT

Default loss rates per type of product during distribution and at consumer (including restaurant, etc.) (assumptions if not specified otherwise). For simplification purposes, the values for restaurant are considered the same as for consumer at home.

Retail trade sector	Category	Loss rate (incl. broken products but not products returned to the manufacturer) during distribution (overall consolidated value for transportation, storage and retail place)	Loss rate at consumer (including restaurant, etc.)
Food	Fruits and vegetables	10% (FAO 2011)	19% (FAO 2011)
	Meat and meat alternatives	4% (FAO 2011)	11% (FAO 2011)
	Dairy products	0.5% (FAO 2011)	7% (FAO 2011)
	Grain products	2% (FAO 2011)	25% (FAO 2011)
	Oils and fats	1% (FAO 2011)	4% (FAO 2011)
	Prepared/processed meals (ambient)	10%	10%
	Prepared/processed meals (chilled)	5%	5%
	Prepared/processed meals (frozen)	0.6% (primary data based on Picard – oral communication from Arnaud Brulaire)	0.5% (primary data based on Picard – oral communication from Arnaud Brulaire)
	Confectionery	5%	2%
	Other foods	1%	2%
Beverages	Coffee and tea	1%	5%
	Alcoholic beverages	1%	5%
	Other beverages	1%	5%

Retail trade sector	Category	Loss rate (incl. broken products but not products returned to the manufacturer) during distribution (overall consolidated value for transportation, storage and retail place)	Loss rate at consumer (including restaurant, etc.)
Tobacco		0%	0%
Pet food		5%	5%
Live animals		0%	0%
Clothing and textile		10%	0%
Footwear and leather goods		0%	0%
Personal accessories	Personal accessories	0%	0%
Home and professional supplies	Home hardware supplies	1%	0%
	Furniture, furnishings and decor	0%	0%
	Electrical household appliances	1%	0%
	Kitchen merchandise	0%	0%
	Information and communication equipment	1%	0%
	Office machinery and supplies	1%	0%
Cultural and recreational goods	Books, newspapers and paper/paper supplies	1%	0%
	Music and videos	1%	0%
	Sporting equipment and gadgets	0%	0%

Retail trade sector	Category	Loss rate (incl. broken products but not products returned to the manufacturer) during distribution (overall consolidated value for transportation, storage and retail place)	Loss rate at consumer (including restaurant, etc.)
	Other cultural and recreational goods	1%	0%
Healthcare		5%	5%
Cleaning/hygiene products, cosmetics and toiletries		5%	5%
Fuels, gases, lubricants and oils		1%	0%
Batteries and power		0%	0%
Plants and garden supplies	Flowers, plants and seeds	10%	0%
	Other garden supplies	1%	0%
Other goods		0%	0%
Gas station	Gas station products	1%	0%

Food losses at the distribution center, during transport and at retail place, and at home: assumed to be 50% trashed (i.e., incinerated and landfilled), 25% composted and 25% methanised.

Product losses (excluding food losses) and packing/repacking/unpacking at distribution center, during transport and at retail place: assumed to be 100% recycled.

Other waste generated at the distribution center, during transport and at the retailer (except food and product losses) such as repacking/unpacking are assumed to follow the same EoL treatment as for home waste.

Liquid food wastes (as for instance milk) at consumer (including restaurant, etc.) are assumed to be poured in the sink and therefore treated in the wastewater treatment plant.

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