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Understanding Product Environmental Footprint and Organisation Environmental Footprint methods

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Abstract

The Product Environmental Footprint (PEF) and the Organisation Environmental Footprint (OEF) are life cycle assessment (LCA) based methods to measure and communicate the potential life cycle environmental impact of products (goods or services) and organisations, respectively. Together they form the basis for the EU Environmental Footprint.

This report aims to describe the elements that characterise the environmental footprint and guide the reader in understanding the fundamentals of the methodology and the tools available for its application. Beginning with a description of the principles of the LCA, additional aspects introduced by the PEF and OEF are discussed, including the system of product environmental footprint category rules and organisation environmental footprint sector rules.

A chapter is dedicated in particular to the requirements on life cycle stages and how to characterise end-of-life through the circular footprint formula, which details how to calculate material inventories and consequently the impacts taking into account recycling, energy recovery and the fraction sent to disposal.

Another important element of the environmental footprint that strengthens its scientific robustness, transparency and transferability are the rules on the quality of primary and secondary data.

The report then deals with the stages of impact assessment, i.e. the classification of elementary flows into 16 impact categories, characterisation through which the magnitude of impacts is calculated, normalisation with respect to a reference parameter (global year per capita), weighting to arrive at a single score and, finally, interpretation.

Finally, bibliographical references on methods, information on available datasets, and some examples of reporting results are provided. A frequently asked questions section completes the report to provide the reader with further information and useful contacts.

1 Introduction

Over the last two decades, the European Commission has been driving a process of implementation of life cycle thinking in European product policies (Figure 1). In particular, the Communication COM/2003/302 on the Integrated Product Policy established the framework conditions for the continuous environmental improvement of all products throughout the production, use and disposal phases of their life cycle. With the development, in a first stage, of the International Reference Life Cycle Data System (ILCD), and thereafter of the European Environmental Footprint methods (EF), the life cycle approach has become a major lever for guiding European policies and investments towards the environmental sustainability goals that the European Union has committed itself to (e.g. COM/2019/640 on the European Green Deal).

The Product Environmental Footprint (PEF) and the Organisation Environmental Footprint (OEF) are life cycle assessment (LCA) based methods to measure and communicate the potential life cycle environmental impact of products (goods or services) and organisations, respectively. Together they form the basis for the EU Environmental Footprint.

The EF builds on existing approaches and international standards (such as ISO 14040 series and the European ILCD guidelines). The overarching purpose of PEF and OEF is to provide information that can enable the reduction of environmental impacts of goods, services, and organisations taking into account all the value chain activities (from extraction of raw materials, through production and use and to final waste management).

The technical details of the EF methods are laid down in the Commission Recommendation (EU) 2021/2279 (Annex I-II on PEF, Annex III-IV on OEF). Additional guidance documents on the EF methods have been developed during the first applications of the PEF/OEF in the pilot phase (2013-2018) and in the transition phase (2019-2022).

The European Platform on Life Cycle Assessment (EPLCA) has been launched in 2005 with the objective of promoting life cycle thinking in business and in policy making in the European Union, by focusing on underlying data and methodological needs ([1]). The Joint Research Centre ([2]) actively contributes to the maintenance and improvement of the EPLCA, providing methodological development and practical application of LCA through its research activities. The EPLCA and the JRC technical reports and scientific publications represent the scientific basis of the EF methods, which then have been applied, tested and improved with strong involvement from industry and other stakeholders.

Who should read this report?

- People who want to know more details about the Environmental Footprint and its main methodological aspects,
- People who want to have fast and direct access to the most up-to-date documents, webpages and tools for a more in-depth analysis.

([1]) COM/2003/302.
([2]) A summary of JRC publications related to the European Platform on Life Cycle Assessment (EPLCA) is available here.

Figure 1. Timeline of the main milestones in life-cycle-supported policy making in the European Commission

2 Life cycle assessment

A systemic perspective is needed to support decisions that have effects on the sustainability of policies, production systems and services, i.e. the environmental, social and economic spheres in which the concept of sustainability is articulated. This is because measures aimed at achieving one specific goal (like reducing greenhouse gases) might have negative consequences that were not considered in the first instance, whether they be different impact types (i.e. triggering unexpected environmental, social or economic mechanisms), involving different geographical areas or stages of the value chain of a product or service (i.e. the life cycle). Including all these aspects in the decision-making process to avoid so-called "burden shifting" is the great advantage that the application of life cycle thinking brings to the development of policies, products and services in today's globalised context.

Life Cycle Assessment (LCA) ([3]) represents the practical realisation of this concept, aiming to analyse comprehensively potential environmental implications of a decision-making process. LCA forms the scientific and methodological foundation of the PEF and OEF methods.

LCA as it is now brings into play very specific features ([4]):

— Life cycle focus: all stages of the life cycle of products and services are considered, from raw materials extraction, to processing and manufacturing, distribution, use, and end of life (Figure 2).

— Multi-criteria analysis: multiple environmental impact categories are included in the analysis.

— Quantitative methodology: indicators are quantitative and based on mathematical models describing the cause-effect relationships deriving from different stressors (e.g. emissions, use of natural resources).

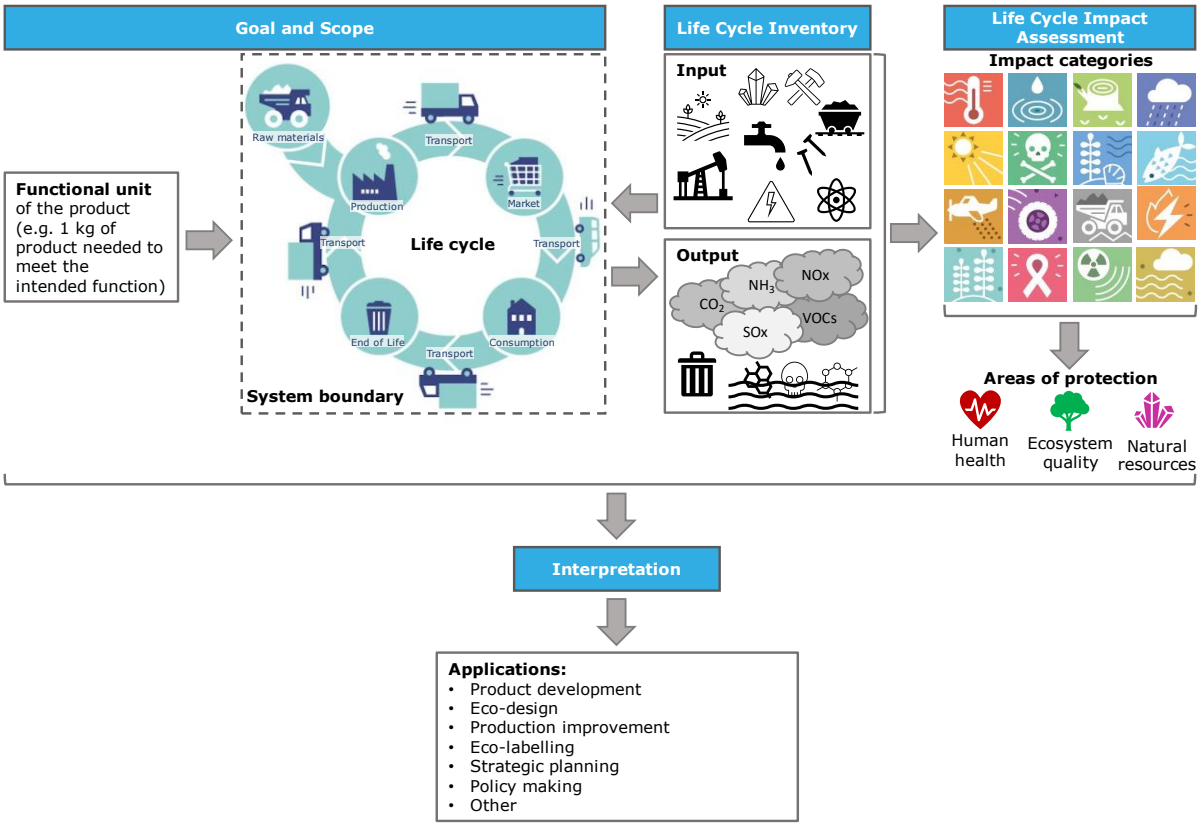
— Comparative approach: LCA is primarily designed to allow the choice of the best option among two or more scenarios, given especially its quantitative nature.

— Global extension: the analysis can adapt to systems extended from the local to the global scale, capturing their peculiarities in relation to spatial variability.

([3]) According to ISO 14040, LCA is a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. LCA is one of several environmental management techniques (e.g. risk assessment, environmental performance evaluation, environmental auditing, and environmental impact assessment) and might not be the most appropriate technique to use in all situations. LCA typically does not address the economic or social aspects of a product, but the life cycle approach and methodologies described in this International Standard can be applied to these other aspects.

([4]) The first life cycle-oriented approaches developed between the 1960s and the 1970s were focused mainly on accounting resource use and energy. The methodology has progressively evolved to analyse complex inventories of flows associated to product systems (i.e. resources, energy, materials, emissions and waste), and to associate to these physical flows potential environmental impact indicators.

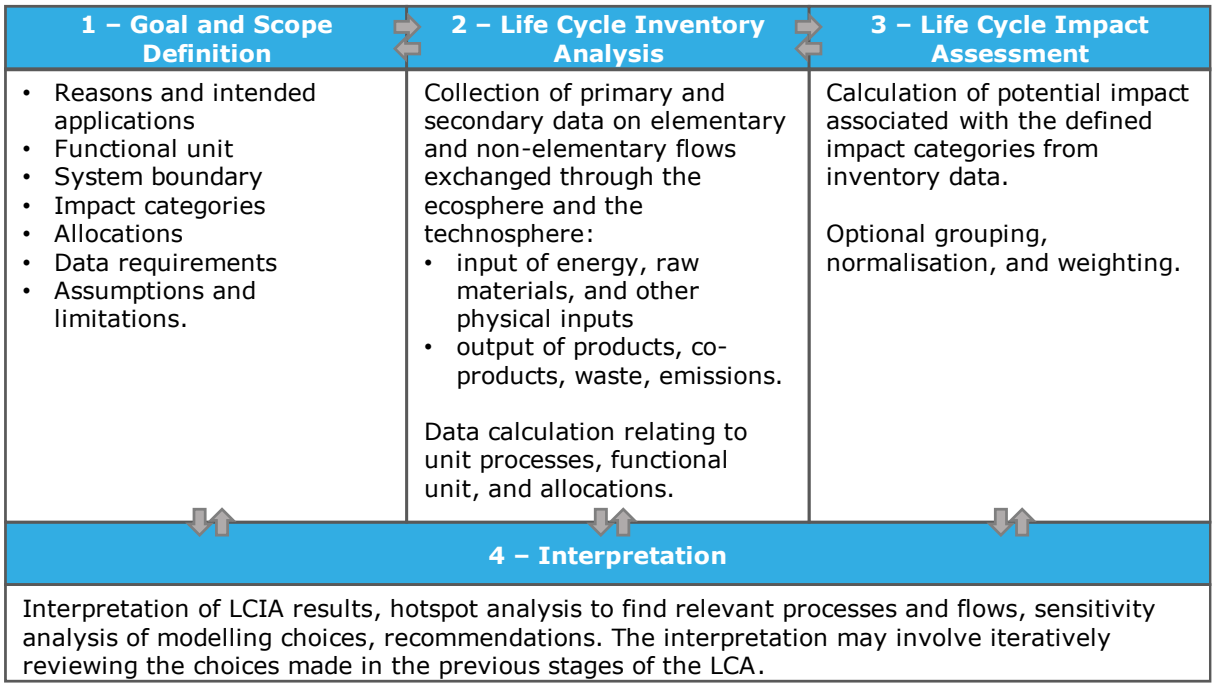
Figure 2. Generic workflow and applications of an LCA. The steps are detailed in Figure 3



The LCA methodology is standardised by ISO 14040 ([5]) and ISO 14044 ([6]) which describe principles, application, phases of an LCA study (Figure 2 and Figure 3), requirements, critical review, and reporting. Other ISO standards of the 14040 series complement the general guidelines such as ISO 14046 ([7]) for water footprint, and more environmental management standards are linked to ISO 14040-44 like ISO 14006 ([8]) (eco-design), ISO 14025 ([9]) (environmental labelling), ISO 14064 ([10]) (carbon footprint of organisations), ISO 14067 ([11]) (carbon footprint of products), ISO 14072 ([12]) (organizational LCA).

([5]) ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework.
([6]) ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines.
([7]) ISO 14046:2014 Environmental management — Water footprint — Principles, requirements and guidelines.
([8]) ISO 14006:2020 Environmental management systems — Guidelines for incorporating ecodesign.
([9]) 14025:2006 Environmental labels and declarations — Type III environmental declarations — Principles and procedures.
([10]) ISO 14064-1:2018 Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.
([11]) ISO 14067:2018 Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification.
([12]) ISO 14072:2014 Environmental management — Life cycle assessment — Requirements and guidelines for organizational life cycle assessment.

Figure 3. Standardised steps of LCA according to ISO 14040-44. Two-way arrows suggest the iterative nature of an LCA. For the technical terms please refer to the section "Nomenclature and Definitions"



An important effort towards the harmonisation of LCA has been made by the European Commission Joint Research Centre with the development of the European International Life Cycle Data System (ILCD). The aim of the ILCD was to provide in depth guidelines for the application of LCA to the European context, both from a procedural and a scientific point of view, defining specific rules for the many options left open by the ISO ([13]), in order to enhance scientific robustness, consistency, reproducibility, and comparability of LCA studies. Based on this background, the European Commission adopted in 2013 the first Recommendation on the Product and Organisation Environmental Footprint ([14]) capitalizing on the methodological foundations of the ILCD, and advancing on scientific development to measure and communicate the life cycle environmental performance of products and organisations, in support to the European market and policymaking. This Recommendation was then amended by Commission Recommendation (EU) 2021/2279.

The necessary limitations to be taken into account in LCA are several. The large amount of data needed to cover all material and energy flows related to the studied systems brings with it a certain degree of uncertainty, especially regarding the life cycle stages farthest up or down in the supply chain. In addition, when performing LCA studies it is often necessary to make assumptions about processes for which data are not available or to use average data in terms of spatial and temporal resolution (e.g. national, annual), due to the fact that very complex and often globalised value chains are analysed. Notwithstanding, in order to ensure the reliability of results despite the many assumptions taken, the standards regulating LCA define some rules to address these issues.

([13]) M. Wolf, R. Pant, K. Chomkhamsri, S. Sala, D. Pennington (2012): International Reference Life Cycle Data System (ILCD) Handbook – Towards more sustainable production and consumption for a resource-efficient Europe. JRC Reference Report, EUR 24982 EN. European Commission – Joint Research Centre. Luxembourg. Publications Office of the European Union; 2012.

([14]) 2013/179/EU: Commission Recommendation of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations.

3 Key aspects of the product and organisation environmental footprint methods

The PEF and the OEF are designed to measure and communicate the life cycle environmental performance of products and organisations. Together, the PEF and OEF, constitute the EF methods, grounded on the LCA standard methodology. A calculation based on the general PEF/OEF methods gives quantitative information on the impacts of the product or organisation, taking into consideration the entire value chain (from the extraction/growing of resources to the end of life stage), i.e. following a life cycle approach.

Following the framework standardised by ISO 14040-44, the EF is structured in similar steps, yet providing further specifications necessary to achieve a higher degree of robustness, consistency, reproducibility, and comparability (see Figure 4 for a simplified overview).

Figure 4. Steps of the EF method. The main additions to ISO 14040-44 are shown in the white boxes and will be detailed further in this document

1 – Environmental Footprint Goal and Scope Definition	2 – Environmental Footprint Inventory Analysis	3 – Environmental Footprint Impact Assessment
Functional unit shall be defined according to "what", "how much", "how long", "how well". In the system boundary cut-off shall be avoided unless following specific rules. A default set of 16 impact categories shall be considered.(*)	Detailed modelling requirements and data (e.g. electricity, transport, agricultural production). Data quality requirements (semiquantitative) are provided and shall be met by specific (primary) and generic (secondary) data. Allocation for recycling shall be applied using the circular footprint formula.	The mandatory steps are: classification, characterisation, normalisation, and weighting. Results shall be calculated as characterised, normalised and weighted for each impact category: and as a single score based on the weighting factors provided.
4 – Interpretation and Reporting		
Interpretation shall include robustness assessment (completeness, sensitivity, consistency), hotspot analysis (most relevant impact categories, life cycle stages, processes, flows), and uncertainty (qualitative or quantitative using e.g. Monte Carlo simulation). Results shall be reported for the total life cycle, and the total life cycle excluding the use stage.		
5 – Verification and validation		
Minimum requirements on reviewers and review panels are defined depending on the intended application.		

(*) Climate change, particular matter, ionising radiation, photochemical ozone formation, acidification, ozone depletion, eutrophication (terrestrial, marine, freshwater), ecotoxicity (freshwater), human toxicity (cancer, non-cancer), land use, water use, resource use (minerals and metals, fossils).

A practitioner conducting an EF study shall perform all the steps illustrated in Figure 4, starting from the definition of the system boundary under study (step 1), the functional unit (FU), i.e. the reference unit defining qualitative and quantitative aspects of the function, and the reference flow, i.e. the amount of product or the output from the product system needed to provide the defined function.

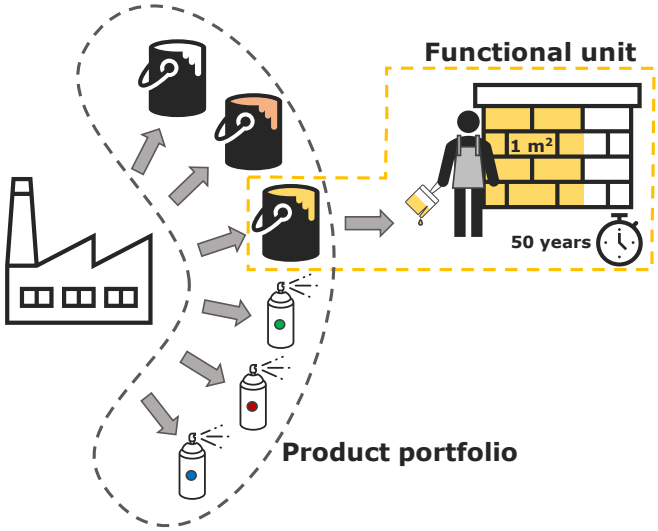
The PEF method requires to define the functional unit as:

- what: the function or service provided;
- how much: the extent of the function or service;
- how long: the duration or the lifetime;
- how well: the expected level of quality.

For example, concerning the analysis of a 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)"([15]).The reference flow is the amount of product needed to fulfil this defined function and measured in kg of paint (Figure 5).

In the case of OEF, the organisation is the reference unit for the analysis. In the most general sense, the overarching function of the organisation, for the purpose of calculating the OEF, is the provision of goods and services over a specified reporting interval (e.g. one year). The product portfolio (PP) refers to the amount and nature of goods and services provided by the organisation over the reporting interval. For example, in the case of an organisation producing decorative paints, the product portfolio could be the type and amount of paintings produced in a year, with the detail of the function that each product is able to grant. The OEF may be also limited to a clearly defined subset of the product portfolio of the organisation (Figure 5).

Figure 5. Example of a functional unit and product portfolio



The PEF and OEF methods provide guidance for the collection and modelling of inventory data (step 2), including allocation rules for recycled materials and data quality requirements (see sections "Inventory Modelling and Circularity in EF" and "Data Collection and Quality Requirements"). In step 3 all inventory flows are translated into impact indicators for each mandatory impact category (see section "Impact Assessment in the EF Methods"). Interpretation and reporting in step 4 shall include mandatory assessments as illustrated in Figure 4. Step 5, verification and validation of the EF studies by a verifier is mandatory whenever the EF study, or part of the information therein, is used for any type of external communication. Verification means the conformity assessment to check whether the EF study has been carried out in compliance with the PEF and OEF methods. Validation means the confirmation that the information and the data in the EF study and their communication are reliable, credible and correct.

An EF study following the general method shall follow the principles of relevance, completeness, consistency, accuracy, and transparency. However, EF results for a product/organisation as obtained from the general EF method are not directly comparable to results of other products/organisations. This is due to the fact that specific products and sectors can be characterised by peculiarities and uniqueness, and in the application of the EF method and of LCA in general, some methodological and data choices can be left to the user's discretion. Therefore, the EF methods foresee the development of Product Environmental Footprint Category Rules (PEFCRs) and Organisation Environmental Footprint Sector Rules (OEFSRs). The PEFCRs and OEFSRs as described in the next section, establish category and sector requirements of EF studies allowing comparability.

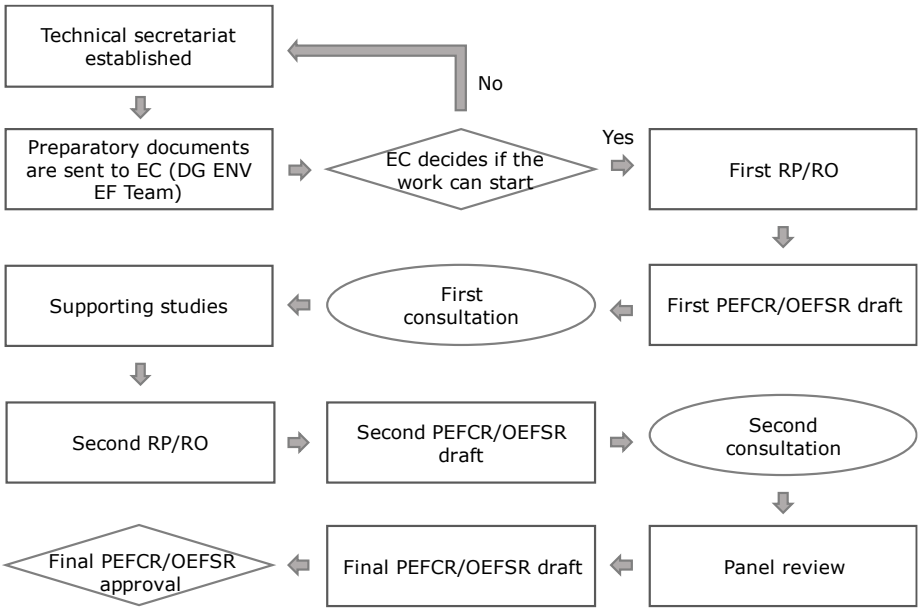
([15]) (EU) 2021/2279, Annex I, section 3.2.1

4 Product environmental footprint category rules and organisation environmental footprint sector rules

PEFCRs and OEFSRs are specific rules that complement the general PEF and OEF methods by providing further specification at the level of a specific product category or sector. These rules help to place the focus of the PEF/OEF studies on those aspects and parameters that matter the most, and hence contribute to increased relevance ([16]), reproducibility ([17]) and consistency ([18]) of the results versus a study based on the general requirements of the EF methods. The latter, although more prescriptive than LCA ISO standards 14040-44, may leave the user a minor margin of discretion in their application. It is for this reason that comparison and comparative assertion ([19]) are only allowed if an EF study is based on specific sector rules. Moreover, PEFCRs and OEFSRs reduce the effort as well and the cost of performing an EF study.

The process of developing category and sector rules is generally very articulated and implies several steps (see Figure 6). It is chaired by a Technical Secretariat representing at least 51% of the EU market in terms of turnover in the EU ([20]) and involves the main stakeholders and experts for the specific product and sector ([21]). The process to develop OEFSRs is formally equivalent to that of PEFCRs.

Figure 6. Process flow to create/revise a PEFCR or an OEFSR. RP: representative product; RO: representative organisation

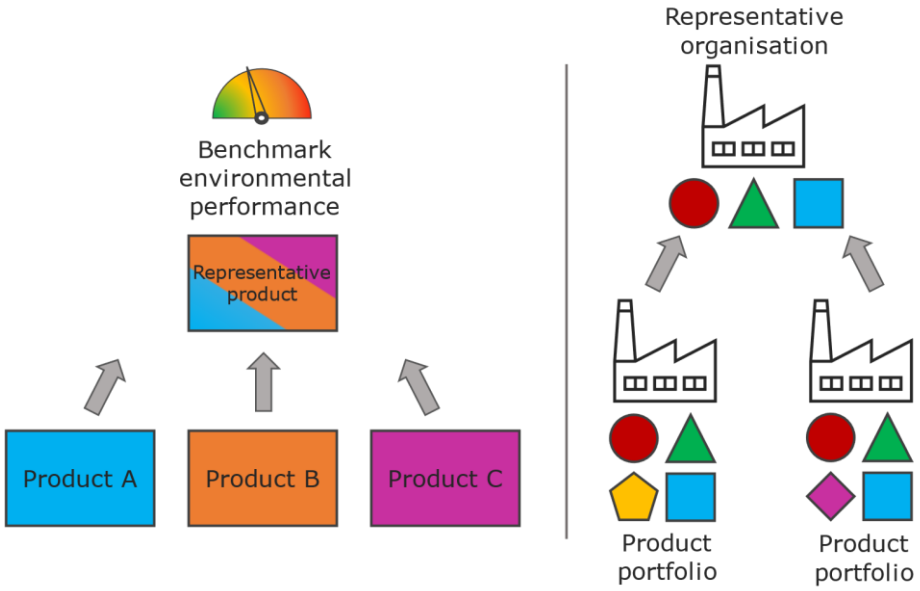


A key step of the development of the PEFCR is the definition of the Representative product (RP), i.e. the average product sold in the EU market that is representative for the considered product group. The RP may be a real or a virtual product (i.e. non-existing product calculated based on weighted average of sales in the European market and taking in consideration all the existing technologies covered by the product category) ([22]). The environmental performance of the RP represents the benchmark, to which regards the environmental

([16]) All methods used and data collected for the purpose of quantifying the PEF shall be as relevant to the study as possible.
([17]) It should be possible to reproduce the results of the PEF/OEF studies, based on the transparency of input data and assumptions.
([18]) Strict conformity to the EF method shall be observed in all steps of the PEF/OEF studies to ensure consistency across the different part of the methodology.
([19]) Comparative assertion: environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function (ISO 14040).
([20]) Should the Technical Secretariat not reach 51% of the EU market, the Commission needs to actively participate in the work of the Technical Secretariat.
([21]) The process as shown in Figure 6 is built to allow and facilitate building consensus among the different stakeholders representing the EU market and the reference sector (e.g. technology).
([22]) For instance, a real product can be chosen when produced with one single technology for 100% of the market. A virtual product can be developed attributing different production technologies to the functional unit (e.g. 1 kg of product) in proportion to their respective market share (e.g. 200 g related to technology A, 350 g to technology B, 450 g to technology C).

performance of other products is compared. Similarly to PEFCR, a Representative Organisation (RO) is set in the OEFSR ([23]), whereas a benchmark organization is not defined ([24]) (Figure 7).

Figure 7. Representative product and benchmark, and representative organization (average based on technology and market share)



Twenty-one PEFCRs/OEFSRs have been developed in the pilot phase (see section "Relevant Documents") and more are under development. The updated list is available on the European Commission web site.

([23]) The RO is a real or virtual organisation calculated based on average European market characteristics of all existing technologies, production processes, organisation types in the sector.

([24]) The OEFSRs developed so far evaluated the possibility to establish a benchmark, but it was found that this was neither possible nor meaningful at this stage. However, the development of benchmark for an OEFSR is not excluded a-priori.

5 Inventory modelling and circularity in the environmental footprint

An inventory of all input and output, elementary (resources, emissions) and non-elementary (energy, waste, materials) flows shall be compiled for all processes included in the value chain. All flows have to be modelled until the elementary flow level to calculate the associated impact on the life cycle of the product or organization in scope (e.g. from the output waste, the specific air, water and soil emissions generated by the treatment processes are determined).

The mandatory life cycle stages included in an EF study are:

- *Raw material acquisition and pre-processing*: e.g., extraction of resources, pre-processing of all materials (including recycled materials), agriculture, forestry, packaging production, and transportation associated with these activities.
- *Manufacturing:* all processes taking place from the entry to the exit gate of the production facility (e.g., chemical processing, manufacturing, assembly).
- *Distribution:* transport and storage of the finished product(s), including the refrigeration and warehouse activities consumptions (e.g., energy).
- *Use stage:* product(s) use for the defined function and lifetime, including all necessary inputs (e.g., energy, maintenance materials, coolant).
- *End of life:* all activities occurring from the moment the product(s) cease to perform its function and is disposed or recycled. This includes e.g., collection and transport, dismantling, sorting, processing into recycled material, landfill, incineration.

For certain products (i.e. intermediate), a limited number of life cycle stages shall be considered (i.e. excluding the use and end-of-life) ([25]).

One crucial aspect of an inventory analysis in LCA studies is to accurately and consistently model waste and recycled materials, and to allocate environmental burdens and credits to users and producers of such flows. The PEF and OEF methods provide an approach that has been developed through a dedicated consensus-building process for this specific purpose: the Circular Footprint Formula (CFF). All waste flows produced during the manufacturing, distribution, use, and end of life stage shall be modelled according to this formula, as well as all recycled or recyclable material entering or leaving the system (i.e. recycled material used in the manufacturing stage and recycling of material from the product's end of life). The CFF is built up on three parts, namely a material, an energy, and a disposal formula (Figure 8 and Table 1). Summing up their results, gives the overall amount of emissions and resources that belong to the system's inventory due to recycling, disposal, and energy recovery processes.

The material part of the formula applies to all stages of the value chain where recycled materials substitute virgin raw materials ([26]). The formula addresses the need of a consistent method to allocate environmental burdens (and credits) to suppliers and users of recycled material and it is based on market characteristics. The underlying rationale of the formula is that when there is low offer and high demand of recyclable material, more credits are attributed to recyclable material production (i.e. manufacturers that enable recycling of materials at the end of life benefit from lower environmental burdens). On the contrary, when there is high availability and low demand, more credits are given to recycled material users. The energy part of the formula relates to the quantity of material that is used for energy recovery at the end of life. In this case, credits are attributed to energy recovery, corresponding to the avoided emissions and resource use of the substituted energy sources. Finally, the disposal part of the formula calculates emissions and resource use related to the disposal of all materials that are not recycled or used for energy recovery.

([25]) Intermediate products are those for which all stages of the life cycle are considered from the extraction of resources through the production process to the factory gate (cradle-to-gate).

([26]) i.e. at each point of substitution, where the emissions of virgin and recycled material production are quantified and allocated to the corresponding percentage of virgin and recycled material.

Figure 8. Example on a fictive product, showing the basic elements included in the circular footprint formula

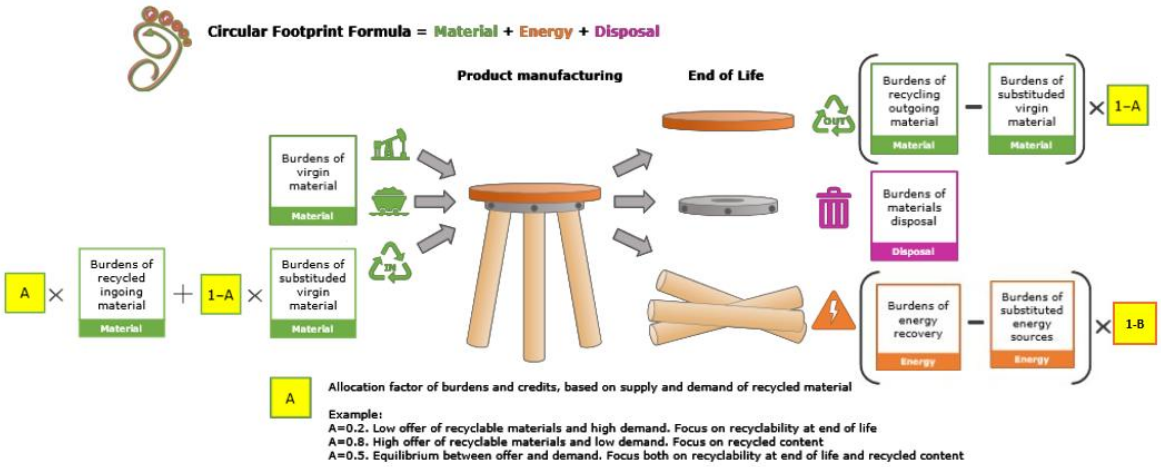


Table 1. Parameters of the Circular Footprint Formula

CFF Formula	Material	Energy	Disposal
Parameters	Proportion of recycled material entering the system (i.e. recycled content) Proportion of material that will be recycled in a subsequent system Emissions and resource use to produce virgin and recycled material Emissions and resource use for the recycling processes Quality ratio of recycled and recyclable material Quality of the substituted virgin material	Proportion of material used for energy recovery at the end of life Lower heating value Efficiency of energy recovery Emissions and resource use for energy recovery Emissions and resource use of substituted energy sources	Emissions and resource use of disposed material

Recycled content values shall be specific to the supply chain or the application. To ensure transparency in the calculation of recyclable materials and recycling output rate, recyclability shall be evaluated and declared, based on company or industry data. In addition, including a quality parameter allows capturing multiple recycling loops, including downcycling (i.e. obtaining material of lower quality than the original). Default, sector-specific values of the CFF parameters are provided in a document (the "Annex C", see section "Datasets"), ([27]) that can be used when company-specific values are not mandatory and company-specific data are not available.

([27]) https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml

6 Data collection and quality requirements

All activities run by a company carrying out a PEF or an OEF require collecting company-specific data for all known inputs and outputs of the processes involved. The data can be for instance on energy consumption, water consumption, land use, materials, emissions (air, soil, water), waste, products and co-products. The datasets created shall be EF-compliant ([28]) (see section "Datasets"). Primary data (company and site-specific) shall be collected for foreground processes (i.e. under direct control of the organisation) and, if possible, for background processes (i.e. not under direct control of the organisation). The PEF/OEF method provides a Data Needs Matrix (DNM) to evaluate the data requirements of all processes modelled in the system according to the level of influence the company has on the process (i.e. the process is run by the company, the process is not run by the company but company-specific data are available or the process is not run by the company and company-specific data are not available).

Secondary data (from e.g. sector-specific databases or literature) shall also be EF-compliant and may be used to model processes that are included in the system boundary for which primary data are not available (e.g. not run by the company). In lack of a PEFCR/OEFSR, secondary data may be used for background processes only.

Data quality rating is calculated for primary data when EF-compliant datasets are developed, and for secondary data when they are applied to an EF study. Data quality requirements are defined by the EF method (Table 2). PEFCRs and OEFSRs further specify the processes for which primary data are required and the data quality requirements of secondary data, following a materiality principle (i.e. considering their relevance within the EF profile and the effort needed in data collection). Each PEFCR and OEFSR provides also requirements on the secondary datasets to be used to carry out PEF and OEF studies.

Table 2. Data quality requirements ([1])

Minimum requirements	Data quality criteria (scored) ([2])	Documentation	Nomenclature	Review
Completeness Methodological appropriateness and consistency	Technological representativeness Geographical representativeness Time-related Representativeness Precision	Compliant with the EF specific format (see section "Datasets" of this document)	Compliant with the EF specific nomenclature (see section "Datasets" of this document)	Review by qualified reviewer Separate review report

([1]) (EU) 2021/2279, Annex I, section 4.6.5.

([2]) The "representativeness" characterises to what degree the processes and products selected are depicting the system, while the precision indicates the way the data is derived and related level of uncertainty

The four data quality criteria in Table 2 are scored from 1 to 5, corresponding to "excellent", "very good", "good", "fair", and "poor" quality level. The average value determines the overall data quality. EF-compliant datasets developed from company-specific data shall be of excellent quality (≤ 1.5), whether they relate to processes run by the company or not. Secondary data from EF-compliant datasets to be applied on processes not run by the company shall be of at least good quality (≤ 3.0).

([28]) Datasets following the required EF structure, nomenclature, and modelling rules which can be used to perform a PEF/OEF study. For further information on data please refer also to the section "Datasets" and to the following document: Fazio S., Zampori L, De Schryver A, Kusche O, Thellier L, Diaconu E. Guide for EF compliant data sets, Version 2.0 Luxembourg, 2020, ISBN 978-92-76-17951-1 (online), doi:10.2760/537292 (online).

All new datasets created when conducting a PEF or an OEF study shall be EF-compliant. If secondary datasets are used, they shall be EF-compliant. If EF-compliant datasets are not available, proxies can be used under specific circumstances ([29]).

The EF-compliant datasets are covered by a royalty-free right of use, exclusively in developing PEF and OEF studies in compliance with any of the PEFCRs and OEFSRs ([30]). Data and information on nodes (i.e. data repositories managed by different data providers in the EF data network) and accessibility are available on the EF data network web site.

([29]) (EU) 2021/2279, Annex I, section 4.6.3.
([30]) The European Commission is dealing with the cost of such royalty-free rights.

7 Impact assessment in the environmental footprint methods

The purpose of life cycle impact assessment (LCIA) is to group and aggregate the information collected from the life cycle inventory of a product (or organisation) and to assess their respective contributions to each EF impact category. EF impact categories are able to cover a broad range of relevant environmental issues following the general requirements of comprehensiveness of PEF and OEF studies. Table 3 illustrates the impact categories considered in PEF/OEF and the indicators used to assess them. Overtime, the set of models has been updated to reflect the best available practices to address each impact category. The updating has been based on the discussions and agreements achieved within the working groups of the Environmental Footprint and in the UNEP Life Cycle Initiative ([31]). An evolution of the selected LCIA models, starting from those in 2013 recommendations up to 2021, is available on the EF resources web site.

Table 3. Impact categories included in PEF/OEF and details of the methods and indicators used to assess them

Impact category		Impact category Indicator (unit of measure)	Description
	Climate change, total	Radiative forcing as global warming potential – GWP100 (kg CO_2 eq)	Increase in the average global temperature resulting from greenhouse gas emissions (GHG)
	Ozone depletion	Ozone Depletion Potential – ODP (kg CFC-11 eq)	Depletion of the stratospheric ozone layer protecting from hazardous ultraviolet radiation
	Human toxicity, cancer	Comparative Toxic Unit for humans (CTUh)	Impact on human health caused by absorbing substances through the air, water, and soil. Direct effects of products on humans are not measured
	Human toxicity, non-cancer	Comparative Toxic Unit for humans (CTUh)	
	Particulate matter	Impact on human health (disease incidence)	Impact on human health caused by particulate matter emissions and its precursors (e.g. sulfur and nitrogen oxides)
	Ionising radiation, human health	Human exposure efficiency relative to U-235 (kBq U-235 eq)	Impact of exposure to ionising radiations on human health
	Photochemical ozone formation, human health	Tropospheric ozone concentration increase (kg NMVOC eq)	Potential of harmful tropospheric ozone formation (“summer smog”) from air emissions
	Acidification	Accumulated Exceedance – AE (mol H^+ eq)	Acidification from air, water, and soil emissions (primarily sulfur compounds) mainly due to combustion processes in electricity generation, heating, and transport

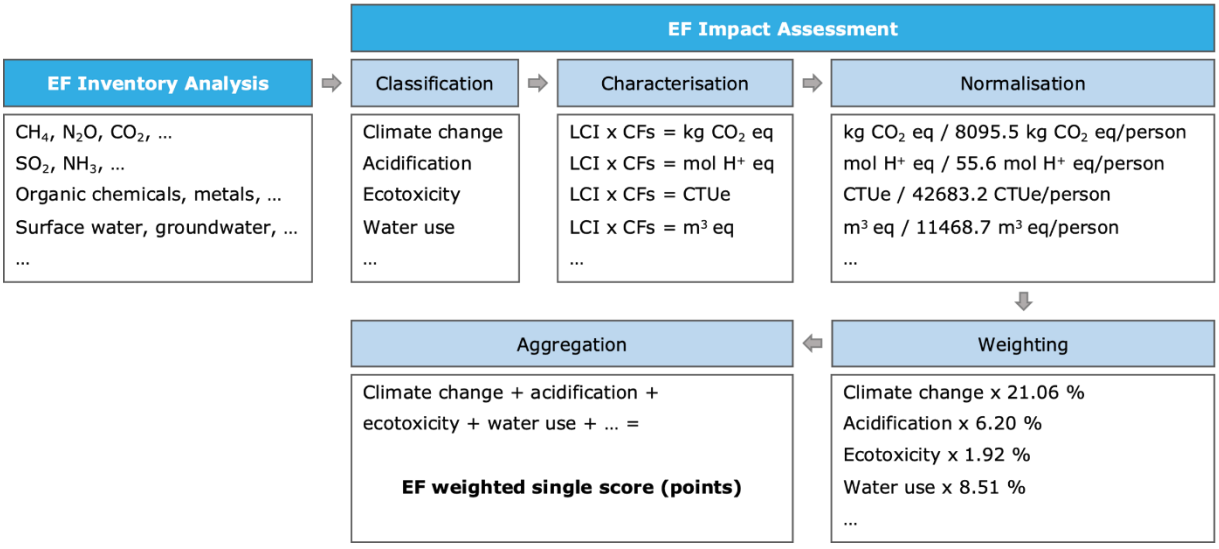
([31]) https://www.lifecycleinitiative.org. The recommendations of the UNEP Life Cycle Initiative and those in the European EF are generally aligned, but some differences may exist.

	Eutrophication, terrestrial	Accumulated Exceedance – AE (mol N eq)	Eutrophication and potential impact on ecosystems caused by nitrogen and phosphorous emissions mainly due to fertilizers, combustion, sewage systems
	Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (kg P eq)	
	Eutrophication, marine	Fraction of nutrients reaching marine end compartment (kg N eq)	
	Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTUe)	Impact of toxic substances on freshwater ecosystems
	Land use	Soil quality index, representing the aggregated impact of land use on: Biotic production; Erosion resistance; Mechanical filtration; Groundwater replenishment (Dimensionless – pt)	Transformation and use of land for agriculture, roads, housing, mining or other purposes. The impact can include loss of species, organic matter, soil, filtration capacity, permeability
	Water use	Weighted user deprivation potential (m^3 world eq)	Depletion of available water depending on local water scarcity and water needs for human activities and ecosystem integrity
	Resource use, minerals and metals	Abiotic resource depletion – ADP ultimate reserves (kg Sb eq)	Depletion of non-renewable resources and deprivation for future generations
	Resource use, fossils	Abiotic resource depletion, fossil fuels – ADP-fossil (MJ)	

Classification implies assigning all input and output flows collected in the inventory to the relevant impact categories. For example, during the classification phase, all inputs and outputs that result in greenhouse gas emissions are assigned to the climate change category (see Figure 9). In some cases, an input or output may contribute to more than one EF impact category.

Characterisation is the process to model environmental mechanisms linking the environmental pressures represented by inventory data (i.e. inputs of resources or emissions associated with the product life cycle) to each EF impact category, and to quantify the impact magnitude. Each impact category hence refers to a stand-alone characterisation model attributing characterisation factors to the relevant flows in the inventory (Figure 9). For example, the climate change impact category is captured by a global warming potential indicator (GWP), which considers the radiative forcing of different substances (e.g. carbon dioxide, methane, dinitrogen oxide, etc.) emitted to air during the life cycle stages. The impact is calculated multiplying the physical quantities associated to the flows in the inventory by the characterisation factors provided by the models.

Figure 9. Steps of the impact assessment phase. LCI: Life Cycle Inventory; CFs: characterisation factors. The numerical normalisation and weighting factors reported in the figure are available here



Two other key steps in the impact assessment are normalization and weighting. These steps are mandatory for PEF/OEF, whereas these are optional for ISO 14040 series.

The environmental impact scores of life cycle assessments are often presented in units that are difficult to grasp. Normalisation is the calculation of the magnitude of the category indicator results relatively to a reference system. The aim of normalisation is to understand better the relative contribution of the studied system to the reference system for each indicator result, and which impact categories are more critical for the product system under study. Some examples of reference values are: the per capita impacts of an average person in a given area or the absolute impacts linked to the activities taking place in the region considered (e.g. the EU or worldwide) over one year. Normalised results are dimensionless. For example, the normalised value of 0.5 for GWP of a certain product would mean that this is responsible of half of the GWP emitted by an average person per year. The updated list of normalisation factors for the PEF/OEF methods is available here. Methodological details are available here. The normalisation set used in the EF was developed considering statistical data on emissions and resources used globally over one year per capita.

Weighting is the process of converting normalised results of the different impact categories by using numerical factors based on the expressed relative importance of the impact categories considered. It may include aggregation of the weighted indicator results. A study for defining the weighting factors for the 16 EF impact categories was conducted by JRC in 2018 based on input from environmental experts and stakeholders. The results of the study are available in a JRC technical report. The updated list of weighting factors for the PEF/OEF methods is available here. Any weighting includes the use of value choices and cannot be based on natural science alone.

Interpretation of EF results follows the life cycle impact assessment stage. At this point results can be used for hotspot analysis to identify the most relevant impact categories, life cycle stages, processes, and elementary flows ([32]). EF results allow optimising environmental performances of products (e.g. ecodesign) and organisations. The single score can serve for marketing purposes and, when calculated in accordance with PEFCRs/OEFSRs, can be used for comparison and comparative assertions.

([32]) (EU) 2021/2279, Annex I, section 6.

8 Relevant documents

The PEF method is available here (Figure 10).

Figure 10. Commission Recommendation (EU) 2021/2279 of 15 December 2021

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RECOMMENDATIONS

* **Commission Recommendation (EU) 2021/2279 of 15 December 2021 on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations** 1

EN

Acts whose titles are printed in light type are those relating to day-to-day management of agricultural matters, and are generally valid for a limited period.
The titles of all other Acts are printed in bold type and preceded by an asterisk.

Existing PEFCRs are reported below (Figure 11). The whole documentation is available here.

Figure 11. Existing PEFCRs

Beer	Dairy	Household liquid laundry detergents	Decorative paints
Hot and cold water supply pipe systems	Intermediate paper product	Feed for food producing animals	IT equipment
Leather	Metal sheets	Packed water	Pasta
Pet Food	Photovoltaic electricity	Rechargeable batteries	T-shirt
Thermal insulation	Uninterrupted Power Supply	Wine	PEFCRs under development

The OEF method is available here (Figure 10).

Existing OEFSRs are reported below (Figure 12). The whole documentation is available here.

Figure 12. Existing OEFCRs

Copper production	Retail

All the other supporting documents including updates of the EF impact assessment method are available on the European Platform on LCA web site.

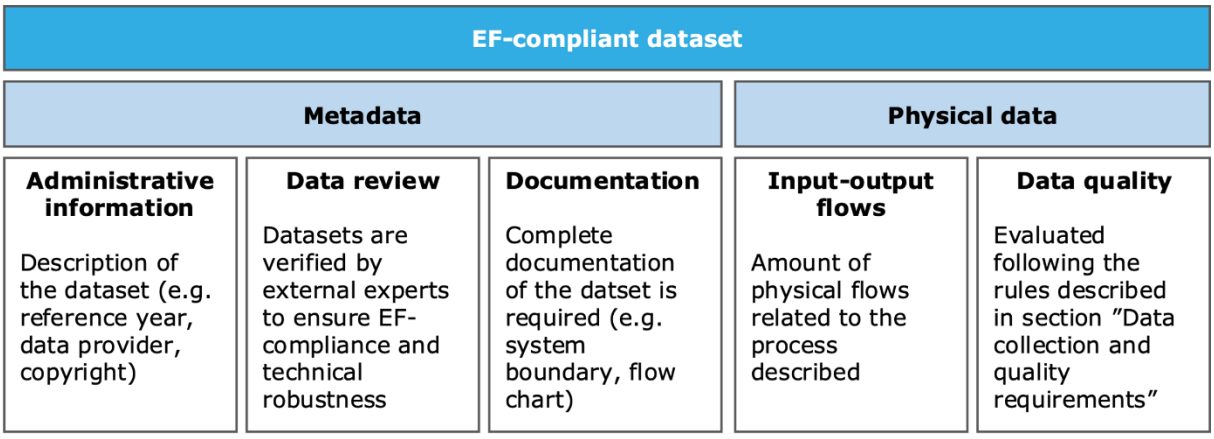
9 Datasets

— *EF-compliant datasets*

Any requirements on how to calculate a PEF or OEF would remain difficult to implement on the ground, if no data can be generated and provided that complies with the EF method requirements. Data related harmonisation has to take place to ensure data is understood and used in a consistent and correct manner.

EF-compliant datasets follow the rules described in the dedicated guidelines. Figure 13 describes the main elements of an EF-compliant dataset. It includes also metadata (i.e. additional information attached to describe the data).

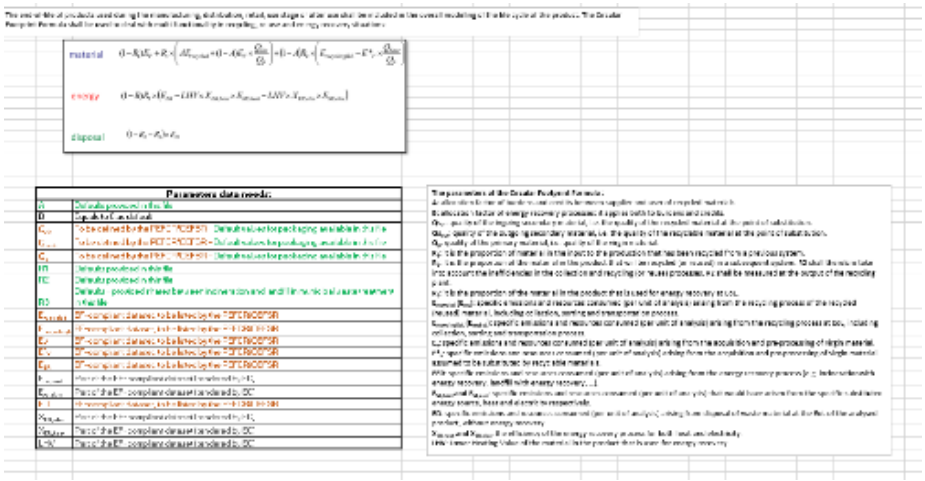
Figure 13. EF- compliant dataset



— *The Circular Footprint Formula – Annex C*

As described in the section "Inventory modelling and circularity in EF" default values for the CFF are reported in the excel file (Annex C, Figure 14) available here.

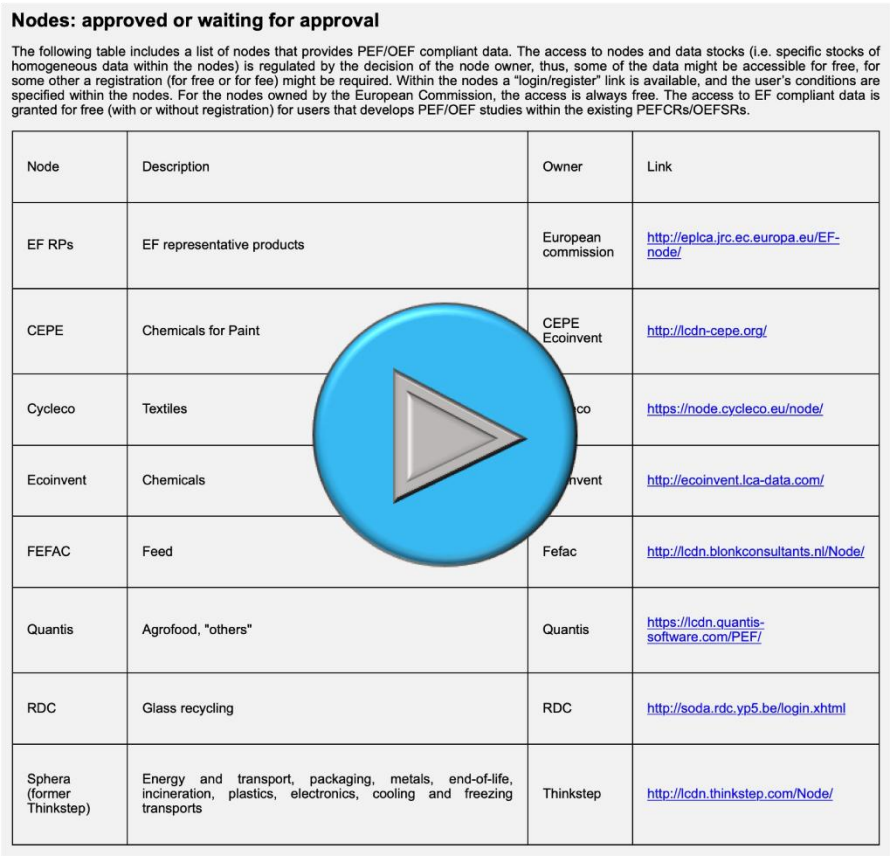
Figure 14. Example of excel file



— *Where to find EF data?*

In the EF framework, dataset repositories (Figure 15) are provided and available here.

Figure 15. How to access datasets



Nodes: approved or waiting for approval

The following table includes a list of nodes that provides PEF/OEF compliant data. The access to nodes and data stocks (i.e. specific stocks of homogeneous data within the nodes) is regulated by the decision of the node owner, thus, some of the data might be accessible for free, for some other a registration (for free or for fee) might be required. Within the nodes a "login/register" link is available, and the user's conditions are specified within the nodes. For the nodes owned by the European Commission, the access is always free. The access to EF compliant data is granted for free (with or without registration) for users that develops PEF/OEF studies within the existing PEFCRs/OEFSRs.

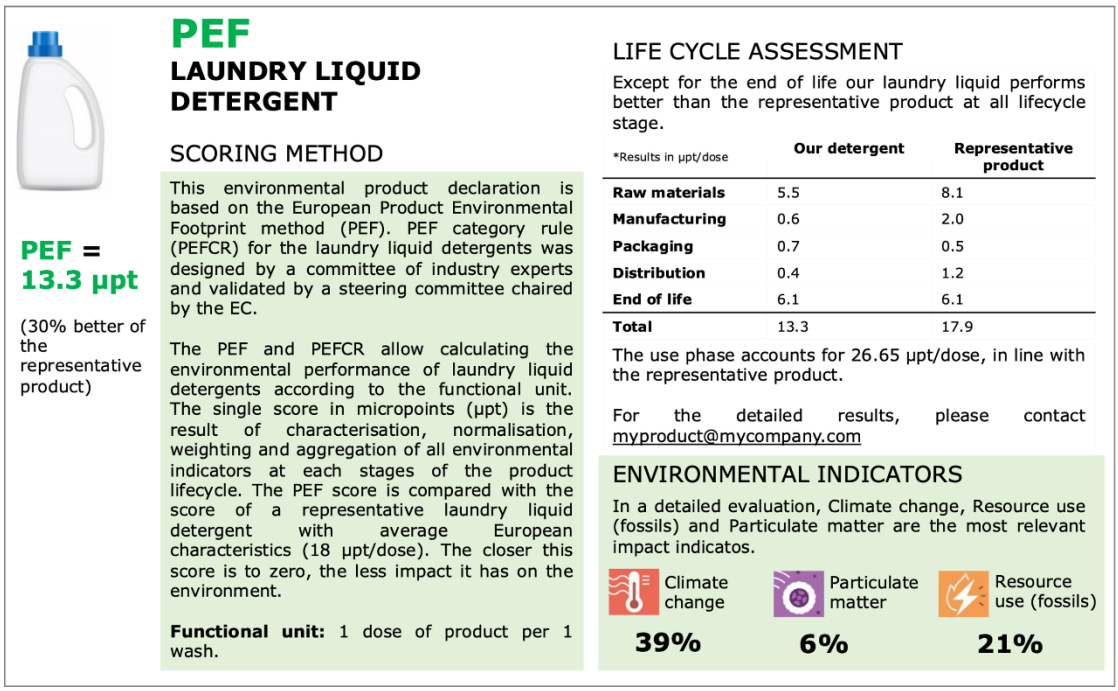
Node	Description	Owner	Link
EF RPs	EF representative products	European commission	http://eplca.jrc.ec.europa.eu/EF-node/
CEPE	Chemicals for Paint	CEPE Ecoinvent	http://lcdn-cepe.org/
Cycleco	Textiles	co	https://node.cycleco.eu/node/
Ecoinvent	Chemicals	nvent	http://ecoinvent.lca-data.com/
FEFAC	Feed	Fefac	http://lcdn.blonkconsultants.nl/Node/
Quantis	Agrofood, "others"	Quantis	https://lcdn.quantis-software.com/PEF/
RDC	Glass recycling	RDC	http://soda.rdc.yp5.be/login.xhtml
Sphera (former Thinkstep)	Energy and transport, packaging, metals, end-of-life, incineration, plastics, electronics, cooling and freezing transports	Thinkstep	http://lcdn.thinkstep.com/Node/

10 Examples of environmental footprint results communication

The examples of communication vehicles of Environmental Footprint results reported in this section are built on real case studies ([33]). Note that comparisons, comparative assertions, and benchmarking against a representative product are not possible without a PEFCR or OEFSR.

— *PEFCR-based factsheet (Figure 16)*

Figure 16. PEF Laundry liquid detergent



PEF

LAUNDRY LIQUID DETERGENT

PEF = 13.3 µpt

(30% better of the representative product)

SCORING METHOD

This environmental product declaration is based on the European Product Environmental Footprint method (PEF). PEF category rule (PEFCR) for the laundry liquid detergents was designed by a committee of industry experts and validated by a steering committee chaired by the EC.

The PEF and PEFCR allow calculating the environmental performance of laundry liquid detergents according to the functional unit. The single score in micropoints (µpt) is the result of characterisation, normalisation, weighting and aggregation of all environmental indicators at each stages of the product lifecycle. The PEF score is compared with the score of a representative laundry liquid detergent with average European characteristics (18 µpt/dose). The closer this score is to zero, the less impact it has on the environment.

Functional unit: 1 dose of product per 1 wash.

LIFE CYCLE ASSESSMENT

Except for the end of life our laundry liquid performs better than the representative product at all lifecycle stage.

*Results in µpt/dose	Our detergent	Representative product
Raw materials	5.5	8.1
Manufacturing	0.6	2.0
Packaging	0.7	0.5
Distribution	0.4	1.2
End of life	6.1	6.1
Total	13.3	17.9

The use phase accounts for 26.65 µpt/dose, in line with the representative product.

For the detailed results, please contact myproduct@mycompany.com

ENVIRONMENTAL INDICATORS

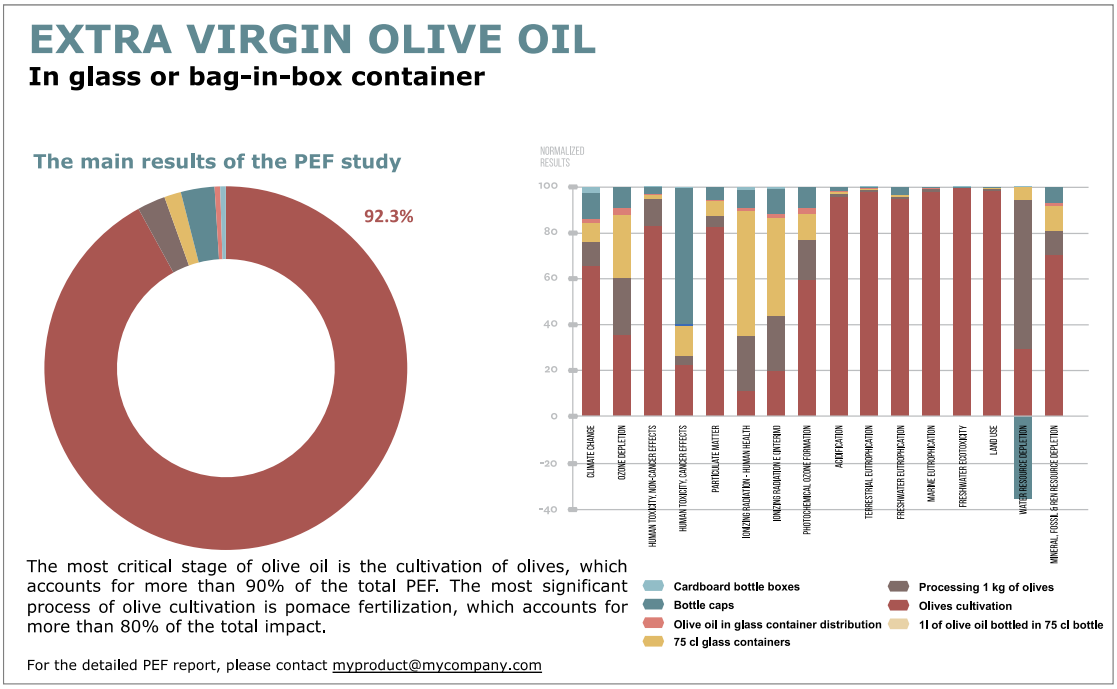
In a detailed evaluation, Climate change, Resource use (fossils) and Particulate matter are the most relevant impact indicatos.

Climate change	Particulate matter	Resource use (fossils)
39%	**6%**	**21%**

([33]) Numbers and figures reported may have been modified for the explanatory purposes of this report.

— *Non PEFCR-based factsheet (Figure 17)*

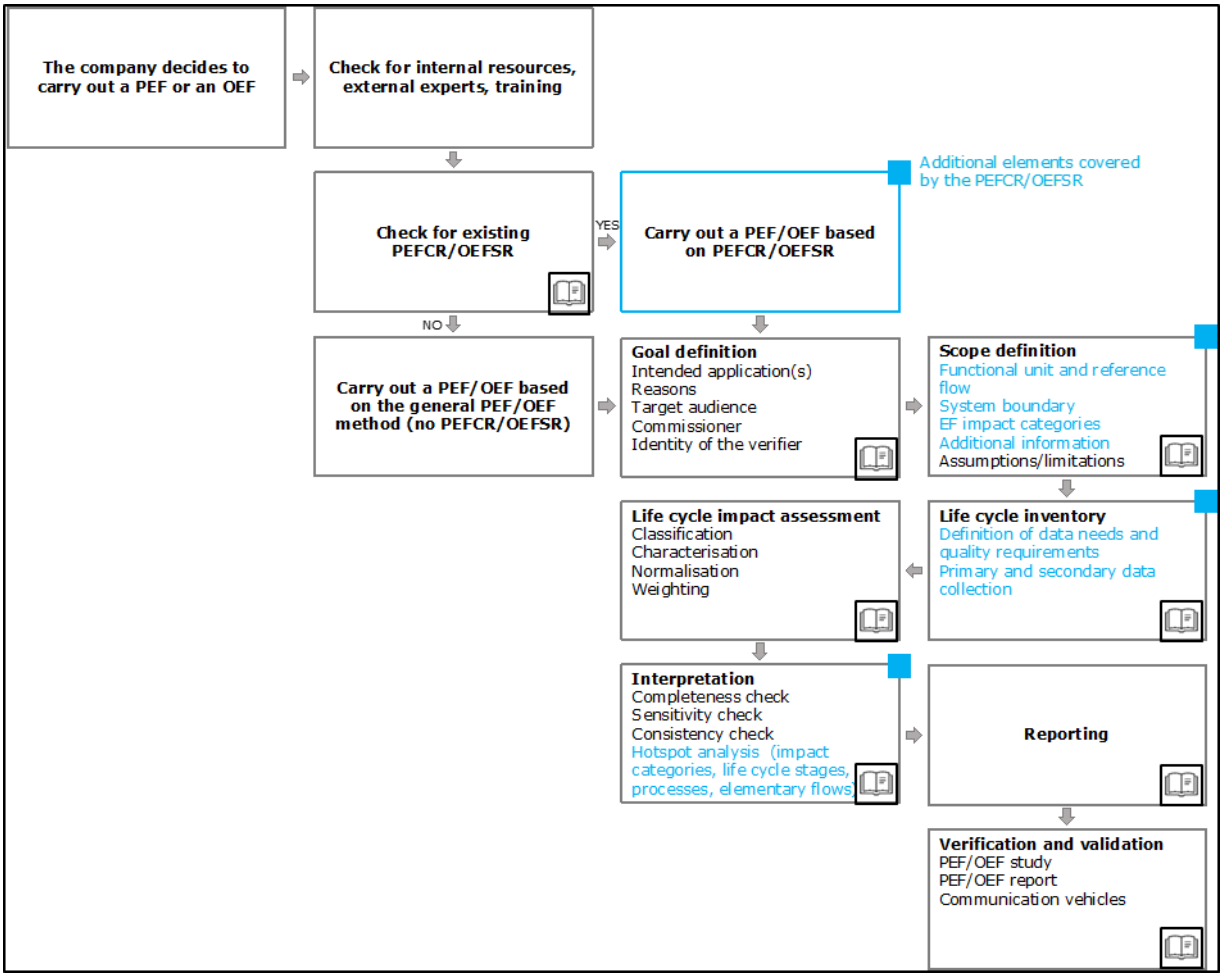
Figure 17. Extra virgin oil



11 Key steps in a product and organisation environmental footprint study development

This section displays the key steps of an EF study development (Figure 18). The list is not exhaustive, and the purpose is to orientate the reader in understanding the overall EF method and its supporting documents. Links to the category rules and the method's guide are available by clicking on the book icons. For simplicity, the links to the study phases refer to the PEF method. For the OEF please refer to the specific guidelines.

Figure 18. Key steps of an EF study development



12 Frequently asked questions

- Who can I contact if I have questions on PEF and OEF?

The EF helpdesk is available for any technical information, the contact details are at The Environmental Footprint transition phase - Environment - European Commission (europa.eu). For questions on the development of PEF and OEF please write to: env-environmental-footprint@ec.europa.eu. For specific questions on EF datasets, you can contact the data provider directly. For information about a specific PEFCR or OEFSR you can contact the corresponding Technical Secretariat. Contact details are reported in the PEFCR and OEFSR documents. For PEFCRs and OEFSRs under development, contacts are available on the website.

- What kind of benefits can organisations draw from EF?

Increased number of EU policies are making reference and requirements based on EF methods. Performing an EF study can support alignment and compliance with these policies, including removing potential obstacles to cross-border trading. An internal use of the EF allows identifying the most relevant activities and materials to improve environmental performance, identify environmental risks along the value chain, optimize production processes, and select suppliers based on their environmental profile ("green supply chain"). Moreover, a growing number of consumers are sensitive to environmental issues when taking their customer loyalty decisions. The EF helps building up profile and reputation, and protecting/increasing market share. Having one method, unnecessary costs are avoided and competition between organisations is based on common rules reducing unfair practices and greenwashing. Finally, banks and finance institutions are increasingly linking risk profile to environmental profile, making EF studies useful to support sustainable investments.

- Can the EF be used to model future product scenarios?

The EF method requires to model the actual situation of the market. Therefore, future projections (e.g. for efficiency improvements) shall not be part of the EF calculations.

Standard LCA studies on prospective scenarios aligned with the EF can be done, but compliance with the EF method shall not be stated.

- What should be the approach to conduct a PEF or OEF study without an existing PEFCR or OEFSR?

A PEF and an OEF study can be carried out also when specific category and sector rules have not been defined for the product or the industrial sector in scope. In this case, the version in force of the PEF and OEF methods shall be used.

- Is it mandatory to follow the requirements set out by PEFCRs and OEFSRs?

When available, a PEFCR or an OEFSR shall be used, in particular when results are used for public communications.

- When/how new PEFCRs and OEFSRs can be developed?

So far, the European Commission invited interested industries/organisations to apply for the development of new PEFCRs and OEFSRs. All calls are published on DG ENV website. The list of available PEFCRs and OEFSRs is updated once new documents are developed.

- Where can I find training material on the PEF and OEF?

Trainings are available at the following link:

https://ec.europa.eu/environment/eussd/smgp/ef_trainings.htm

- Is the EF method aligned with the recommendations of the UN Life Cycle Initiative?

The European Commission is a funding partner of the Life Cycle Initiative and contributes to consensus building and scientific development. The general recommendations and the methods provided in the context of the Life Cycle Initiative and the European Environmental Footprint are in general aligned. However, some differences may exist. The EF provides additional methodological and procedural guidance to improve harmonization, robustness, consistency, and comparability of results. Where operational improvements are proposed by the Life Cycle Initiative, these can be evaluated and included in periodic updates of the EF method.

- Are PEF and OEF studies verified?

The verification and validation of PEF and OEF studies is mandatory whenever the PEF study, or part of the information therein, is used for any type of external communication. The verification may take place at the end of the PEF study or in parallel. Further information on verification and validation is available in the most recent guidance documents, including the requirements for the verifiers.

- Are EF datasets available for free?

The access to EF-compliant datasets is granted for free by data providers only to users developing PEF and OEF studies within existing PEFCRs and OEFSRs. For any other use, the access follows the license policy of the data provider. The data in the nodes owned by the European Commission are always free to use.

- What is the Circular Footprint Formula for?

The CFF is meant to quantify the inventory of resources used and emissions associated of recycled content, recyclability, disposal, and energy recovery.

- Where can I find default values for the Circular Footprint Formula parameters?

Default values are available under Annex C at the following link:

https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml

Guidance on the end-of-life modelling of specific representative products is also available in the PEFCRs.

- How is the transport modelled in PEF/OEF?

Modelling requirements, allocation rules, and default scenarios are available in section 4.4.3 of the PEF and OEF methods at the following links:

PEF method

OEF method

The transport datasets give the possibility to adjust the payload and utilization, including the empty return rate.

- What allocation rules should be used in the EF of multi-functional systems?

Allocation rules are set out by the most recent guidelines and follow ISO 14044. The decision hierarchy determines that preference is given in descending order to subdivision and system expansion, allocation based on relevant underlying physical relationships (e.g. mass), allocation based on other relationships (e.g. economic). Specific allocation rules can be defined in a PEFCR or OEFSR that shall be followed when conducting a PEF/OEF in compliance with the PEFCR/OEFSR.

- How can a single score from the various impact categories be derived?

Details on the methodology and weighting factors can be found on the most updated version of the EF guidelines and at the following links:

Commission Recommendation (EU) 2021/2279

https://eplca.jrc.ec.europa.eu/EFtransition.html

- What would then be the unit of the EF overall single score?

The overall single score is dimensionless, and measured in "points", multiple (e.g. kilo-points) or sub-multiples (e.g. micro-points). Specific information is available on the normalisation and weighting reference documents.

- For more information concerning the status of the EF pilot and transition phases please visit DG ENV website.

Conclusions

The environmental footprint guidelines are the result of a decade of research and methodological development by the European Commission, in consultation with a wide range of European stakeholders. The EF further develops the indications of the ISO 14040-44 standards on LCA with the aim of guaranteeing greater scientific soundness, transparency, transferability, and comparability of results among European market players. This is achieved through the determination of precise rules on, among others, the modelling of production systems, data collection, the development of datasets, and the characterisation of impacts. The purpose of EF methods is to guide the practitioner in the realisation of a PEF or OEF study from the beginning to the communication of results, leaving as little room as possible for interpretations and choices that would compromise the comparability of results between different market players and with European benchmarks.

This report therefore schematically describes some of these distinctive elements of the EF method, to guide the reader in understanding it and possibly support him/her in its use, whether he/she is an LCA practitioner or simply someone who is interested in understanding a methodology that is today at the basis of an increasing number of European policies. The European Platform on Life Cycle Assessment of the Joint Research Centre and the Directorate-General for Environment are engaged every day in maintaining and constantly improving the EF methodology. This is done both through the deployment of internal resources and through collaboration with institutions, industry associations and companies across Europe in thematic interest groups (e.g. the technical secretariats of PEFCRs and OEFSRs or the environmental footprint Technical Advisory Board), with the aim of working together towards a more sustainable Europe.

References

14025:2006 Environmental labels and declarations — Type III environmental declarations — Principles and procedures.

2013/179/EU: Commission Recommendation of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations.

(EU) 2021/2279, Annex I, section 3.2.1, section 4.6.5, section 4.6.3, section 6

Fazio S., Zampori L, De Schryver A, Kusche O, Thellier L, Diaconu E. Guide for EF compliant data sets, Version 2.0 Luxembourg, 2020, ISBN 978-92-76-17951-1 (online), doi:10.2760/537292 (online)

ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework.

ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines.

ISO 14046:2014 Environmental management — Water footprint — Principles, requirements and guidelines.

ISO 14006:2020 Environmental management systems — Guidelines for incorporating ecodesign.

ISO 14064-1:2018 Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.

ISO 14067:2018 Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification.

ISO 14072:2014 Environmental management — Life cycle assessment — Requirements and guidelines for organizational life cycle assessment.

M. Wolf, R. Pant, K. Chomkhamsri, S. Sala, D. Pennington (2012): International Reference Life Cycle Data System (ILCD) Handbook – Towards more sustainable production and consumption for a resource-efficient Europe. JRC Reference Report, EUR 24982 EN. European Commission – Joint Research Centre. Luxembourg. Publications Office of the European Union; 2012.

List of abbreviations and definitions

Allocation: 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.

Background processes: those processes that are operated as part of the system but that are not under direct control or decisive influence of the producer of the good (or operator of the service, or user of the good).

Benchmark: in the context of PEF, the term 'benchmark' refers to the average environmental performance of the representative product sold in the EU market.

Characterisation: calculation of the contribution of each classified elementary flow to an impact category. The characterisation is done by means of characterisation factors specific for a certain flow within the impact category considered.

Characterisation factor: factor derived from a characterisation model which is used to convert an inventory flow to the unit of the impact category indicator.

Circular Footprint Formula (CFF): formula used to allocate to the system under study the burdens of ingoing virgin and recycled material, outgoing recyclable material, disposal, and energy recovery.

Circularity: contribution of a system to the circular economy, which embraces a concept of economic growth decoupled from resource use through reduction, reuse, and recycling.

Classification: assigning the elementary flows to one or more impact categories according to their potential to contribute to them.

Completeness analysis: verifying whether the information on life cycle stages and impacts is sufficient to reach conclusions according to the goal and scope of the study.

Consistency analysis: verifying whether assumptions, methods, and data are consistently applied throughout the study and are in accordance with the defined goal and scope

Cut-off: omission of not relevant life cycle stages, processes, and elementary flows from the system. The EF processes and elementary flows that (cumulatively) account for less than 3.0% of the material and energy flow may be excluded, as well as the environmental impact for each impact category may be excluded from PEF study. The processes subject to cut-off shall be made explicit and justified.

Ecosphere: the biosphere of the Earth and the interaction between living and non-living components.

EF-compliant dataset: Dataset developed in compliance with the EF requirements provided at https://eplca.jrc.ec.europa.eu/permalink/Guide_EF_DATA.pdf.

Elementary flow: in the LCI, an elementary flow is the 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. Elementary flows include, for example, resources taken from nature or emissions into air, water, soil.

Environmental Footprint (EF): comprehensive assessment of environmental impacts over the life cycle of products and organisations. It includes the Product Environmental Footprint (PEF) and Organisation Environmental Footprint (OEF) methods.

Foreground processes: those processes of the system that are regarding their selection or mode of operation directly affected by decisions analysed in the study. The foreground processes are hence those that are under direct control of the producer of the good or operator of the service or user of the good or where he has decisive influence.

Functional unit: the reference unit defining qualitative and quantitative aspects of the function, to be used as a reference unit for an EF study.

Grouping: sorting and ranking of impact categories.

Hotspot analysis: analysis of the main contributing life cycle stages, processes, and flows to the impacts of the life cycle of a product, service or organisation.

Impact category: class representing environmental issues of concern to which life cycle inventory analysis results may be assigned.

Life cycle assessment (LCA): compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.

Life cycle environmental performance: quantified measurement of the potential environmental performance taking all relevant life cycle stages of a product or organisation into account, from a supply chain perspective.

Life cycle impact assessment (LCIA): phase of life cycle assessment 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.

Life cycle inventory (LCI): phase of the LCA involving the compilation and quantification of inputs and outputs for a product throughout its life cycle.

Non-elementary flow: flows exchanged within the technosphere (e.g. electricity, waste).

Normalisation: calculation of the magnitude of the category indicator results relatively to a reference system. Normalisation transforms an indicator result by dividing it by a selected reference value.

Organisation Environmental Footprint (OEF): method to measure and communicate the potential life cycle environmental impact of an organisation or result of an OEF study based on the OEF method.

Organisation Environmental Footprint Sector Rules (OEFSRs): sector-specific, rules that complement general methodological guidance for OEF studies by providing further specification at the level of a specific sector.

Primary data: company and site-specific data in a life cycle inventory.

Product Environmental Footprint (PEF): method to measure and communicate the potential life cycle environmental impact of a product or result of a PEF study based on the PEF method.

Product Environmental Footprint Category Rules (PEFCRs): product category specific rules that complement general methodological guidance for PEF studies by providing further specification at the level of a specific product category.

Product portfolio: a set of products or services provided to the market by an organization.

Reference flow: the amount of product or the output from the product system needed to provide the defined function.

Representative organisation (RO): reference, real or virtual (non-existing) organisation for which the OEF is calculated. The virtual RO should be calculated based on average European market sales-weighted characteristics of all existing technologies/production processes/organisation types covered by the sector or sub-sector. Other weighting sets may be used, if justified.

Representative product (RP): reference, real or virtual (non-existing) product for which the PEF is calculated. The virtual RP 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).

Secondary data: data not from a specific process within the supply-chain of the company performing an EF study. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third-party database or other sources (e.g. industry average data, literature studies, engineering studies and patents), and may also be based on financial data, and contain proxy data, and other generic data.

Sensitivity analysis: estimation of the effects of the choices made regarding methods and data used.

System boundary: defines the life cycle stages and processes included in the system evaluated.

Technosphere: the sphere of human technological activity or the technologically modified environment.

Unit process: the smallest element of a system for which input and output inventory data are quantified.

Weighting: Weighting is a step that supports the interpretation and communication of the results of the analysis. Results are multiplied by a set of weighting factors, which reflect the expressed 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. Weighting includes the use of value choices and cannot be based on natural science alone.

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