Product Environmental Footprint Category Rules (PEFCR) for hot and cold water supply plastic piping systems in the building

Version 6.3

Date of publication: February 2020 (original publication date is 11 September 2019)

Validity date: 31.12.2021

Draft PEFCR based on the following documents:

- Commission Recommendation on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations (2013/179/EU) (April 9, 2013)
- PEFCR Guidance document of the EC for the pilot phase, Version 6.3 (December, 2017)

Prepared by the Technical Secretariat of the PEF pilot on hot and cold water supply plastic piping systems in the building

Study accomplished under the authority of the Technical Secretariat of the PEF pilot

Contents

List of tables

List of figures

Acronyms

Al	Aluminium
AP	Acidification potential
B2B	Business to business
B2C	Business to consumer
BoC	Bill of Components
BoM	Bill of Materials
CEN	European Committee for Standardization
CEN/TC	European Committee for Standardization/Technical Committee
CEWEP	Confederation of European Waste-to-Energy Plants
CFF	Circular Footprint Formula
In line with their internationally accepted nomenclature	Chemical elements
CPA	Classification of Products by Activity
CPC	Central Product Classification
CPVC	Chlorinated polyvinylchloride
DC	Distribution Centre
DNM	Data Needs Matrix
DQR	Data Quality Rating
EC	European Commission
ECI	European Copper Institute
EEA	European Economic Area
EF	Environmental Footprint
EI	Environmental Impact

ELCD	European reference Life Cycle Database
EoL	End-of-Life
EP	Eutrophication Potential
EPD	Environmental Product Declaration
EU	European Union
FU	Functional Unit
GHG	Greenhouse gas
GR	Geographical Representativeness
GWP	Global Warming Potential
HCWD	Hot and Cold Water Distribution
HDPE	High Density Polyethylene
IBU	Institut Bauen und Umwelt
ILCD	International reference Life Cycle Data System
ISO	International Organization for Standardization
LCA	Life cycle assessment
LCDN	Life Cycle Data Network
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
ML	Multilayer
NACE	Statistical classification of economic activities in the European Community
NMVOC	Non-methane volatile compounds
ODP	Ozone depletion potential
P	Precision

PA	Polyamide
PB	Polybuthene
PCR	Product Category Rules
PE	Polyethylene
PE-HD	Polyethylene High Density
PE-RT	Polyethylene of Raised Temperature resistance
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PE-R	Polyethylene Raised Temperature
PEX	Crosslinked Polyethylene
POCP	Photochemical Oxidant Creation Potential
PPFA	US Plastic Pipes and Fittings Association
PPSU	Polyphenylenesulphone
PRE	Plastics Recyclers Europe
PVC	Polyvinylchloride
PVDF	Polyvinylidenfluoride
RER	Representative for the European Region
RF	Reference Flow
RP	Representative Product
SC	Steering Committee
SME	Small and Medium Enterprise
TAB	Technical Advisory Board

TEPPFA	The European Plastic Pipes and Fittings Association
TeR	Technological Representativeness
TiR	Time Representativeness
TS	Technical Secretariat
UUID	Universally Unique Identifier
VITO	Flemish Institute for Technological Research

Definitions

Activity data: This term refers to information which is associated with processes while modelling Life Cycle Inventories (LCI). In the PEF Guide it is also called “non-elementary flows”. 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 a process (See Figure 1). 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. In the context of PEF the amounts of ingredients from the bill of material (BOM) shall always be considered as activity data

Aggregated dataset: This term is defined as a life cycle inventory of multiple unit processes (e.g. material or energy production) or life cycle stages (cradle-to-gate), but for which the inputs and outputs are provided only at the aggregated level. Aggregated datasets are also called "LCI results", “cumulative inventory” or “System processes” datasets. The aggregated dataset can have been aggregated horizontally and/or vertically. Depending on the specific situation and modelling choices a "unit process" dataset can also be aggregated. See ***Figure 1***.

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.

Benchmark – A standard or point of reference against which any comparison can be made. In the context of PEF, the term ‘benchmark’ refers to the average environmental performance of the representative product sold in the EU market. A benchmark may eventually be used, if appropriate, in the context of communicating environmental performance of a product belonging to the same category.

[1] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute, 2004).

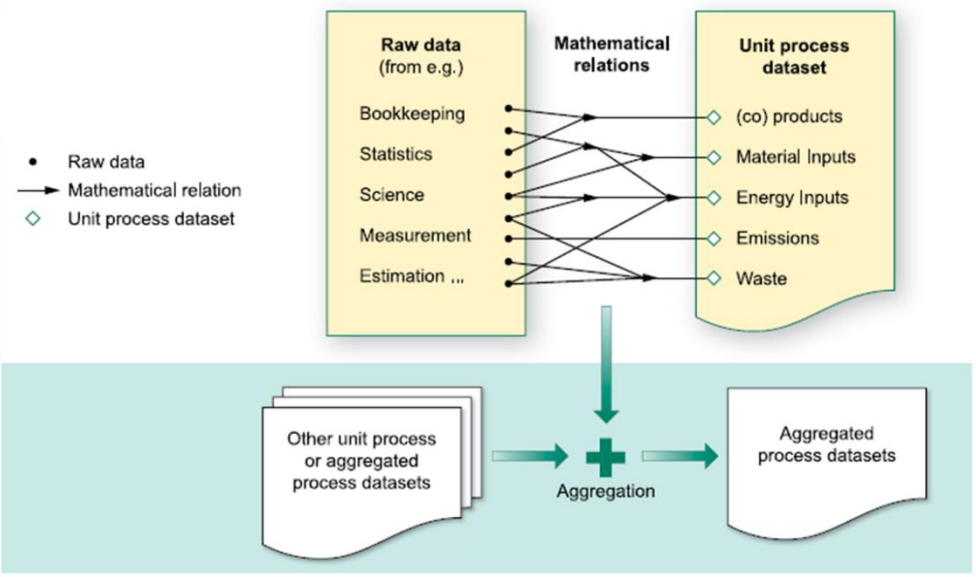


Figure 1: Definition of a unit process dataset and an aggregated process dataset (Source: UNEP/SETAC "Global Guidance Principles for LCA Databases")

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 an end product.

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

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".

Commissioner of the EF study - Organisation (or group of organisations) that finances the EF study in accordance with the PEF Guide, PEFCR Guidance 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 representative of activities at a specific facility or set of facilities. It is synonymous to "primary data".

Comparative assertion – environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function (adapted from ISO 14025:2006).

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.

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.

Direct elementary flows: All emissions and resource use (also named elementary flows) that arise directly in the context of a process. Examples are emissions from a chemical process, or fugitive emissions from a boiler directly onsite. See ***Figure 2***.

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

Elementary flow: 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.

Environmental aspect – element of an organisation's activities, products or services that can interact with the environment (ISO 14025:2006).

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

Foreground system: This term refers to those processes in the product life cycle for which access to company-specific 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.

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

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 - an intermediate product is a product that requires further processing before it is saleable to the final consumer.

Life Cycle Inventory (LCI): The combined set of exchanges of elementary, waste and product flows in an 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.

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

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).

Piping system is a network of pipes, fittings and valves intended to perform a specific job i.e. to carry or transfer fluids from one equipment to another. The plumbing network supplying water at your home is a

[2] http://www.e-track-project.org/

common example of a piping system. Other more rigorous examples include steam piping in a power plant, milk piping in a dairy, paint piping in a paint manufacturing plant, oil piping in a refinery, so and so forth. (https://www.cheresources.com/invision/blog/52/entry-250-what-is-a-piping-system/)

Partially disaggregated dataset: A dataset with an LCI that contains elementary flows and activity data, and that only in combination with the complementing aggregated datasets that represent the activities yields a complete aggregated LCI data set. We refer to a partially disaggregated dataset at level 1 in case the LCI contains elementary flows and activity data, while at least some of the complementing sub-processes are in their aggregated form (see an example in Figure 2). The underlying sub-processes should be based on EF-compliant secondary datasets (if available).

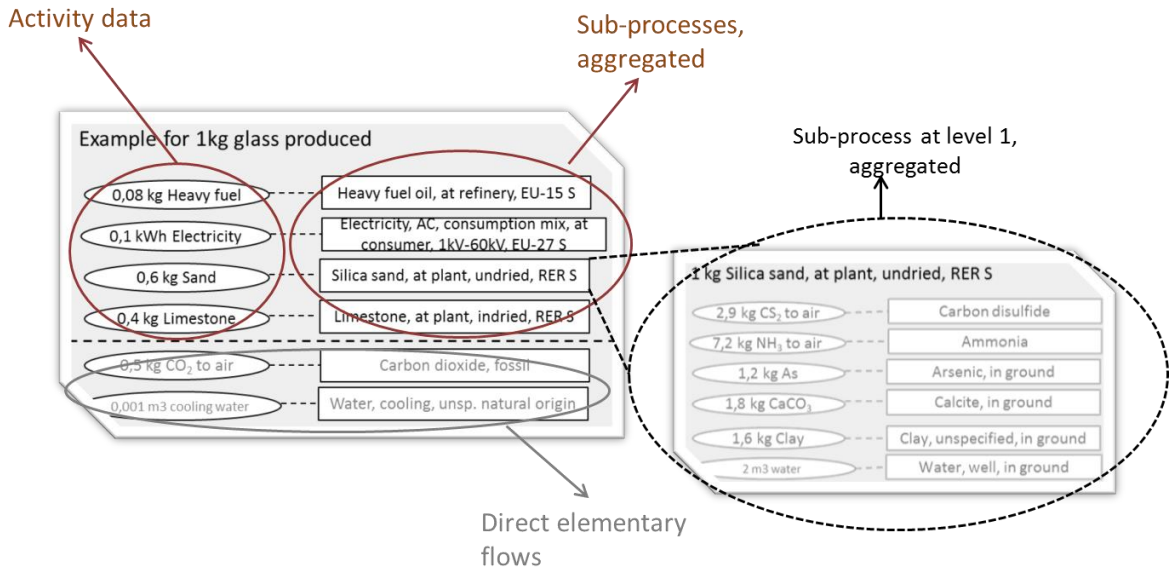


Figure 2: An example of a partially aggregated dataset, at level 1 with its activity data and direct elementary flows (to the left), and the complementing sub-processes in their aggregated form (to the right). The grey text indicates elementary flows

PEFCR Supporting study – the PEF study done on the basis of 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 be reported.

PEF screening – a preliminary study carried out on the representative product(s) and intended to identify the most relevant life cycle stages, processes, elementary flows, impact categories and data quality needs to derive the preliminary indication about the definition of the benchmark for the product category/sub-categories in scope, and any other major requirement to be part of the final PEFCR.

Primary data[3]: This term refers to data from specific processes within the supply-chain of the company applying 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 a 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 company applying the PEFCR. In this Guidance, primary data is synonym of "company-specific data" or "supply-chain specific data".

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

Product Category Rules (PCR) – 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 guide.

Refurbishment: 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.

Representative product (model) - The “representative product” may or may not be a real product that one can buy on the EU market. Especially when the market is made up of different technologies, the “representative product” can be a virtual (non-existing) product built, for example, from the average EU sales-weighted characteristics of all technologies around. A PEFCR may include more than one representative product if appropriate.

Secondary data[4]: refers to data not from specific process within the supply-chain of the company applying the PEFCR. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third-party life-cycle-inventory 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 can also be based on financial data, and contain

[3] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute, 2004).

[4] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute, 2004)

proxy data, and other generic data. Primary data that go through a horizontal aggregation step are considered as secondary data.

Sub-processes: those processes used to represent the activities of the level 1 processes (=building blocks). Sub-processes can be presented in their (partially) aggregated form (see Figure 2).

Supply-chain: refers to all of the upstream and downstream activities associated with the operations of the company applying the PEFCR, 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 can produced by a specific company.

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.

Unit process dataset: Smallest element considered in the life cycle inventory analysis for which input and output data are quantified (ISO 14040:2006). In LCA practice, both physically not further separable processes (such as unit operations in production plants, then called “unit process single operation”) and also whole production sites are covered under "unit process", then called “unit process, black box” (ILCD Handbook).

Validation statement – Conclusive document aggregating the conclusions from the *verifiers* or the verification team regarding the EF study. This document is mandatory and shall be electronically or physically signed by the *verifier or in case of a* verification panel, by the lead verifier. The minimum content of the validation statement is provided in this document.

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 can be confidential. However, it shall be signed, electronically or physically, by the *verifier or in case of a* verification panel, by 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.

1. Introduction

The Product Environmental Footprint (PEF) Guide provides detailed and comprehensive technical guidance on how to conduct a PEF study. PEF studies may be used for a variety of purposes, including in-house management and participation in voluntary or mandatory programmes.

For all requirements not specified in this PEFCR the applicant shall refer to the most recent version of the PEF Guide.

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.

This Product Environmental Footprint Category Rules (PEFCR) shall be used in parallel with the PEF Guide[5] and the latest version of the Guidelines from the European Commission (version 6.3 - Guidance for the implementation of the EU Product Environmental Footprint (PEF) during the Environmental Footprint (EF) pilot phase)[6] for PEF studies for hot and cold water supply piping systems consisting of either Multilayer (PEX or PE-RT/Aluminium/PEX or PE-RT) or PEX pipes. The PEFCR is developed according to the requirements included in the PEF Guide and the Template provided in Annex B to the PEF Pilot Guidance document (version 6.3).

The target audience of this PEFCR are:

i) Plastic piping system manufacturers, including pipes, fittings and other components;
ii) fitting manufacturers, who deliver the whole piping system and have primary data on pipes manufacturing.

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.

[5] PEF Guide - Annex II to Recommendation (2013/179/EU) and the Product Environmental Footprint Pilot Guidance, as it was published in the Official Journal of the European Union number L124 from 4 May 2013 which includes the Recommendation 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.

[6] European Commission, 2016, *Environmental Footprint Pilot Guidance document,* - Guidance for implementation of the EU Product Environmental Footprint (PEF) during the Environmental Footprint (EF) pilot phase, v.6.3, June 2017

2. General information about the PEFCR

2.1 Technical secretariat

The members of the Technical Secretariat (TS) of the PEF pilot on hot and cold water supply piping systems in buildings that jointly developed the PEFCR are presented in the table below:

Name of the organization	Type of organization	Name of the members (not mandatory)	Participation since – till (if the case)
TEPPFA (the European Plastic Pipes and Fittings Association)	Trade/industrial/sectoral association at EU level	▪ Bauke Vollebregt (Wavin); ▪ Bernd Schuster (Georg Fischer Piping Systems); ▪ Claudia Topalli (TEPPFA); ▪ David Harget (Uponor); ▪ Eric Gravier (Aliaxis), representing the TS in the Technical Advisory Board (TAB); ▪ Georg Taubert (Geberit); ▪ Horst Stimmelmayr (Rehau); ▪ Janis Cernnajs (Uponor); ▪ Ilari Aho (Uponor); ▪ Oliver Bannert (Pipelife); ▪ Sándor Aranyi (TEPPFA); ▪ Peter Sejersen (TEPPFA); ▪ Tony Calton (TEPPFA); ▪ Ludo Debever ▪ Zoran Davidovski (Pipelife)	▪ January 2014 - July 2017 ▪ January 2014 ▪ January 2014 - September 2016 ▪ January 2014 - January 2016. ▪ January 2014 ▪ January 2014 ▪ January 2014 ▪ January 2014 - March 2017 ▪ March 2017 ▪ January 2014 ▪ January 2014 - September 2016 ▪ September 2016 ▪ January 2014 - April 2017 ▪ Since April 2017 ▪ January 2014
PlasticsEurope:	Trade/industrial/sectoral association at EU level	▪ Arjen Sevenster (PlasticsEurope); ▪ Guy Castelan (PlasticsEurope); ▪ Pierre Van-Grambezen (Total).	▪ January 2014 ▪ January 2014 ▪ January 2014
PRE (Plastics Recyclers Europe)	Trade/industrial/sectoral association at EU level	▪ Antonio Furfari	▪ January 2014

VITO (the Flemish Institute for Technological Research)	Research Institute	▪ Carolin Spirinckx; ▪ Karolien Peeters; ▪ Mihaela Thuring	▪ January 2014 ▪ January 2014 – September 2017 ▪ July 2014

Besides the TS, the following life cycle assessment (LCA) consultant companies provided feedback for the improvement of drafts towards the current PEFCR, and via supporting studies, since:

- maki Consulting GmbH, represented by Marc-Andree Wolf (since December 2013);
- Ecoinnovazione, represented by Alessandra Zamagni (since October 2015).

2.2 Consultations and stakeholders

The process of developing this PEFCR was open and transparent and included an open consultative format with relevant stakeholders.

The TS of the PEF pilot on hot and cold water supply piping systems in buildings identified and invited as much as possible relevant stakeholders to participate in the PEFCR development. The relevant stakeholders for the PEFCR include representatives from several material suppliers, manufacturers, trade associations, purchasers, users, consumers, government representatives, non-governmental organizations, public agencies, independent parties and certification bodies. The list with stakeholders that registered for the PEF pilot on hot and cold supply piping system can be found in Annex 4.VI – Stakeholders of the PEF pilot on hot and cold water supply plastic piping system in the building of this PEFCR. On 09.08.2016 there were 142 stakeholders registered.

The TS of the PEF pilot on hot and cold water supply piping systems in buildings produced a document describing the major comments received and how they have been addressed after each consultation phase. These documents are made public in the EF virtual consultation Forum. In this framework the TS created and maintained a log of the stakeholders that have been communicated with and responded to.

The stakeholder workspace can be found here:

https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/Stakeholder+workspace%3A+PEFCR+pilot+Hot+and+cold+water+supply+pipes

One public physical consultation meeting was organised during the PEF pilot on hot and cold water supply piping systems in buildings and two virtual took place.

A **first physical consultation** on the definition of representative product, a description of the model for the PEF screening studies and the definition of the scope of the PEFCR took place on the **20th of March 2014**.

The **second consultation** was a virtual consultation that took place between the **9th of April 2015** and the **9th of May 2015**.

The **third consultation** was a virtual consultation on the draft final PEFCR, that took place between the **29th of August 2016** and the **26th of September 2016**.

2.3 Review panel and review requirements

Name of the member	Affiliation	Role
Ugo Pretato	Studio Fieschi & soci Srl	Chair of the review panel
Manfred Russ	DEKRA Assurance Services Gmb/ Thinkstep since 2017	Member of the review panel
Sebastien Humbert	Quantis	Member of the review panel

The reviewers have verified that the following requirements have been fulfilled:

- The PEFCR has been developed in accordance with the requirement provided in the PEFCR Guidance 6.3, and where appropriate in accordance with the requirements provided in the most recent approved version of the PEF Guide, and supports creation of credible and consistent PEF profiles,
- The functional unit, allocation and calculation rules are adequate for the product category under consideration,
- Company-specific and secondary datasets used to develop this PEFCR are relevant, representative, and reliable,
- The selected LCIA indicators and additional environmental information are appropriate for the product category under consideration and the selection is done in accordance with the guidelines stated in the PEFCR Guidance version 6.3 and the most recent approved version of the PEF Guide,
- The benchmark is correctly defined,
- Both LCA-based data and the additional environmental information prescribed by the PEFCR give a description of the significant environmental aspects associated with the product.

2.4 Review statement

This PEFCR has been developed in compliance with Version 6.3 of the PEFCR Guidance, and with the PEF Guide adopted by the Commission on 9 April 2013, published in the official journal of the European Union Volume 56, 4 May 2013.

The representative product(s) correctly describe the average product(s) sold in Europe for the product group 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 detailed review report is provided in ANNEX 3 - Critical review report of the PEFCR of this PEFCR.

2.5 Geographic validity

This PEFCR is valid for products in scope installed 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.

This PEFCR is developed for hot and cold water supply plastic piping systems in buildings installed in the European Union (EU) and European Free Trade Association (EFTA) countries, more specifically Multilayer (PEX or PE-RT/Aluminium/PEX or PE-RT) and Crosslinked Polyethylene (PEX) piping systems.

2.6 Language

The PEFCR is written in English. The original in English supersedes translated versions in case of conflicts.

If the PEFCR is translated in other languages, the following information shall be indicated:

- Title, revision number and date;
- Name of the translator(s) and its/their accreditation number, if possible, or name of the institution providing the translation.

2.7 Conformance to other documents

This PEFCR has been prepared in conformance with the following documents (in prevailing order):

- PEFCR Guidance 6.3
- Product Environmental Footprint (PEF) Guide; Annex II to the Recommendation 2013/179/EU, 9 April 2013. Published in the official journal of the European Union Volume 56, 4 May 2013

At the time of writing, no European product standards dealing with product category rules (PCR) for the environmental assessment of hot and cold water supply piping systems in buildings were available.

3. PEFCR scope

3.1 Product classification

The scope of the PEFCR includes:

- Multilayer (PEX or PE-RT/Aluminium/PEX or PE-RT) piping system;
- PEX piping system.

These products are included in the following CPA codes:

- C22.2.1: Manufacture of plastic plates, sheets, tubes and profiles;
- C24.4.4.26.50: Copper and copper alloy tube/pipe fittings including couplings, elbows, sleeves, tees and joints excluding bolts and nuts used for assembling/fixing pipes/tubes, fittings with taps, cocks, valves.

Any other solutions/materials for pipes which are not specifically listed shall be considered out of scope and therefore not compliant with this PEFCR. Fittings and other components can be made from different materials, while the data needs matrix requirements on data sources, data compliance and data quality apply as specified more below in this document.

3.2 Representative product(s)

The representative product is a **virtual product,** composed out of two specific plastic piping systems based on market shares calculated by length of pipes:

- Multilayer (PEX or PE-RT/Aluminium/PEX or PE-RT) piping system with press and expansion fittings;
- PEX piping system with press and expansion fittings.

Specific requirements for PEF studies on piping systems carried out by **pipe producers**:

- They shall use primary data for the production of the pipes;
- Regarding the production of fittings:
    - They shall use primary data for the production of the fittings that are part of the pipe system in case this production is under their operational control;
    - Otherwise they shall use the default secondary datasets provided in the PEFCR. Otherwise means when primary data for the production of the fittings (from a specific fitting producer that produces the fittings that are compatible with the pipes used for PEF study) can not be acquired.

Specific requirements for PEF studies on piping systems carried out by **fitting producers**:

- They shall use primary data for the production of the pipes (from a specific pipe producer);
- When the applicant to a PEF study is a fitting producer, the production process of at least one fitting used in the studied piping system shall be under the operational control of the applicant. For those fittings that they produce and that are used for the piping system under study, they

shall use primary data for the production of those fittings;

- In case other fittings, that are not under the applicant's operational control, are used in addition:
  - they shall use primary data from the fittings producer that produces those other fittings that are compatible with the pipes used for the PEF study;
  - If these data cannot be acquired, the default secondary fittings datasets provided in the PEFCR shall be used.

The benchmark has been calculated as follows:

- The PEF profile of the 2 different plastic piping systems considered in the scope (, Multilayer (PEX or PE-RT/Aluminium/PEX or PE-RT) and PEX) has been calculated;
- The two individual results were then merged, based on market shares as follows: the results of each system was multiplied with its market share, they were then added;
- The result is defined as the benchmark for hot and cold water supply plastic piping systems in buildings.

Figure 3 shows how the environmental profile of the representative product and the related benchmark is calculated.

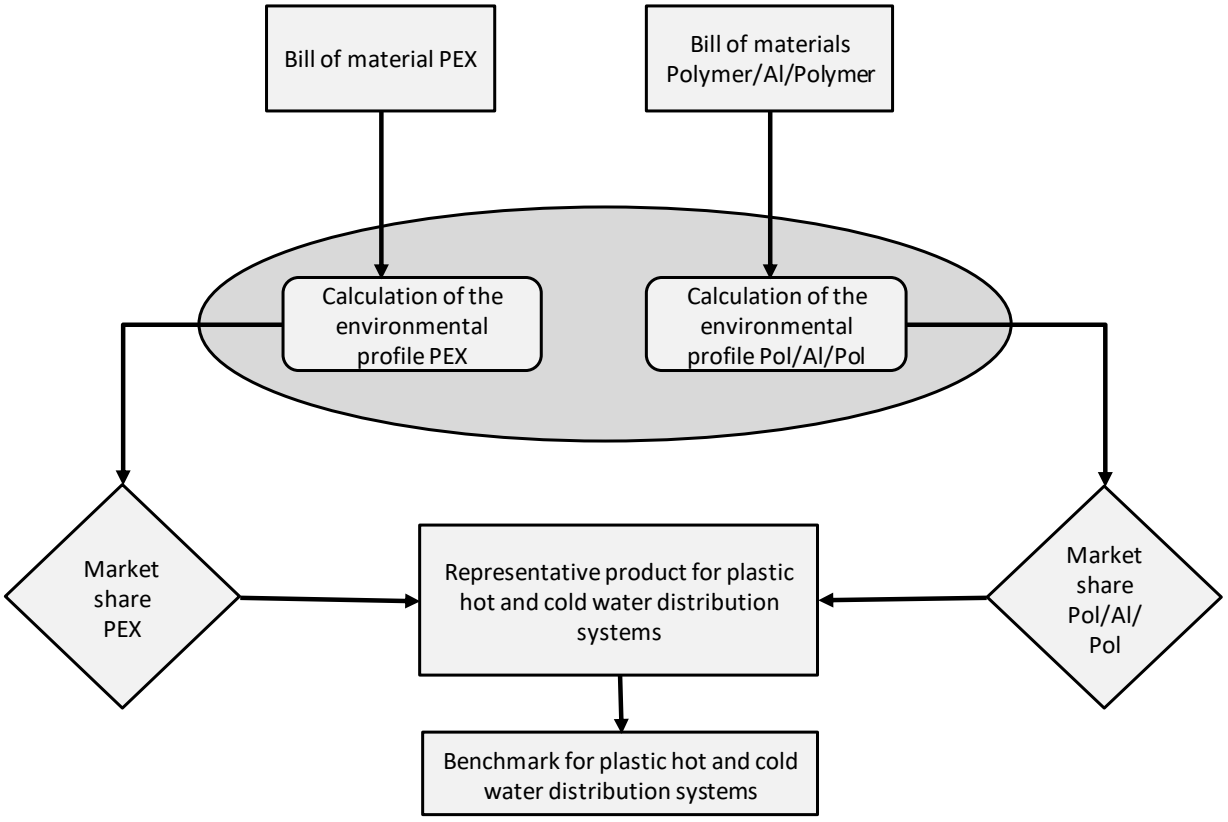


Figure 3: Illustration on the process of creating a representative product and the related benchmark

The screening study is available upon request to the TS coordinator that has the responsibility of distributing it with an adequate disclaimer about its limitations.

3.3 Functional unit and reference flow

> The functional unit (FU) of the hot and cold water supply plastic piping systems in buildings is defined as:
>
> "The pressure supply and transport of hot and cold drinking water, from the entrance of a well-defined apartment building to the tap, by means of a hot and cold drinking water plastic piping system installation supplying a house as defined in EN 806-3[7] (5-story apartment building with one apartment per floor (100 m^2 each, plus cellar), with a design life time of 50 years".

Table 1 defines the key aspects used to define the FU.

Table 1: *Key aspects of the FU*

What?	The pressure supply and transport of hot and cold drinking water , from the entrance of a well-defined apartment building to the tap, by means of a hot and cold drinking water plastic piping system installation supplying the building
How much?	As defined in EN 806-3[8] (5-story apartment building with one apartment per floor (100 m^2 each, plus cellar)
How well?	The water flow to be guaranteed, according to the standard EN 806-3
How long?	Design life time of 50 years

The reference flow is the amount of product needed to fulfil the defined function and shall be measured in meters and kilograms, but also pieces, as appropriate, as detailed in section 3.3.3. All quantitative input and output data collected in the study shall be calculated in relation to this reference flow.

This PEFCR considers a group of products which serve the same function. The PEFCR focusses on hot and cold water supply plastic piping systems that were included in the composition of the representative product, as specified in section 3.2.

[7] EN 806-3: Specifications for installations inside buildings conveying water for human consumption. Pipe sizing. Simplified method, 2006

[8] EN 806-3: Specifications for installations inside buildings conveying water for human consumption. Pipe sizing. Simplified method, 2006

3.3.1 Measuring the function of the system

In order to make the PEF assessment a **reference "building system"** shall be considered: a 5-story apartment building with one apartment (100 m^2 each) per floor plus cellar, with all the facilities, like bath, shower, etc. clearly positioned in the apartments, as specified in EN 806-3. The apartment building design shall be used for modelling the hot and cold water supply plastic piping system. The life time of the hot and cold water supply piping systems is determined by the specific application in the building. So the reference flow shall be related to the 50 years of design life time.

The technical performance of the piping system for hot and cold water supply in the building shall be according to EN 806 part 1, 2, 3, 4, 5. EN 806, Specifications for installations inside buildings conveying water for human consumption:

- Part 1: General;
- Part 2: Design;
- Part 3: Pipe sizing;
- Part 4: Installation;
- Part 5: Operation and maintenance.

3.3.2 Setting design parameters

The design parameters of the apartment building are visualized in Figure 4. The appliances necessary inside the flats shall be based on the reference apartment shown in

Figure 5.

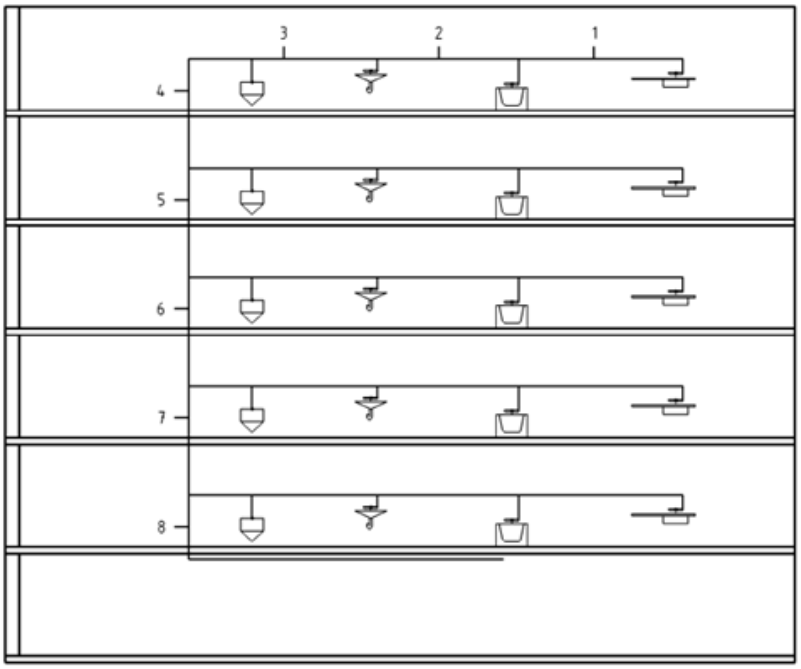


Figure 4: Design of the hot and cold drinking water supply plastic piping systems for a 5-story apartment building according to the EN 806-3, Annex A

Figure 5: Architectural design of a representative 100 m^2 apartment

Figure 6 presents the schematic plumbing design for hot and cold water supply plastic piping systems in buildings according to the representative product. The design has the precise length of pipes for the representative product and location of fittings. Any deviation from this design (and only eligible if the technical performance of the system meets that of the local, legal and functional requirements) shall be justified in the PEF study. Justification needs to be fully reported in the PEF report together with the reasons why the PEF applicant is deviating from the design presented in Figure 6, and be subject to the PEF verification.The location of the outlets shall not be modified from the ones specified in

Figure 5 and Figure 6.

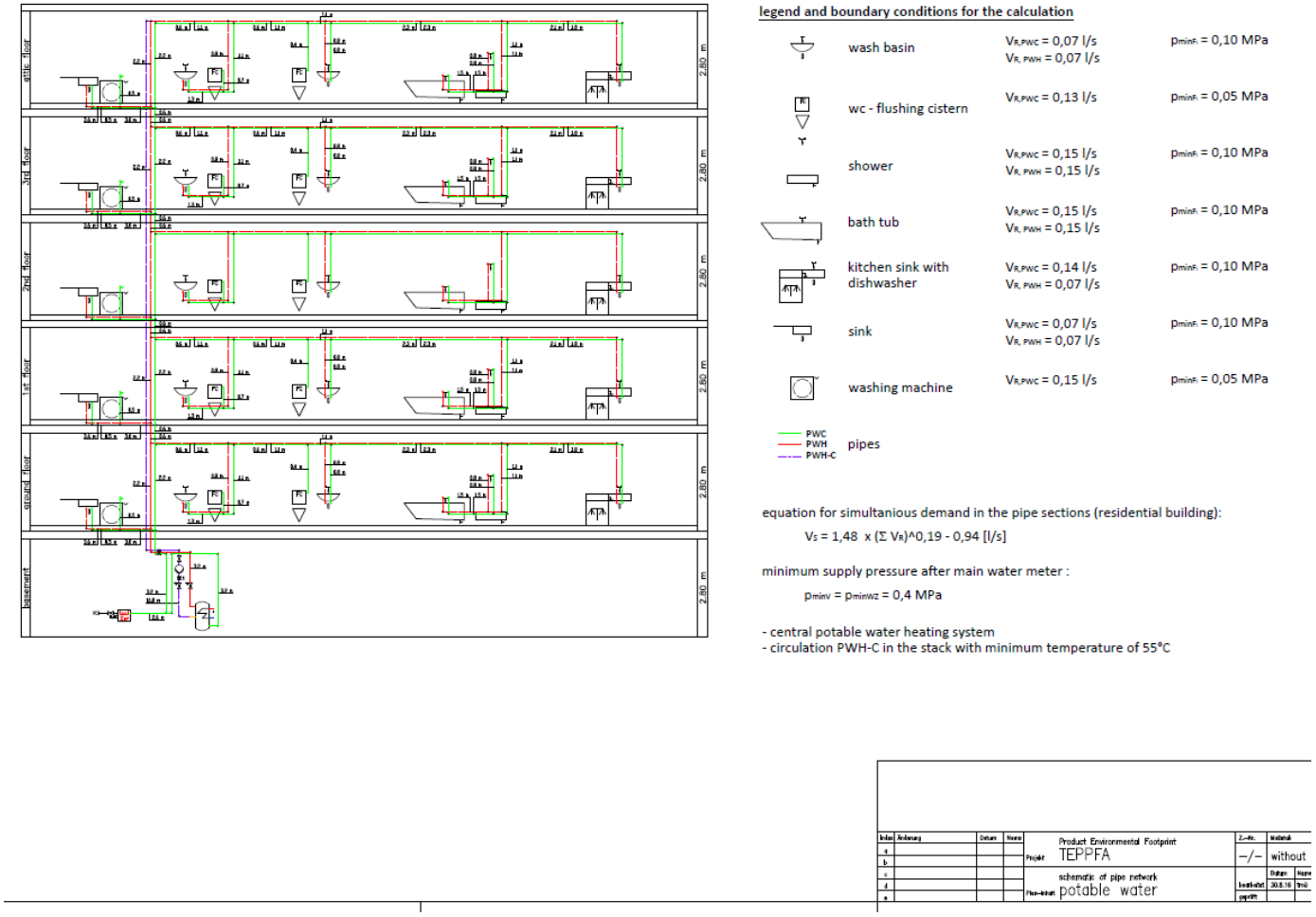


Figure 6: Schematic plumbing design for hot and cold water supply plastic piping systems in buildings according to the representative product[9]

[9] Fittings that make the connection to the shut-off values are included in the functional unit

The installation shall conform to the manufacturer's technical information and recommendations. The drawings give a clear description about the apartment.

The hot water producing device (boiler) is situated centrally in the cellar and is considered outside the system boundaries of the PEF study.

The other elements that are **excluded** from the reference flow and the system boundaries are listed in

ANNEX 4.II – Elements excluded from the reference flow and the system boundaries.

3.3.3 Reporting on the reference flow

The reference flow shall be reported in terms of meters and kilograms of **pipes**, pieces (number) and kilograms of **fittings** and pieces (number) and kilograms of **other components**, and shall refer to the complete piping system which includes:

- Pipes;
- Fittings and tie-ins;
- Connections to the several sanitary appliances (tap connectors), risers, joints (compression);
- Brackets and clips;
- Circulation line;
- Clamps;
- Downstairs cellar installation (risers).

The reference flow shall be reported by means of a **Bill of Components (BoC)** and **Bill of Materials (BoM),** the latter on the level of each component.

The Bill of Components (BoC) shall be specific for the manufacturer of the specific piping system studied in the PEF study. The BoC shall be considered as activity data. The applicant shall use its own BoC and shall add the missing components that are not yet presented in the templates but that are used in reality.

For each component in the BoC a Bill of Materials (BoM) shall be presented in the PEF study. For each component, the BOM shall provide a clear definition of the materials, their qualities, and their quantities per FU. The amounts to be considered for the above listed materials include all additives, fillers, and the like, as used.

The templates for the BoC including the BoM for the three piping systems that are part of the scope of this PEFCR are presented in the tables below. They are an example, and the practitioner has to prepare the actual BoC and BoM of the specific piping system under study.

TEMPLATE MULTILAYER (PEX OR PE-RT/ALUMINIUM/PEX OR PE-RT) PIPING SYSTEM BOC/BOM

Table 2: Template bill of components (BoC)and bill of materials (BoM) for multilayer (PEX or PE-RT/aluminium/PEX or PE-RT) piping system

Multilayer piping system components	Length (m)/pieces (No.) per FU	Multilayer piping system materials	Mass (kg) per FU
Multilayer pipes		Inner layer PE-Xb, or Inner layer PE-RT, or Inner layer PEX Aluminium sheet Outer layer PE-HD, or Outer layer PE-RT, or Outer layer PE Glue (please specify)	
Compression (PPSU) fittings		Composite PPSU EPDM Stainless steel PA	
PVDF fittings		PVDF EPDM	
Copper alloy fittings		Copper alloy EPDM Aluminium Stainless steel PA	
PVDF compression ring		PVDF	
Steel clamps		Galvanised steel	

Should fittings and ancillary components contain other materials than listed in the table, they shall be specified and additionally listed in the table that shall be presented in the PEF study report.

TEMPLATE PEX PIPING SYSTEM BOC/BOM

Table 3: Template bill of components (BoC) and bill of materials (BoM) for PEX piping system

PEX piping system components	Length (m)/pieces (No.) per FU	PEX piping system materials	Mass (kg) per FU
PEX pipes		PEX	
Compression (PPSU) fittings		Composite PPSU Stainless steel	
PEX compression rings		PEX	
Copper alloy fittings		Copper alloy EPDM	
Steel clamps		Galvanised steel	

Should fittings and ancillary components contain other materials than listed in the table, they shall be specified and additionally listed in the table that shall be presented in the PEF study report. Should special coatings (such as polyvinylalcohol coating) be added to the pipes, they shall be included in the BOM as applicable, specifying always the adhesive layer as well as the barrier layer.

3.3.4 Scalability

It is considered that in principle the methodology presented in this PEFCR is suitable for the calculation of the PEF of hot and cold water supply plastic piping systems installed in other types and sizes of buildings.

In case of a specific building project the following essential requirements shall be complied with:

- The environmental assessment shall be based on a piping system design and detailed BoC created for the specific project;
- The requirements for primary and secondary data sets as specified in the PEFCR shall be strictly adhered to;
- The scope is limited to Multilayer (PEX or PE-RT/aluminium/PEX or PE-RT) and PEX hot and cold water supply piping systems;
- Default values for transportation distances shall be adjusted relative to the specific locations of the project site and manufacturing plant;
- The results of this kind of product environmental footprint assessment can only be used for providing the environmental impact data for the piping system selected for the specific building project;
- The PEF results of a specific building pipe system design installed in other types and sizes of buildings, that is not in line with the design specified in the functional unit of this PEFCR, shall not be compared to the benchmark. The results of the benchmark also cannot be modified e.g. be scaled to different size of buildings.

Any comparison with the benchmark can only be made under full compliance with this PEFCR document including the functional unit.

3.4 System boundary

To clearly define the **system boundaries** for PEF studies, the following life cycle stages and processes shall be included in the PEF study as indicated in Table 4. A detailed description of each of the life cycle stages can be found in Chapter 5 (life cycle inventory) of this PEFCR.

Table 4 presents also the processes that shall be considered under the cut-off rules (i.e. excluded from the modeling) for each life cycle stage.

621 *Table 4: Life cycle stages and processes that shall be included and cut-offs related to the respective life cycle stages*

Life cycle stage	Processes which shall be included	Cut-offs , i.e. not considered
Upstream		
LCS1 - **Pre-processing and acquisition of materials for the pipes**	• Extraction and processing of materials (virgin and recycled) for the production of pipes;	• Packaging, their related labels and stickers (and their EoL) for all materials
LCS2 - **Pre-processing and acquisition of materials for the fittings and other pipe system components**	• Extraction and processing of materials (virgin and recycled) for the fittings and other piping system components needed like clamps, compression rings, etc.;	• EPDM rings used with metal clamps • Packaging, their related labels and stickers (and their EoL) for all materials
LCS3 - **Transport of all materials for pipes, fittings and other pipe system components to the manufacturers**	• All transport of all materials for the pipes, fittings and all other pipe system components to their respective manufacturing sites.	
Core business for pipes and fitting		
LCS4 - **Manufacturing processes for the pipes**	• Production process of the pipes, • Cradle to materials acquisition gate life cycle of the packaging of the pipes (extraction and processing of materials for the packaging, packaging production process and transport of the packaging materials to the pipe manufacturer). Heating of the converting plants of the pipes shall be fully included in the manufacturing life cycle inventory data used for the production of the pipes.	• Lubricants (all types) • Ink for printing on the pipes • Infrastructure over the complete life cycle chain[10] • • Internal transport at production site • Environmental impacts caused by the personnel of the production plants[11]

[10] **Capital goods (infrastructure)** are excluded in all life cycle stages when not already included in background dataset. Capital goods are included in the datasets purchased by EC unless there is a clear evidence that they fall under the cut-off rules (then excluded). Capital goods for the foreground processes (production of pipes and fittings) is excluded. This decision was based on the application of the cut-off principle. During the supporting studies infrastructure was identified as having a contribution below the cut-off threshold for the large majority impact categories. It was agreed to include it in the cut-off list based on expert judgement for the impact categories that were not under cut-off due to the low data quality of the dataset.

[11] Environmental impacts caused by the personnel of the production plants shall not be included in the PEF study, e.g. waste from the cafeteria and sanitary installations or accidental pollution caused by human mistakes, or environmental effects caused by commuter traffic.

Life cycle stage	Processes which shall be included	Cut-offs , i.e. not considered
LCS5 - **Manufacturing process of the fittings and all other pipe system components**	• Production process of the fittings and all other components. • Cradle to materials acquisition gate life cycle of the packaging of the fittings, (extraction and processing of materials for the packaging, packaging production process and transport of the packaging materials to the fitting manufacturer). For the other pipe system components the packaging can be neglected. Heating of the converting plants of the fittings shall be fully included in the manufacturing life cycle inventory data used for the production of the fittings.	• Lubricants (all types) • Infrastructure over the complete life cycle chain • Ink for printing on the fittings • Infrastructure over the complete life cycle chain[12] • Internal transport at production site • • Environmental impacts caused by the personnel of the production plants[13]
Downstream		
LCS6 - **Transport of the complete piping system to the building (installation site)**	• Transport of packed pipes, fittings and other pipe system components to building (installation site).	
LCS7 - **Installation of the piping system in the building (apartment)**	• Processes used for the installation of the complete piping system in the building, transport to EoL of packaging materials and EoL of the packaging materials that were used for pipes and fittings and that are released at the building site; • All processes related to any losses during this installation stage (i.e. production, transport, and waste processing and disposal of the lost products).	

[12] **Capital goods (infrastructure)** are excluded in all life cycle stages when not already included in background dataset. Capital goods are included in the datasets purchased by EC unless there is a clear evidence that they fall under the cut-off rules (then excluded). Capital goods for the foreground processes (production of pipes and fittings) is excluded. This decision was based on the application of the cut-off principle. During the supporting studies infrastructure was identified as having a contribution below the cut-off threshold for the large majority impact categories. It was agreed to include it in the cut-off list based on expert judgement for the impact categories that were not under cut-off due to the low data quality of the dataset.

[13] Environmental impacts caused by the personnel of the production plants shall not be included in the PEF study, e.g. waste from the cafeteria and sanitary installations or accidental pollution caused by human mistakes, or environmental effects caused by commuter traffic.

Life cycle stage	Processes which shall be included	Cut-offs , i.e. not considered
LCS8 - **Transport of the pipe system components to EoL**	• Transport of all pipe system components **(pipes, fittings and other pipe system components)** to sorting and EoL treatment facilties (recycling, incineration and/or disposal) after dismantling after 50 years of reference service life time.	
LCS9 - **EoL treatment**	• Sorting of all pipe system components; • EoL treatment of the different pipe system components (pipes, fittings and other pipe system components (incineration, recycling and disposal processes).	

622

According to this PEFCR, the following life cycle stages/ processes are excluded based on the cut-off rule:

- The use stage of the piping system in the building;
- The dismantling of the piping system in the building after 50 years of reference service life time.
- Accidental pollutions are often difficult to distinguish from emissions that occur under normal conditions (accidental pollutions are not measured and reported separately) and do not need to be considered in the PEF study.

The reasons for exclusion of these life cycle stages are explained in ANNEX 4.II – Elements excluded from the reference flow and the system boundaries, as well as based on cut-off rules.

Each PEF study done in accordance with this PEFCR shall provide in the PEF study a diagram indicating the organizational boundary, to highlight those activities under the control of the organization and those falling into Situation 1, 2 or 3 of the data need matrix.
Figure 7 and Figure 8 present the system boundaries for the hot and cold water supply plastic piping systems in the building. Figure 7 presents the system boundaries when the PEF applicant is a pipe producer, where Figure 8 presents the system boundaries when the PEF applicant is a fitting producer.

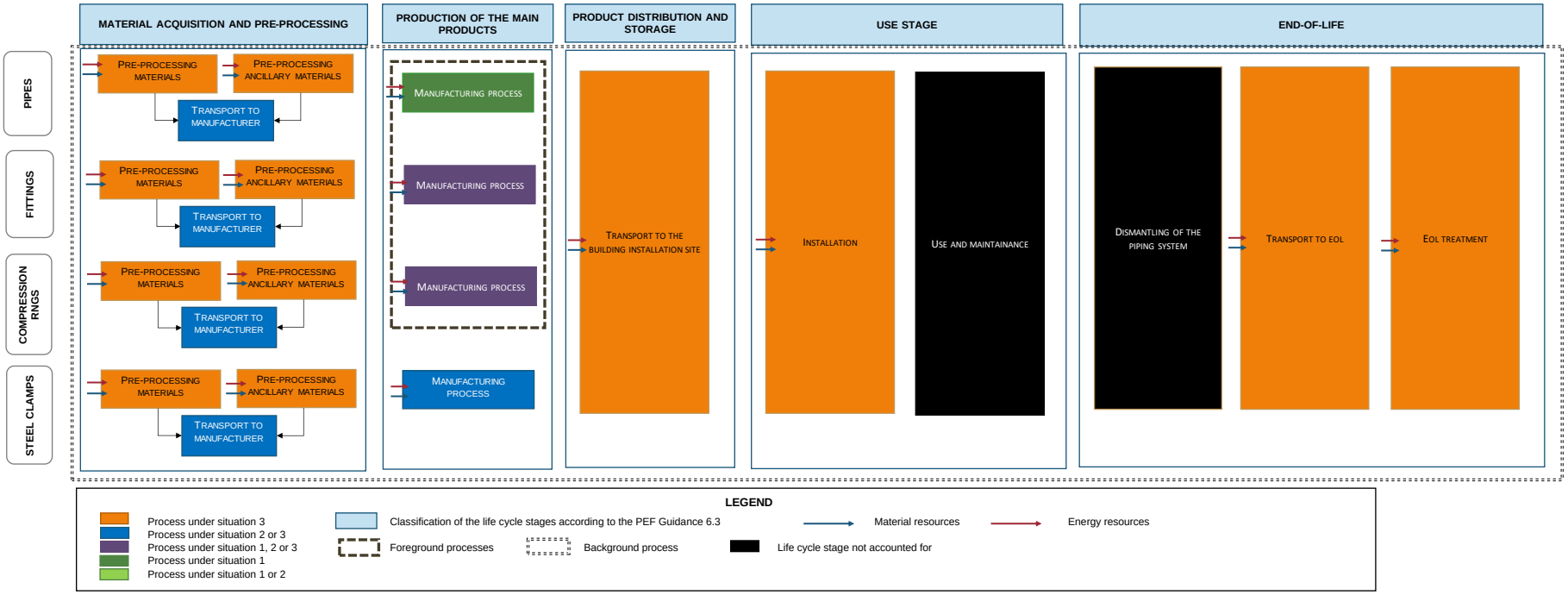


Figure 7: System boundary for hot and cold water supply plastic piping system (for pipe producers)

As per Data Needs Matrix:

Situation 1: the process is run by the company applying the PEFCR;

Situation 2: the process is not run by the company applying the PEFCR but it is possible to have access to (company-)specific information;

Situation 3: the process is not run by the company applying the PEFCR and this company has no possibility to have access to (company-)specific information.

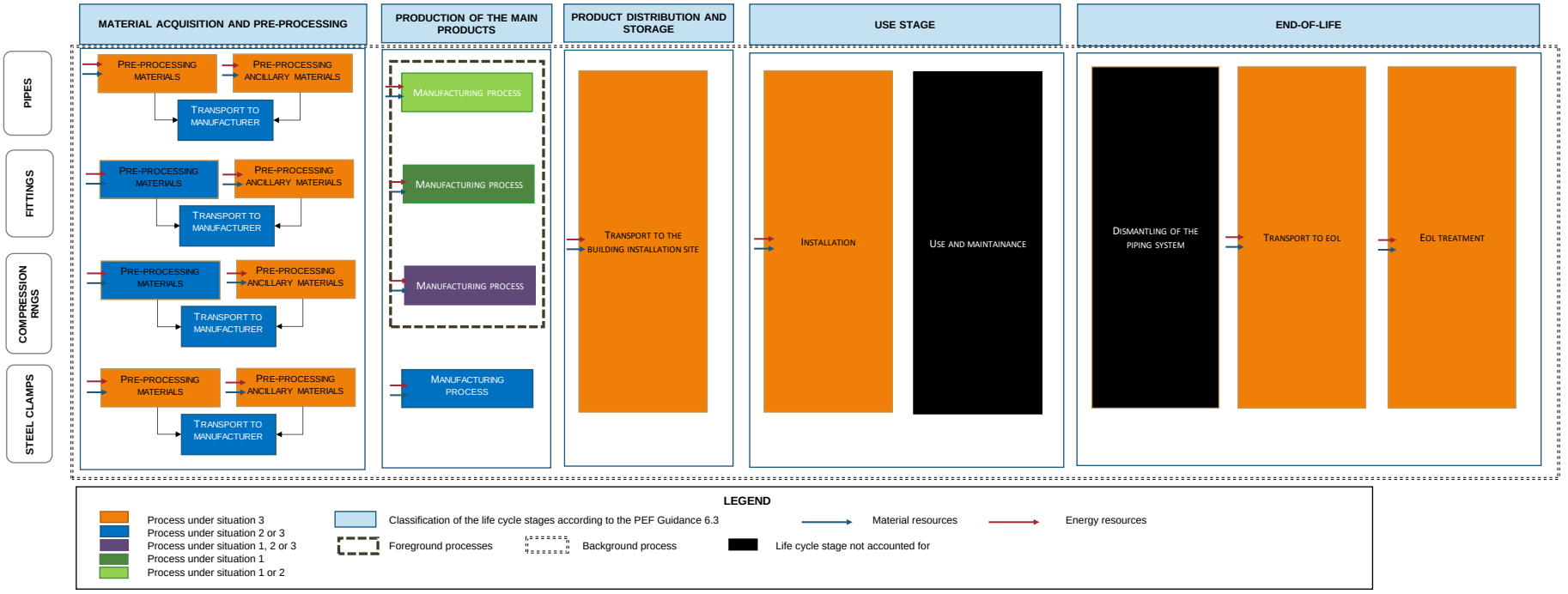


Figure 8: System boundary for hot and cold water supply plastic piping system (for fitting producers)

As per Data Needs Matrix :

Situation 1: the process is run by the company applying the PEFCR;

Situation 2: the process is not run by the company applying the PEFCR but it is possible to have access to (company-)specific information;

Situation 3: the process is not run by the company applying the PEFCR and this company has no possibility to have access to (company-)specific information.

3.4.1 Cut-offs

The cut-off processes, presented in Table 4 (section 3.4 above), were determined based on:

a) the results from the supporting studies[14];
b) expert judgement.

Details on the criteria adopted for defining the cut-off rules are provided in Annex 4.V – Background information on methodological choices taken during the development of the PEFCR Cut-off rules.

Any additional cut-off than those defined in Table 4 shall be clearly documented, be in line with the cut-off rules (demonstrated quantitative lack of environmental relevance) and shall be a mandatory element to be verified by the external verifier(s).

3.5 EF impact assessment

Each PEF study carried out in compliance with this PEFCR shall calculate the PEF-profile including all PEF impact categories listed in the Table below.

Table 5: List of the impact categories to be used to calculate the PEF profile

Impact category	**Indicator**	**Unit**	**Recommended default LCIA method**
Climate change	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 1999 as in WMO assessment
Human toxicity, cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al., 2008)
Human toxicity, non-cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al., 2008)
Particulate matter	Impact on human health	disease incidence	UNEP recommended model (Fantke et al. 2016)
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
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., 2009b) as implemented in ReCiPe

[14] Meaning, each process contributed with less the 1% to the environmental profile, and all of them contributing together no more than 5% to the total environmental profile. Please note that this deviates from the PEFCR guidance 6.3, which indicates a cut-off for those processes that cumulatively contribute up to 1% for all impact categories.

Impact category	Indicator	Unit	Recommended default LCIA method
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N_{eq}	EUTREND model (Struijs et al., 2009b) as implemented in ReCiPe
Ecotoxicity, freshwater*	Comparative Toxic Unit for ecosystems (CTU_e)	CTUe	USEtox model, (Rosenbaum et al., 2008)
Land use	• Soil quality index[15] • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Dimensionless (pt) • kg biotic production[16] • kg soil • m^3 water • m3 groundwater	• Soil quality index based on LANCA (EC-JRC)[17] • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010)
Water use**	User deprivation potential (deprivation-weighted water consumption)	m^3 world $_{eq}$	Available WAter REmaining (AWARE) Boulay et al., 2016
Resource use, 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

*Long-term emissions (occurring beyond 100 years) shall be excluded from the toxic impact categories. Toxicity emissions to this sub-compartment have a characterisation factor set to 0 in the EF LCIA (to ensure consistency). If included by the applicant in the LCI modelling, the sub-compartment 'unspecified (long-term)' shall be used.

**The results for water use might be overestimated and shall therefore be interpreted with caution. Some of the EF datasets tendered during the pilot phase and used in this PEFCR/OEFSR include inconsistencies in the regionalization and elementary flow implementations. This problem has nothing to do with the impact assessment method or the implementability of EF methods, but occurred during the technical development of some of the datasets. The PEFCR/OEFSR remains valid and usable. The affected EF datasets will be corrected by mid-2019. At that time it will be possible to review this PEFCR/OEFSR accordingly, if seen necessary.

***The ADP crustal content/ultimate reserves is considered as an intermediate recommendation in terms of life cycle impact assessment method. The results of this impact category shall be interpreted with caution, because the results of ADP after normalization may be overestimated. The EU Commission in cooperation with industry intends to develop a new method moving from depletion to dissipation model to better quantify the potential for conservation of resources.

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

[16] This refers to occupation. In case of transformation the LANCA indicators are without the year (a)

[17] Forthcoming document on the update of the recommended Impact Assessment methods and factors for the EF

3.6 Limitations

Two types of limitations have been identified, as per below:

1. Limitations on comparability:

    1. Comparisons shall only be made directly against the benchmark and not within and among different PEX systems or different Multilayer piping systems or different piping systems for hot and cold water supply piping systems in buildings;
    2. Any comparison with the benchmark can only be made under full compliance with this PEFCR document including the functional unit.

2. Limitations related to the use of "proxy" datasets as listed below:
    1. Alkylbenzene production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result] – proxy for specific additives in plastic components formulations;
    2. Phenol production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result] – proxy for specific additives in plastic components formulations;
    3. Nylon 6 granulate| reaction of caprolactam with water| production mix, at plant| 1.08 g/cm3 {EU-28+EFTA} [LCI result], i.e. PA 6.6 – proxy for PA;
    4. Plastic granulate secondary (low metal contamination) | from post-consumer plastic waste, via grinding, metal separation, washing, pelletization | production mix, at plant | plastic waste with low metal fraction {EU-28} [Partly terminated system] – proxy for various secondary plastic granulates (PE, PVDF, PPSU, PA, EPDM, PET).
    5. Recycling of copper from clean scrap| collection, transport, pretreatment| production mix, at plant| copper waste, efficiency 90% {EU-28+EFTA} [LCI result] – proxy for secondary copper alloy
    6. Testliner (2015) | technology mix, thermal energy sold/used externally | production mix, at plant | 1.09 kg waste paper input per kg Testliner {EU-27} [Partly terminated system] – proxy for recycled content and recycling process for corrugated board packaging

Other datasets related limitations:

- The datasets used to describe the manufacturing processes for fittings represent only one specific type of manufacturing process/technology.

3. Limitation related to the data gaps, as indicated in Section 5.3 Data gaps:
    - The current PEFCR lists exclusively the aggregated EF secondary datasets for developing PEF profiles. The level-1 EF secondary datasets to be used for Situation 2 are not yet available. The names of the datasets in aggregated and level -1 disaggregated form have the same but different UUIDs. Please note that this implies that for the time being, the EF secondary datasets can be adjusted to a limited degree only, limiting the possible PEF-specificity. Once they will be released by the European Commission, the applicant shall use the appropriate disaggregated datasets that have the same name as indicated in the PEFCR Excel tables, and will indicate the UUID of the dataset used. Alternatively, the user can

728 develop EF compliant new data sets from suppliers' or own data, as specified in detail in
729 the data needs matrix.

4. Most relevant impact categories, life cycle stages and processes

4.1 Most relevant impact categories

The most relevant impact categories for the product group in scope of this PEFCR are the following:

- Climate change
- Resource use, fossils
- Respiratory innorganics
- Resource use, minerals and metals

The background on the definition of the most relevant impact categories is provided in Annex 4.V – Background information on methodological choices taken during the development of the PEFCRof this PEFCR.

Reference to the normalization and weighting methods to be used can be found in Annex 1 of this PEFCR.

4.2 Most relevant life cycle stages

The most relevant life cycle stages for the product group in scope of this PEFCR are the following:

- Pre-processing and acquisition of materials for the pipes;
- Pre-processing and acquisition of materials for the fittings and other pipe system components;
- Manufacturing process of pipes including the life cycle of the packaging for the pipes;
- EoL treatment of the piping system components (pipes, fittings and other pipe system components).

The background on the definition of the most relevant life cycle stages is provided in Annex 4.V – Background information on methodological choices taken during the development of the PEFCR.

4.3 Most relevant processes

The most relevant processes for the product group in scope of this PEFCR are the following:

Table 6: Most relevant processes

Impact categories and most relevant processes	LCS1_ Pre-processing and acquisition of materials for the pipes	LCS2_ Pre-processing and acquisition of materials for the fittings and other pipe system components	LCS4_ Manufacturing process of pipes including the life cycle of the packaging for the pipes	LCS9_ EoL treatment of the piping system components (pipes, fittings and other pipe system components)	Total
Climate change	**45,60%**	**18,27%**	**6,67%**	**11,05%**	**81,59%**
Aluminium ingot mix | primary production | consumption mix, to consumer | aluminium ingot product, primary production {EU-28+EFTA} [LCI result]	27,15%				27,15%
Brass| anode furnace and casting, from copper and zinc, primary production| single route, at plant| 8.41- 8.86 g/cm3 {EU-28+EFTA} [LCI result]		6,54%		5,92%	12,46%
Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, at consumer| 1kV - 60kV {EU-28+3} [LCI result]			6,67%		6,67%
HDPE granulates| Polymerisation of ethylene| production mix, at plant| 0.91- 0.96 g/cm3, 28 g/mol per repeating unit {EU-28+EFTA} [LCI result]	18,45%				18,45%
Polyphenylene Sulfide (PPS)| polycondensation of dichlorobenzene with		5,58%			5,58%

sodium sulfide| production mix, at plant| 1.35 g/cm3 {EU-28+EFTA} [LCI result]					
Polyvinylidene fluoride (PVDF)| polymerisation of vinyl fluoride| production mix, at plant| 1.76 g/cm3 {World} [LCI result]		6,14%			6,14%
Waste incineration of PE| waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment| production mix, at consumer| polyethylene waste {EU-28+EFTA} [LCI result]				5,13%	5,13%
Resource use, fossil	**58,31%**	**16,58%**	**6,40%**		**81,28%**
Aluminium ingot mix | primary production | consumption mix, to consumer | aluminium ingot product, primary production {EU-28+EFTA} [LCI result]	21,16%				21,16%
Brass| anode furnace and casting, from copper and zinc, primary production| single route, at plant| 8.41- 8.86 g/cm3 {EU-28+EFTA} [LCI result]		4,04%			4,04%
Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, at consumer| 1kV - 60kV {EU-28+3} [LCI result]			6,40%		6,40%
HDPE granulates| Polymerisation of ethylene| production mix, at plant| 0.91- 0.96 g/cm3, 28 g/mol per repeating unit {EU-28+EFTA} [LCI result]	37,15%				37,15%
Polyphenylene Sulfide (PPS)| polycondensation of dichlorobenzene with sodium sulfide| production mix, at plant| 1.35 g/cm3 {EU-28+EFTA} [LCI result]		6,48%			6,48%

Polyvinylidene fluoride (PVDF)| polymerisation of vinyl fluoride| production mix, at plant| 1.76 g/cm3 {World} [LCI result]		6,06%			6,06%
Resource use, mineral and metals		**49,49%**		**44,78%**	**94,27%**
Brass| anode furnace and casting, from copper and zinc, primary production| single route, at plant| 8.41- 8.86 g/cm3 {EU-28+EFTA} [LCI result]		49,49%		44,78%	94,27%
Respiratory inorganics	**16,73%**	**49,83%**		**16,37%**	**82,94%**
Aluminium ingot mix | primary production | consumption mix, to consumer | aluminium ingot product, primary production {EU-28+EFTA} [LCI result]	11,96%				11,96%
Brass| anode furnace and casting, from copper and zinc, primary production| single route, at plant| 8.41- 8.86 g/cm3 {EU-28+EFTA} [LCI result]		18,10%		16,37%	34,47%
HDPE granulates| Polymerisation of ethylene| production mix, at plant| 0.91- 0.96 g/cm3, 28 g/mol per repeating unit {EU-28+EFTA} [LCI result]	4,77%				4,77%
Polyphenylene Sulfide (PPS)| polycondensation of dichlorobenzene with sodium sulfide| production mix, at plant| 1.35 g/cm3 {EU-28+EFTA} [LCI result]		4,45%			4,45%
Polyvinylidene fluoride (PVDF)| polymerisation of vinyl fluoride| production mix, at plant| 1.76 g/cm3 {World} [LCI result]		27,29%			27,29%

The background on the definition of the most relevant processes is provided in Annex 4.V – Background information on methodological choices taken during the development of the PEFCR of this PEFCR.

5. Life cycle inventory

All newly created processes shall be EF-compliant.

5.1 List of mandatory company-specific data

The following processes, that are expected to be under the operational control of the company implementing the PEFCR, are considered mandatory company-specific data:

- The manufacturing process of pipes for all applicants to a PEF study, be they either pipes manufacturers or fittings manufacturers. This means that no PEF study compliant with this PEFCR may be carried out without providing the company specific data for the manufacturing process of **pipes** as per the requirements listed below:
  - BoM (type of materials and quantities) of the pipes;
  - Consumption of energy and other consumables for the manufacturing process of pipes;
  - Emissions types and amounts to air and water of the manufacturing process of pipes production;
  - Waste types and amounts produced at the manufacturing stage of pipes production;
  - The collected company specific data must be provided in the table from the PEFCR piping systems Excel file corresponding to the type of pipe used, as indicated in Table 12.

5.2 List of processes expected to be run by the PEF applicant

The processes expected to be run by the company are:

- The manufacturing process of fittings for those producers of pipes that produce also fittings, and for all producers of specific fittings used in the piping systems in the scope of this PEFCR;
- The transport of materials to the pipes manufacturing and/or the transport of the piping system to the installation site.

For the fittings manufacturing run by the PEF applicant, company specific data for the manufacturing process of those **fittings** is required as per the requirements listed below:

  - BoM (type of materials and quantity) of the fittings manufacturing
  - Consumption of energy and other consumables for the manufacturing process of fittings
  - Emissions types and amounts to air and water of the manufacturing process of fittings production
  - Waste types and amounts produced at the manufacturing stage of fittings production
  - The collected company specific data must be provided in the table from the PEFCR piping systems Excel file corresponding to the type of fittings used, as indicated in Table 12.

In case fittings are not produced by the PEF applicant, see the provisions on the use of EF secondary data in Section 6.1.

For the transport of materials and/or the transport of the product to the site, in case these processes are run by the company applying this PEFCR, then the following tables shall be filled in. The table shall be filled in for each typology of transport (truck, material, etc).

Table 7: Template table with data requirements for transportation related processes that are expected to be run by the PEF applicant

	Requirements for data collection purposes			**Requirements for modelling purposes**								**Remarks**
	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)*	*UUID*	*TiR*	*GR*	*TeR*	*P*	*DQR*	
Transport	**Inputs**											
	Distance	Average year	km	*The most appropriate transport dataset among those available in the corresponding EF-node*	http://lcdn.thinkstep.com/Node/							
	Utilisation rate	Average year	%									

5.3 Data gaps

Whenever no specific or generic data that is sufficiently representative of the given process is available, the applicant shall use collected data or a selection of available datasets that is a best available proxy, provided that these proxies meet the minimum DQR requirements.

The following data gaps have been identified due to lacking EF compliant datasets and due to lacking of alternative datasets:

- Recycling at the end of life for wooden pallets (packaging materials).

5.4 Data quality requirements

The data quality of each dataset and the total EF study shall be calculated and reported. The calculation of the DQR shall be based on the following formula with 4 criteria:

$$DQR = \frac{\overline{Te_R}+\overline{G_R}+\overline{Ti_R}+\overline{P}}{4} \quad \text{[Equation1]}$$

where TeR is the Technological-Representativeness, GR is the Geographical-Representativeness, TiR is the Time-Representativeness, and P is the Precision/uncertainty. 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. If a dataset is constructed with company-specific activity data, company -specific emission data and secondary sub-processes, the DQR of each shall be assessed separately.

5.4.1 Company-specific datasets

The score of criterion P cannot be higher than 3 while the score for TiR, TeR, and GR cannot be higher than 2 (the DQR score shall be ≤1.6). 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 sub-processes 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.

2) Calculate the DQR criteria TeR, TiR, GR and P for each most relevant process and. The values of each criterion shall be assigned based on Table 8.

2.a) For mandatory processes, each most relevant elementary flow consists of the amount and elementary flow naming (e.g. 40 g carbon dioxide). For each most relevant elementary flow, evaluate the 4 DQR criteria named TeR-EF, TiR-EF, GR-EF, PEF in Table 8. It shall be evaluated for example, the timing of the flow measured, for which technology the flow was measured and in which geographical area.

2.b) Each most relevant process is a combination of activity data and the secondary dataset used. For each most relevant process, the DQR is calculated by the applicant of the PEFCR as a combination of the 4 DQR criteria for activity data and the secondary dataset: (i) TiR and P shall be evaluated at the level of the activity data (named TiR-AD, PAD) and (ii) TeR, TiR and GR shall be evaluated at the level of the secondary dataset used (named TeR-SD , TiR-SD and GR-SD). As TiR is evaluated twice, the mathematical average of TiR-AD and TiR-SD represents the TiR of the most relevant process.

3) Calculate the environmental contribution of each most-relevant process to the total environmental impact of all most-relevant processes, in % (weighted using 13 EF impact categories, with the exclusion of the 3 toxicity-related ones). For example, the newly developed dataset has only two most relevant processes, contributing in total to 80% of the total environmental impact of the dataset:

- Process 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).
- Process 1 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, GR and P criteria of the newly developed dataset as the weighted average of each criterion of the most relevant processes and direct elementary flows. The weight is the relative contribution (in %) of each most relevant process and direct elementary flow calculated in step 3.

5) The applicant of the PEFCR shall calculate the total DQR of the newly developed dataset using the equation B.2, where $\overline{Te_R}, \overline{G_R}, \overline{Ti_R}, \bar{P}$ are the weighted average calculated as specified in point 4).

$$DQR = \frac{\overline{Te_R}+\overline{G_R}+\overline{Ti_R}+\bar{P}}{4}$$ [Equation.2]

NOTE: in case the newly developed dataset has most relevant processes filled in by non-EF compliant datasets (and thus without DQR), then these datasets cannot be included in step 4 and 5 of the DQR calculation. (1) The weight of step 3 shall be recalculated for the EF-compliant datasets only. Calculate the environmental contribution of each most-relevant EF compliant process and elementary flow to the total environmental impact of all most-relevant EF compliant processes and elementary flows, in %. Continue with step 4 and 5. (2) The weight of the non-EF compliant dataset (calculated in step 3) shall be used to increase the DQR criteria and total DQR accordingly. For example:

- Process 1 carries 30% of the total dataset environmental impact and is ILCD entry level compliant. The contribution of this process to the total of 80% is 37.5% (the latter is the weight to be used).
- Process 1 carries 50% of the total dataset environmental impact and is EF compliant. The contribution of this process to all most-relevant EF compliant processes is 100%. The latter is the weight to be used in step 4.
- After step 5, the parameters $\overline{\mathrm{Te_R}}$, $\overline{\mathrm{G_R}}$, $\overline{\mathrm{Ti_R}}$, $\overline{\mathrm{P}}$ and the total DQR shall be multiplied with 1.375.

Table 8: How to assess the value of the DQR criteria for datasets with company-specific information

	P_{EF} and P_{AD}	$Ti_{R\text{-}EF}$ and $Ti_{R\text{-}AD}$	$Ti_{R\text{-}SD}$	$Te_{R\text{-}EF, TeR\text{-}AD,}$ and $Te_{R\text{-}SD}$	$G_{R\text{-}SD}$
1	Measured/calculated and externally verified	The data refers to the most recent completed annual administration period with respect to the EF report publication date. The end of the period must not be more than 12 months prior to the EF report publication date.	The EF report publication happens within the time validity of the dataset [18]	The kinds and amounts of the elementary flows and of the products and services represented by the secondary datasets reflect exactly the pipes/fittings manufacturing process of the newly developed dataset	The data(set) reflects the geographical location of the products or services represented by the secondary dataset
2	Measured/calculated and internally verified, plausibility checked by verifier	The data refers to the second most recent completed annual administration period with respect to the EF report publication date. The end of the period must not be more than 24 months prior	The EF report publication happens not later than 2 years beyond the time validity of the dataset	The kinds and amounts of the elementary flows and the products and services represented by the secondary datasets sufficiently well reflect the pipes/fittings manufacturing while they are derived	The data(set) sufficiently reflects the key characteristics of the geographical location of the products or services represented by the secondary datasets, in terms of electricity mix and development status regarding technology and environmental

[18] The time validity of a data set is surpassed automatically, if the production processes of the compay have been substantialy altered compared to the operations for which the primary data has been collected either resulting in higher values of consumables or emissions OR a different technology of the actual production process(es) has been implemented.

	P_{EF} and P_{AD}	$Ti_{R\text{-}EF}$ and $Ti_{R\text{-}AD}$	$Ti_{R\text{-}SD}$	$Te_{R\text{-}EF, TeR\text{-}AD,}$ and $Te_{R\text{-}SD}$	$G_{R\text{-}SD}$
		to the EF report publication date.		from multiple production lines (including the actual line) or from site level	legislation, and is located in the same region (e.g Europe, Latin America, …)
3	Measured/calculated and plausibility not checked by verifier OR Qualified estimate based on calculations with plausibility checked by verifier	The data refers to the third most recent completed annual administration period with respect to the EF report publication date. The end of the period must not be more than 36 months prior to the EF report publication date.	Not applicable	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

5.5 Data needs matrix (DNM)

All processes required to model the product and outside the list of mandatory company-specific shall be evaluated using the Data Needs Matrix (see **Table 9**). The DNM shall be used by the PEFCR applicant to evaluate which data is needed and shall be used within the modelling of its PEF, depending on the level of influence the applicant (company) has on the specific process. The following three cases can be 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.

890 *Table 9: Data Needs Matrix (DNM)[19] *Disaggregated datasets shall be used*

		Most relevant process	Other process
Situation 1: process run by the company applying the PEFCR	**Option 1**	Provide company-specific data (as requested in the PEFCR) and create a company specific dataset partially disaggregated at least at level 1 (DQR ≤1.6). Calculate the DQR values (for each criteria + 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 applying 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 partially disaggregated at least at level 1 (DQR ≤1.6). Calculate the DQR values (for each criteria + 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 PEF 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 PEF compliant datasets (DQR ≤4.0). Use the default DQR values
Situation 3: process not run by the company applying the PEFCR and without access to (company)-specific information	**Option 1**	Use default secondary dataset, in aggregated form (DQR ≤3.0). Re-evaluate the DQR criteria within the product specific context	
	Option 2		Use default secondary dataset in PEFCR, in aggregated form (DQR ≤4.0) Use the default DQR values

891

[19] The options described in the DNM are not listed in order of preference

5.5.1 Processes in 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 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 company applying the PEFCR uses company specific data. The DQR of the newly developed dataset shall be evaluated as described in section B.5.4.1.

Situation 1/Option 2

For the non-most relevant processes only, if the applicant decides to model the process without collecting company-specific data, then the applicant 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 applicant of the PEFCR shall take the DQR values from the metadata of the original dataset.

5.5.2 Processes in situation 2

When a process is not run by the company applying the PEFCR, but there is access to company-specific data, then there are three possible options:

- The company applying the PEFCR has access to extensive supplier-specific information and wants to create a new EF-compliant dataset[20] (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 prefers to use a secondary dataset (Option 3).

Situation 2/Option 1

For all processes run by the company and where the company applying the PEFCR uses company specific data. The DQR of the newly developed dataset shall be evaluated as described in section 5.4.

Situation 2/Option 2

Company-specific activity data for transport are used and the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets are substituted 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.

[20] The review of the newly created dataset is optional

The applicant of the PEFCR shall make the DQR values of the dataset used context-specific by re-evaluating Te_R and Ti_R, using the table(s) provided in Section 5.4.1. The criteria G_R shall be lowered by 30%[21] and the criteria P shall keep the original value.

Situation 2/Option 3

For the non-most relevant processes, the applicant may use 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 applicant of the PEFCR shall take the DQR values from the original dataset.

Table 10: How to assign values to parameters in the DQR formula when secondary datasets are used

	TiR	TeR	G_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	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

5.5.3 Processes in situation 3

When a process is not run by the company applying 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)

[21] In situation 2, option 2 it is proposed to lower the parameter G_R by 30% in order to incentivize 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.

Situation 3/Option 1

In this case, the applicant of the PEFCR shall make the DQR values of the dataset used context-specific by re-evaluating Te_R, Ti_R and G_r, using the table(s) provided. The criteria P shall keep the original value.

Situation 3/Option 2

For the non-most relevant processes, the applicant shall use 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 applicant of the PEFCR shall take the DQR values from the original dataset.

5.6Which datasets to use?

The secondary datasets to be used by the applicant are those listed in this PEFCR.

Due to secondary datasets limited availability the current PEFCR is applicable only with the indicated aggregated datasets. The use of level-1 datasets will be reviewed and included in the PEFCR accordingly once they will become available.

Whenever a dataset needed to calculate the PEF-profile is not among those listed in this PEFCR, then the applicant shall choose between the following options (in hierarchical order):

- Use an EF-compliant dataset available on one of the following nodes:
  - http://eplca.jrc.ec.europa.eu/EF-node
  - http://lcdn.blonkconsultants.nl
  - http://ecoinvent.lca-data.com
  - http://lcdn-cepe.org
  - https://lcdn.quantis-software.com/PEF/
  - http://lcdn.thinkstep.com/Node
- 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 "limitation" section of the PEF report.
- Use an ILCD-entry level-compliant dataset. In such case this information shall be included in the "data gap" section of the PEF report.

5.7How to calculate the average DQR of the study

In order to calculate the average DQR of the EF study, the applicant shall calculate separately the TeR, TiR, GR and P for the EF study as the weighted average of all most relevant processes, based on their relative environmental contribution to the total single score (excluding the 3 toxicity-related ones). The calculation rules explained in PEFCR Guidance 6.3 chapter 5.4 shall be used.

5.8 Allocation rules

For all foreground processes mass allocation shall be applied whenever direct measurements of energy consumption at the converting plants (pipes and fittings) are not available.

In case a secondary dataset is replaced with a newly created one, then the same allocation as in the replaced dataset shall be applied.

5.9 Electricity modelling

The guidelines in this section shall only be used for the processes where company-specific information is collected (situation 1 / Option 1 & 2 / Option 1of the DNM).

The following electricity mix shall be used in hierarchical order:

(i) Supplier-specific electricity product shall be used if:
   (a) available, and
   (b) the set of minimum criteria to ensure the contractual instruments are reliable is met.

(ii) The supplier-specific total electricity mix shall be used if:
   (a) available, and
   (b) the set of minimum criteria that to ensure the contractual instruments are reliable is met.

(iii) As a last option the 'country-specific residual grid mix, consumption mix' shall be used (available at http://lcdn.thinkstep.com/Node/). Country-specific means the country in which the life cycle stage occurs. This can be an EU country or non-EU country. The residual grid mix characterizes the unclaimed, untracked or publicly shared electricity. This prevents double counting with the use of supplier-specific electricity mixes in (i) and (ii).

Note: if for a country, there is a 100% tracking system in place, case (i) shall be applied.

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 minimal criteria to ensure contractual instruments from suppliers:

A supplier-specific electricity product/mix may only be used when the applicant ensures that any contractual instrument meets the criteria specified below. If contractual instruments do not meet the criteria, then 'country-specific residual grid mix, consumption mix' shall be used in the modelling.

A contractual instrument used for electricity modelling shall:

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 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.

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).

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

<u>Modelling 'country-specific residual grid mix, consumption mix':</u>

Datasets for residual grid mix, per energy type, per country and per voltage have been purchased by the European Commission and are available in the dedicated node (http://lcdn.thinkstep.com/Node/). In case the necessary dataset is not available, an alternative dataset shall be chosen according to the procedure described in section 5.7. If no dataset is available, the following approach may 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 combined 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 can be found in the publications of the International Energy Agency (IEA).

- Available LCI datasets per fuel technologies in the node. 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:

Table 11: Allocation rules for electricity

Process	***Physical relationship***	***Modelling instructions***
Manufacturing process of pipes (ML, PEX)	Mass	Based on total annual consumption of the next higher level for which the data is available (e.g. line, building, or site, but not across sites)

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 can be allocated to one specific product in the following conditions:

a. The production (and related electricity consumption) of a product occurs in a separate site (building), the energy type physical related to this separated site can be used.
b. 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) can be used.
c. All the products produced in the specific plant are supplied with a public available PEF study. The company who wants 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 can 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 can 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 wind mill on its production site and export 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[22].
- Subdivision is considered as not possible when upstream impacts or direct emissions are closely related to the product itself.

5.10 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 andcalcination/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 (CO_2, CO and CH_4) 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[23] shall be modelled under sub-category 3 (incl. connected soil emissions, derived products, residues). The emission flows ending with '(biogenic)' shall be used.

   A simplified modelling approach shall be used when modelling the foreground emissions: "Only the emission 'methane (biogenic)' is modelled, while no further biogenic emissions and uptakes from 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."Does the product life cycle or part of the life cycle has a lifetime beyond 100 years and therefore credits from biogenic carbon storage shall NOT be modelled.

Temporary benefits of carbon storage and delayed emissions shall not be considered in the calculation of the environmental footprint for the default impact categories in the PEF studies.

3. Climate change – land use and land transformation: 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 (incl. 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[24] and residues), while their CO_2 uptake is excluded. The emission flows ending with '(land use change)' shall be used.

[22] For some countries, this option is a best case rather than a worst case.

[23] 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.

[24] 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. 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.

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 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.

Soil carbon storage shall be modelled, calculated and reported as additional environmental information.

The sum of the three sub-categories shall be reported.

The sub-category 'Climate change-biogenic' shall NOT be reported separately.

The sub-category 'Climate change-land use and land transformation' shall NOT be reported separately.

5.11 Modelling of wastes and recycled content

The waste 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 gives guidelines on how to model the End-of-Life of products as well as the recycled content.

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

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

Disposal $(\mathbf{1}-\mathbf{R_2}-\mathbf{R_3})\times\mathbf{E_D}$

The Circular Footprint Formula is used to model the End-of-Life of products as well as the recycled content:

Production burdens	$(1 - R_1)E_V + R_1 \times E_{recycled}$	**Cradle-to-gate**
Burdens and benefits related to secondary materials input	$-(1 - A)R_1 \times \left(E_{recycled} - E_V \times \frac{Q_{Sin}}{Q_P}\right)$	
Burdens and benefits related to secondary materials output	$(1 - A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P}\right)$	**Additional information from the EoL stage**
Energy recovery	$(1 - B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$	
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.

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 unit of analysis) 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 unit of analysis) arising from the recycling process at EoL, including collection, sorting and transportation process.

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

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

EER: specific emissions and resources consumed (per unit of analysis) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, …).

$E_{SE,heat}$ and $E_{SE,elec}$: specific emissions and resources consumed (per unit of analysis) that would have arisen from the specific substituted energy source, heat and electricity respectively.

ED: specific emissions and resources consumed (per unit of analysis) 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.

6. Life cycle stages

Under section 6.1 the information necessary for developing the life cycle stages 1 to 5 are provided. Furthermore, in sections 6.2 to 6.4 the information for life cycle stages 6 to 9 are presented.

The details of all the information necessary to model each life cycle stage, and the secondary datasets to be used per system, are available in the Excel file "PEFCR piping systems_life cycle stages" (PEFCR Excel file) downloadable at

http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm.

In case one or more of the datasets needed to model a life cycle stage are not available among those included in the PEFCR piping systems Excel file, the applicant shall identify an appropriate dataset according to the procedure in section 5.6.

Table 12 below presents the overview with the tables included in PEFCR piping systems Excel file, which presents the necessary information for modelling the life cycle stages per system.

Table 12: Overview with the tables included in PEFCR piping systems Excel file, presenting the information necessary for modelling the life cycle stages, including secondary datasets, scenarios and default values for each piping system

NOTE: Special attention to be given to the specific multiplication factors for each material. Details on how it should be done are reported in the PEFCR Excel file.

LCS1 - Pre-processing and acquisition of materials for the pipes	Table C.II. ML pipes: default datasets for the pre-processing and acquisition of materials and mandatory company-specific data for the manufacturing process of pipes	Table D.II. PEX pipes: default datasets for the pre-processing and acquisition of materials and mandatory company-specific data for the manufacturing of pipes
	Table B.I. System materials modelling: application of the circular footprint formula	
LCS2 - Pre-processing and acquisition of materials for the fittings and other pipe system components	Table C.IV. ML components: default datasets for materials and manufacturing for fittings and all other system componentsfor the ML piping system	Table D.IV. PEX components: default datasets for materials and manufacturing for fittings and all other system components for the PEX system
	Table B.I. System materials modelling: application of the circular footprint formula	
LCS3 - Transport of all materials for pipes, fittings and other pipe system components to the manufacturers	Table G.I. Transport - secondary datasets for transportation modes across the supply chain	
	Table G.II. Transport materials: default processes and activity data to be collected	
LCS4 - Manufacturing process of pipes	Table C.II. ML pipes: default datasets for the pre-processing and acquisition of materials and mandatory company-specific data for the manufacturing process of pipes*	Table D.II. PEX pipes: default datasets for the pre-processing and acquisition of materials and mandatory company-specific data for the manufacturing of pipes*
	Table C.III. ML pipes: emissions to be collected for the ML pipes manufacturing process*	Table D.III. PEX pipes: emissions to be collected for the PEX pipes manufacturing process*
	Table B.II. Packaging modelling: application of the circular footprint formula	
	Table G.III. Transport packaging: default secondary datasets and activity data to be collected for transportation of packaging materials used for pipes	
LCS5 - Manufacturing process of fittings and all other pipe system components	Table C.IV. ML components: default datasets for materials and manufacturing for fittings and all other system componentsfor the ML piping system	Table D.IV. PEX components: default datasets for materials and manufacturing for fittings and all other system components for the PEX system

	Table E.III. Injection moulding: default datasets and activity data to be collected for the manufacturing plastic components**
	Table E.IV. Injection moulding: emissions to be collected for the manufacturing process of plastic components**
	Table E.I. Copper alloy fittings: default datasets and activity data to be collected for the manufacturing of copper alloy fittings**
	Table E.II. Copper alloy fittings - emissions to be collected for the production of copper alloy fittings**
	Table B.II. Packaging modelling: application of the circular footprint formula
	Table G.III. Transport packaging: default secondary datasets and activity data to be collected for transportation of packaging materials used for pipes
LCS6 - Transport of complete packed piping system to the installation site	Table G.I. Transport - secondary datasets for transportation modes across the supply chain
	Table G.IV. Transport to installation: default secondary datasets and activity data to be collected
LCS7 - Installation of the piping system in the building	Table F.I. Installation: default inputs and outputs for the installation phase
	Table B.II. Packaging modelling: application of the circular footprint formula
	Table G.V. Transport EOL Packaging: Default secondary datasets and activity data to be collected for transportation to EoL of system components and their packaging
	Table H.II. EoL scenarios for packaging materials
LCS8 - Transport of the piping system components to EoL	Table G.I. Transport - secondary datasets for transportation modes across the supply chain
	Table G.V. Transport EOL: default secondary datasets and activity data to be collected for transportation to EoL of system components and their packaging
LCS9 - EoL treatment of the piping system components	Table H.I. EOL scenarios for system materials
	Table B.I. System materials modelling: application of the circular footprint formula
	Table G.VI. Subtraction transport to EOL: default datasets to be used at the EoL modelling to avoid double counting of transportation of the waste flows

* Table to be filled for mandatory company-specific data

**Table to be filled for processes expected to be run by the company

1233

6.1 Pre-processing and acquisition of materials, their transport to the manufacturers and corresponding manufacturing processes

6.1.1 General considerations

6.1.1.1 Material acquisition and pre-processing

The applicant shall report the DQR values (for each criterion + total) for all the datasets used.

Modelling the recycled content (if applicable)

The following 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 or default as provided in the table above, in relation with the DNM. Material-specific values based on supply market statistics are not accepted as a proxy. 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 general 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 his 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 can be applied as long as they cover the general guidelines outlined above.

6.1.1.2 Manufacturing

The applicant shall report the DQR values (for each criterion + total) for all the datasets used.

The secondary datasets can be replaced by specifically collected ones with a higher data quality (i.e. a lower DQR score), as per the default datasets substitution rules. All newly created processes shall be EF-compliant.

The waste of products used during the manufacturing shall be included in the modelling.

6.1.2 Pre-processing and acquisition of materials for the pipes

This life cycle stage shall include material extraction and processing as well as processing of secondary material (e.g. recycling processes) that are needed for the production of pipes.

Default data records to be used in modelling are presented in the PEFCR piping systems Excel file, as indicated in Table 12. The secondary datasets can be replaced by specifically collected ones with a lower DQR score, as per the default datasets substitution rules in section 5.6. Additional ingredients specific to the application under study shall be included.

6.1.3 Transport of all materials for pipes to the manufacturers of the pipes

All transportation processes across the products supply chain shall be modelled using secondary datasets. Activity data to be collected are **distance**, **transport mode**, **utilisation ratio**.

The list of processes as well as the default activity data to be collected for the transportation of all materials used in the system are presented in the PEFCR piping systems Excel file as indicated in Table 12. Whenever no primary data is available, the default scenarios can be used. In case one or more of the processes needed are not among those indicated by default, the approach reported in section 5.6 shall be applied.

If the **load of the truck is mass limited**: a default utilisation ratio of 64% shall be used if the real load rate is unknown. This utilisation ratio includes empty return trips. Therefore, empty returns shall not be modelled separately. If a specific load rate is used based on primary data, the empty returns shall be accounted for. If information about the empty returns is lacking, a default value of 30% shall be assumed.

6.1.4 Manufacturing process of pipes

Inputs (energy, packaging materials, recipe of materials) and outputs (emissions, waste, co-products) related to the production of the pipes, including the ancillary materials, shall be included in this life cycle stage.

6.1.4.1 Process related inputs

The overview of the data to be collected, indicating the default datasets and the activity data for the piping system, as well as the requirements for data collection and the lists with emissions to be reported for each system are presented in the PEFCR piping systems Excel file, as indicated in Table 12.

The period for which data is to be collected is fixed to 1 year.

6.1.4.2 Inputs related to the packaging for the pipes

The acquisition of the materials for the packaging, their production process and transportation to the manufacturers of the pipes shall be included in the manufacturing stage. This shall include the material extraction and processing as well as processing of secondary material (e.g. recycling

processes) needed for the production of the packaging materials, and the production process of the packaging materials.

Default data records to be used in modelling of the materials are presented in the PEFCR piping systems Excel file, as indicated in Table 12. An overview of the modelling of packaging materials using the circular footprint formula is provided. The circular footprint formula has to be applied for modelling of the production of the different packaging materials and the related transportation steps. The used datasets and the application of the circular footprint formula is presented using the same structure as for the main materials.

Wherever not already included in the materials dataset for plastic packaging, the default datasets to be used to model the production process for plastic packaging is the film extrusion dataset indicated in the table.

Reusable packaging shall account for the additional energy and resource used for cleaning, repairing or refilling.

For the transportation of the packaging materials to production plants semi-specific data may be used. Activity data to be collected for the transport of packaging materials to production plants are **distance, transport mode, utilisation ratio**. When not available, the default scenario that shall be used is provided in the PEFCR piping systems Excel file, as indicated in Table 12.

6.1.4.3 Outputs - production waste from the manufacturing process and packaging waste

Production waste and packaging waste related to the production of pipes need to be transported over an average distance from the producers of the pipes to a specific waste treatment facility. The list of processes as well as the default activity data to be collected for the transport to end of life for the production waste are detailed in the PEFCR piping systems Excel file, as indicated in Table 12.

The EoL treatment scenarios for packaging materials shall apply unless specific scenarios are available. For the packaging that is reused, the reuse rate determines the quantity of packaging material (per product sold) to be treated at end of life. The amount of packaging treated at end of life shall be calculated by dividing the actual weight of the packaging by the number of times this packaging was reused. The list of processes as well as the default activity data to be collected are detailed in the PEFCR piping systems Excel file, as indicated in Table 12.

If Euro-flat pallets are used, they are considered as being used 25 times[25].

[25] PEF Guidance 6.3, Section 7.16.2

6.1.5 Pre-processing and acquisition of materials for the fittings and other pipe system components

This life cycle stage shall include material extraction and processing as well as processing of secondary material (e.g. recycling processes) for the production of fittings and all other pipe system components).

Default data records to be used in modelling are presented in the PEFCR piping systems Excel file, as indicated in Table 12.

6.1.6 Manufacturing process of the system components

Inputs (energy, recipe of materials) and outputs (emissions, waste, co-products) related to the production of the system components, including the ancillary materials shall be included in this life cycle stage. The overview of the data to be collected, indicating the default datasets and the activity data are presented in the PEFCR piping systems Excel file, as indicated in Table 12. Appropriate attention shall be paid to the situation when the components are under the operational control (level 1 of influence) of the PEF applicant (or not), for which specific requirements for data collection and lists with emissions to be reported apply.

The period for which data is to be collected is fixed to 1 year.

6.1.7 Transport of all materials for fittings and other pipe system components to the manufacturers of the fittings and other pipe system components

All transportation processes across the products supply chain shall be modelled using secondary datasets. Activity data to be collected are **distance**, **transport mode**, **utilisation ratio**.

The list of processes as well as the default activity data to be collected for the transportation of all materials used in the system are presented in the PEFCR piping systems Excel file as indicated in Table 12. Whenever no primary data is available, the default scenarios can be used. In case one or more of the processes needed are not among those indicated by default, the approach reported in section 5.6 shall be applied.

6.2 Distribution stage - Transport of complete packed piping system to the installation site

The transport from factory to final client (including consumer transport) shall be modelled within this life cycle stage. The final client is defined as the end user at the installation side.

In case supply-chain-specific information is available for one or several transport parameters, they may be applied following the Data Needs Matrix.

The applicant shall report the DQR values (for each criterion + total) for all the datasets used.

The waste of products during the distribution and retail shall be included in the modelling.

All transportation processes across the products supply chain shall be modelled using secondary datasets. Activity data to be collected are **distance, transport mode, utilisation ratio**. Whenever no primary data is available, the default scenario's can be used.

The list of processes as well as the default activity data to be collected for the transportation to installation site of all materials used in the system are presented in the PEFCR piping systems Excel file as indicated in Table 12. Whenever no primary data is available, the default scenarios can be used. In case one or more of the processes needed are not among those indicated by default, the approach reported in section 5.6 shall be applied.

If the **load of the truck is mass limited**: a default utilisation ratio of 64% shall be used if the real load rate is unknown. This utilisation ratio includes empty return trips. Therefore, empty returns shall not be modelled separately. If a specific load rate is used based on primary data, the empty returns shall be accounted for. If information about the empty returns is lacking, a default value of 30% shall be assumed.

6.3 Installation of the piping system in the building

This life cycle stage shall include all input and output flows involved during the installation of the piping system. The inputs and outputs of processes as well as the default activity data to be considered for the installation phase are presented in the PEFCR piping systems Excel file as indicated in Table 12.

Thus, all waste, all energy consumption, use of any other resource or any other flow[26] shall be reported in this life cycle stage. Reporting of the waste flows shall include all the different related steps, from its collection at the building site until its End-of-Life. Default scenario for the transport of the packaging waste to EOL as well as the EoL treatment scenarios for packaging materials provided in section in the PEFCR piping systems Excel file, as indicated in Table 12 shall apply unless specific scenarios are available.

[26] Watrer for testing is excluded from system boundaries

Installation of the piping system in the building is considered to be performed according to good and environmentally sound installation practices. Therefore, no cutting waste is generated.

Whenever no primary data is available, the default scenarios can be used. In case one or more of the processes needed are not among those indicated by default, the approach reported in section 5.6 shall be applied.

6.4 End of life of the piping system

The End-of-Life stage is a life cycle stage that in general includes the waste of the product in scope, such as the food waste, primary packaging, or the product left at its end of use.

The applicant shall report the DQR values (for each criterion + total) for all the datasets used.

The end of life shall be modelled using the formula and guidance provided in chapter5.11 of this PEFCR together with the default parameters listed in the PEFCR Excel file.

Before selecting the appropriate R_2 value, an evaluation for recyclability of the material shall be done and the PEF study shall include a statement on the recyclability of the materials/products. The statement on the 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[27].

Following the evaluation for recyclability, the appropriate R_2 values (supply-chain specific or default) shall be used. If one criteria is not fulfilled or the sector-specific recyclability guidelines indicate a 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 when available. If no company-specific values are available and the criteria for 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, then the European average shall be used.

[27] E.g. the EPBP design guidelines (http://www.epbp.org/design-guidelines), or Recyclability by design (http://www.recoup.org/)

- 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.

6.4.1 Dismantling of the piping system in the building after 50 years of reference service life time

The dismantling of the piping sytem in the building after 50 years of reference service life time is excluded in PEF studies for hot and cold water supply piping systems, being identified as a cut-off process. Impacts of this life cycle stage have been identified as negligible during the screening studies and confirmed by the supporting studies.

6.4.2 Transport of the piping system components (pipes, fittings and other pipe system components) to EOL

Default scenario for the transport of the piping system components (pipes, fittings and other pipe system components) to EOL is presented in the PEFCR piping systems Excel file as indicated in Table 12. Whenever no primary data is available, the default scenarios can be used. In case one or more of the processes needed are not among those indicated by default, the approach reported in section 5.6 shall be applied.

6.4.3 EOL treatment of the piping system components (pipes, fittings and other pipe system components)

For the pipes, fittings and other components the default EoL scenario presented below shall be considered when specific scenarios are not available, depending on the type of component:

- The components that consists of plastics[28]: 45,25% incinerated and 54,75% landfilled[29].
  - Exception: in situation when small metal parts are part of mainly plastic components (such as fittings) the entire component (with the metal parts included) will follow the EoL scenario of the plastic component. Below are examples of such situations based on the template BoM/BoC.
    - **Stainless steel** (45,25% incineration + 54,75% landfill) – as part of PPSU fittings
    - **Aluminium** (45,25% incineration + 54,75% landfill) – as part of the ML pipe.

[28] Some materials have more than one end-of-life route, depending on their application. For example in the copper alloy fitting for the multilayer system a small part of polyamide (PA) is used in the metal fitting. The metal part of the fitting will go for 95% to recycling and for 5% to landfill. It is assumed that the small PA part in the fitting is incinerated within the melting furnace of the metal recycling facility, as it is highly unlikely to be removed from the fitting at the dismanteling of the system. The EoL for this small amount of PA is covered by 'PA (95% incineration + 5% landfill)'. Other option for the EoL scenario for PA is 'PA (45,25% energy recovery + 54,75% landfill)'. In this case the fitting is mainly or completely made of plastic materials which follow the end-of-life scenario 45,25% to incineration with energy recovery and 54,75% to landfill.

[29] Scenario is based on information provided by PlasticsEurope (2016).

- The components that consists of metals: 95% recycled and 5% landfilled (deviation from Annex C justified by the practice on the ground, as 5% metals that cannot be sent to recycling will never be sent to incineration but to landfill);
    - Exception: in situation when small plastic parts are part of mainly metal components (such as copper alloy fittings) the entire component (with the plastic parts included) will follow the EoL scenario of the metal component. Below are examples of such situations based on the template BoM/BoC.
        - **PA** (95% incineration without energy recovery during the recycling process of the metal + 5% landfill) [30] – as part of copper alloy fittings;
        - **EPDM** (95% incineration without energy recovery during the recycling process of the metal + 5% landfill) [31] – as part of copper alloy fittings;
    - Exception: in situation when small metal parts are part of mainly metal components (such as copper alloy fittings) the entire component (with the metal parts included) will follow the EoL scenario of the main component. Below are examples of such situations based on the template BoM/BoC.
        - **Aluminium** (95% incineration without energy recovery + 5% landfill), as part of production scrap of copper alloy fittings);
        - **Stainless steel** (95% incineration without energy recovery + 5% landfill), part of copper alloy fittings).
- Metals contained in the pipes: % of aluminium recovery from incinerator bottom ash (if any) shall be documented.

The modelling of alternative End-of-Life treatment is only possible for production waste and packaging waste and shall be documented and justified.

Default data records to be used in modelling are presented in the PEFCR piping systems Excel file as indicated in Table 12. To be noted that landfilling and incineration EF datasets are aggregated datasets, with EoL transport scenario included. However, in this PEFCR a separate modelling of End of Life transport and End of Life treatment are specified. To avoid double counting and to be able to use the available datasets, the impact of transport shall be subtracted from the EF End of Life treatment datasets when needed. The following steps shall be applied:

- For the corresponding EoL treatment check if the transport processes named **converter** are used.
- If the two converter processes are passenger car and transport **converter** then the transport shall be subtracted in the amounts as indicated in the PEFCR piping systems Excel file.

[30] Explanation on the EoL of the materials that are included in the copper alloy fittings:

- Recycling: 95%
- Landfill: 5%
- The copper alloy fittings consist mainly of copper alloy, but contain in addition to copper alloy, aluminium, stainless steel, PA and EPDM. Only the copper alloy is considered to be recovered and recycled. The other parts are modelled as being incinerated in the melting furnace (for recycling of copper) or go to landfill (5% of the cases) and the remaing 95% is incinerated (during recycling of copper). No credits for energy recovery are given.

[31] Idem above

7. PEF results

The following section shows the characterised, normalised and weighted results of the benchmark for the hot and cold water supply piping system in a building. Use phase is excluded from the system boundaries therefore the results are provided only for this situation, with excluded use stage.

7.1 Benchmark values

Table 13: Characterised benchmark values for the hot and cold water supply plastic piping systems in buildings representative product

Impact category	Unit	Life cycle excl. use stage
Climate change	kg $CO_{2\ eq}$	2,66E+02
Climate change - biogenic		-2,73E-01
Climate change – land use and land transformation		1,36E-01
Ozone depletion	kg CFC-11 $_{eq}$	1,36E-05
Particulate matter	disease incidence	1,40E-05
Ionising radiation, human health	kBq U^{235} $_{eq}$	3,92E+01
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	5,25E-01
Acidification	mol H+ $_{eq}$	8,46E-01
Eutrophication, terrestrial	mol N $_{eq}$	1,76E+00
Eutrophication, freshwater	kg P $_{eq}$	2,08E-03
Eutrophication, marine	kg N $_{eq}$	1,69E-01
Land use	Dimensionless (pt)	6,34E+02
Water use	m^3 world $_{eq}$	3,58E+01
Resource use, minerals and metals	kg Sb $_{eq}$	1,47E-03
Resource use, fossils	MJ	4,67E+03

Table 14: Normalised benchmark values for the hot and cold water supply plastic piping systems in buildings representative product

Impact category	Life cycle excl. use stage
Climate change	3,42E-02
Ozone depletion	5,83E-04
Particulate matter	2,19E-02

Impact category	Life cycle excl. use stage
Ionising radiation, human health	9,30E-03
Photochemical ozone formation, human health	1,29E-02
Acidification	1,52E-02
Eutrophication, terrestrial	9,94E-03
Eutrophication, freshwater	8,17E-04
Eutrophication, marine	5,97E-03
Land use	4,77E-04
Water use	3,11E-03
Resource use, minerals and metals	2,53E-02
Resource use, fossils	7,16E-02

Table 15: Weighted benchmark values for the hot and cold water supply plastic piping systems in buildings representative product

Impact category	Life cycle excl. use stage
Climate change	7,59E-03
Ozone depletion	3,93E-05
Particulate matter	2,09E-03
Ionising radiation, human health	4,99E-04
Photochemical ozone formation, human health	6,60E-04
Acidification	1,01E-03
Eutrophication, terrestrial	3,89E-04
Eutrophication, freshwater	2,41E-05
Eutrophication, marine	1,86E-04
Land use	4,01E-05
Water use	2,81E-04
Resource use, minerals and metals	2,05E-03
Resource use, fossils	6,38E-03

7.1.1 Range in which results could be seen as not being significantly different in comparisons or comparative assertions

The TS opted for a single benchmark as this PEFCR is not meant to be used for comparisons within and among different PEX systems or different Multilayer piping systems for hot and cold water supply plastic piping systems in buildings. Comparisons shall only be made directly against the benchmark and shall be based on the requirements outlined in this PEFCR, considering the life cycle stages as described in this PEFCR.

7.2 PEF profile

The applicant 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 (including toxicity; as a table);
- normalised and weighted result in absolute values, for all impact categories (including toxicity; as a table);
- the aggregated single score in absolute values.

Together with the PEF report, the applicant shall develop an aggregated EF-compliant dataset of its product in scope. This dataset shall be made available on the EF node (http://eplca.jrc.ec.europa.eu/EF-node). The disaggregated version may stay confidential.

7.3 Additional technical information

No additional technical information are required.

7.4 Additional environmental information

Biodiversity is relevant for most applications so it may also be for piping systems. There is, however, no scientifically sound methodology to address this issue specifically. The PEF results for Climate Change; Acidification; Photochemical ozone creation, Eutrophication – terrestrial; Eutrophication – aquatic (freshwater); Eutrophication – aquatic (marine); Water scarcity; and Land use collectively address potential impacts on biodiversity. As biodiversity impacts may also arise from site-based practices rather than material/energy flows, it might be possible in the future to indicate under Additional Environmental Information if a material risk of biodiversity impacts resulting from site-based practices is identified. In most jurisdictions, production operations assess potential biodiversity impacts through Environmental Impact Assessment and as part of their license to operate have management plans in place where appropriate.

Biodiversity is therefore not further addressed in the PEFCR of pipes, fittings and other pipe system components as a separate additional aspect.

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 PEFCR Guidance 6.3 and the requirements listed below.

The verifier(s) shall verify that the EF study is conducted in compliance with this PEFCR.
These requirements will remain valid until an EF verification scheme is adopted at European level or alternative verification approaches applicable to EF studies/report are included in existing or new policies.

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 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[32];
- all the newly created datasets shall be checked on their EF compliancy (for the meaning of EF compliant datasets refer to Annex H of the Guidance). 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 available on the EF node (http://eplca.jrc.ec.europa.eu/EF-node).
- for at least 70% of the most relevant processes in situation 2 option 2 of the DNM, 70% of the underlying data shall be validated. The 70% data shall including all energy and transport sub processes for those in situation 2 option 2;
- for at least 60% of the most relevant processes in situation 3 of the DNM, 60% of the underlying data shall be validated;
- for at least 50% of the other processes in situation 1, 2 and 3 of the DNM, 50% of the underlying data shall be validated;
- correct implementation of the CFF formula, with particular attention to the datasets in which the formula is already included in the dataset;
- check the use and source of primary data on pipes manufacturing, when a fitting producer is carrying out the PEF study;
- the design of the system shall be verified to ensure compliance with the EN 806 standard
- Any deviations from the benchmark (e.g. the use of fittings of different materials then included in template BOM/BOC, and the inclusion of coating for pipes) shall be verified.

In particular, it shall be verified for the selected processes if the DQR of the process satisfies the minimum DQR as specified in the DNM.

[32] Available at: http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml

The selection of the processes to be verified for each situation shall be done ordering them from the most contributing to the less contributing one and selecting those contributing up to the identified percentage starting from the most contributing ones. In case of non-integer numbers, the rounding shall be made always considering the next upper integer.

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 possible subject of check.

The verification of the EF report shall be carried out by randomly checking enough information to provide reasonable assurance that the EF report fulfils all the conditions listed in section 8 of the PEFCR Guidance.

9. References

CEN TC 350. 2013. EN 15804:2012+A1:2013 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products, incl. amendment.

European Commission. 2011. REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC.

European Commission. 2013. PEF Guide - Annex II to Recommendation (2013/179/EU) and the Product Environmental Footprint Pilot Guidance, Official Journal of the European Union number L124 from 4 May 2013 which includes the Recommendation 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.

European Commission. 2014. Guidance for the implementation of the EU PEF during the EF pilot phase – Version 3.4. 50p.

European Commission, 2017, *Environmental Footprint Pilot Guidance document,* - Guidance for implementation of the EU Product Environmental Footprint (PEF) during the Environmental Footprint (EF) pilot phase, v.6.3, December 2017

IBU. 2006. PCR Anleitungstexte für gebäudebezogene Produkte und Dienstleistungen Aus dem Programm für Umwelt-Produktdeklarationen des Instituts Bauen und Umwelt e.V. (IBU) Teil B: Anforderungen an die EPD für Metallrohre für Hausinstallationen.

Lindner C. 2011. Plastic waste from building and construction – results overview. Study performed by Consultic Marketing & Industrieberatung GmbH under the authority of the European Council of Vinyl Manufacturers. Available online:

Plastic Waste from Building and Construction, - http://www.plasticseurope.org/documents/document/20120312160758-eol_plastics_b&c_2010_augmented.pdf, date of search: 04/02/2014

Russ Manfred, Guillon Laura and Tikana Ladji. 2010. European Update Study on Life Cycle Assessment of Copper Products. Commissioned by LCC-DKI and ECI and performend by PE International (now Thinkstep). 60p

Spirinckx C., Vanderreydt I., Vercalsteren A., Boonen K. 2011. Life cycle assessment of a PEX Hot & Cold water pipe system for hot and cold water in the building (according to EN ISO 15875). Study accomplished under the authority of The European Plastic Pipes and Fittings Association – TEPPFA

Final LCA background report, ref.: 2010/TEM/R/229.

1617 Spirinckx C., Peeters K., Boonen K. 2012b. Life cycle assessment of a Polymer/Al/Polymer composite
1618 pipe system for hot and cold water in the building (according to EN ISO 21003). Study accomplished
1619 under the authority of The European Plastic Pipes and Fittings Association - TEPPFA

1620 TEPPFA, 2011 - Life Cycle Assessment of a PEX Hot & Cold water pipe system for hot and cold water
1621 in the building (according to EN ISO 15875) - Final LCA background report, ref.: 2010/TEM/R/229

ANNEXES

ANNEX 1 - 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.

Impact category	Unit	Normalisation factor	Normalisation factor per person	Impact assessment robustness	Inventory coverage completeness	Inventory robustness	Comment
Climate change	kg CO_2 eq	5.35E+13	7.76E+03	I	II	I	
Ozone depletion	kg CFC-11 eq	1.61E+08	2.34E-02	I	III	II	
Human toxicity, cancer	CTUh	2.66E+05	3.85E-05	II/III	III	III	
Human toxicity, non-cancer	CTUh	3.27E+06	4.75E-04	II/III	III	III	
Particulate matter	disease incidence	4.39E+06	6.37E-04	I	I/II	I /II	NF calculation takes into account the emission height both in the emission inventory and in the impact assessment
Ionising radiation, human health	kBq U^{235} eq	2.91E+13	4.22E+03	II	II	III	
Photochemical ozone formation, human health	kg NMVOC eq	2.80E+11	4.06E+01	II	III	I/II	
Acidification	mol H+ eq	3.83E+11	5.55E+01	II	II	I/II	
Eutrophication, terrestrial	mol N eq	1.22E+12	1.77E+02	II	II	I/II	

Eutrophication, freshwater	kg P_{eq}	1.76E+10	2.55E+00	II	II	III	
Eutrophication, marine	kg N_{eq}	1.95E+11	2.83E+01	II	II	II/III	
Land use	pt	9.20E+15	1.33E+06	III	II	I I	The NF is built by means of regionalised CFs.
Ecotoxicity, freshwater	CTUe	8.15E+13	1.18E+04	II/III	III	III	
Water use	m^3 world $_{eq}$	7.91E+13	1.15E+04	III	I	II	The NF is built by means of regionalised CFs.
Resource use, fossils	MJ	4.50E+14	6.53E+04	III	I	II	
Resource use, minerals and metals	kg Sb_{eq}	3.99E+08	5.79E-02	III			

1626 **Weighting factors for Environmental Footprint**

	Aggregated weighting set	Robustness factors	Calculation	**Final weighting factors**
	(50:50)	(scale 1-0.1)		
WITHOUT TOX CATEGORIES	A	B	C=A*B	C scaled to 100
Climate change	15.75	0.87	13.65	**22.19**
Ozone depletion	6.92	0.6	4.15	**6.75**
Particulate matter	6.77	0.87	5.87	**9.54**
Ionizing radiation, human health	7.07	0.47	3.3	**5.37**
Photochemical ozone formation, human health	5.88	0.53	3.14	**5.1**
Acidification	6.13	0.67	4.08	**6.64**
Eutrophication, terrestrial	3.61	0.67	2.4	**3.91**
Eutrophication, freshwater	3.88	0.47	1.81	**2.95**
Eutrophication, marine	3.59	0.53	1.92	**3.12**
Land use	11.1	0.47	5.18	**8.42**
Water use	11.89	0.47	5.55	**9.03**
Resource use, minerals and metals	8.28	0.6	4.97	**8.08**
Resource use, fossils	9.14	0.6	5.48	**8.92**

ANNEX 2 - Check-list for the PEF study

Each PEF study shall include this annex, completed with all the requested information.

ITEM	**Included in the study (Y/N)**	**Section**	**Page**
[This column shall list all the items that shall be included in PEF studies. One item per row shall be listed.]	[The PEF study shall indicate if the item is included or not in the study]	[The PEF study shall indicate in which section of the study the item is included]	[The PEF study shall indicate in which page of the study the item is included]
Summary			
General information about the product			
General information about the company			
Diagram with system boundary and indication of the situation according to DNM			
List and description of processes included in the system boundaries			
List of co-products, by-products and waste			
List of activity data used			
List of secondary datasets used			

ITEM	Included in the study (Y/N)	Section	Page
Data gaps			
Assumptions			
Scope of the study			
(sub)category to which the product belongs			
DQR calculation of each dataset used for the most relevant processes and the new ones created.			
DQR (of each criteria and total) of the study			

1629

ANNEX 3 - Critical review report of the PEFCR

The current PEFCR included initially 3 products, copper, Multilayer (PEX or PE-RT/Aluminium/PEX or PE-RT) and PEX systems. The data for the copper system came from the European Copper Institute, who was part of the TS as follows:

ECI (The European Copper Institute):	Trade/industrial /sectoral association at EU level	▪ Laia Perez Simbor (ECI); ▪ Nigel Cotton (ECI); ▪ Ladji Tikana (ECI); ▪ Frank Otten replacing Heinrich Rausch (KME); ▪ Stefan Priggemeyer (Wieland); ▪ Rolf Werner (Wieland).	▪ January 2014 - September 2017 ▪ January 2014 – September 2018 ▪ January 2014 – September 2018 ▪ January 2014 – September 2018 ▪ January 2014 – September 2018 ▪ January 2014 – September 2018

However on the 28 August 2018 ECI announced their intention to withdraw from the pilot, and the letter of withdrawal was officially submitted on 11 September 2018. ECI does not endorse this final PEFCR, however their contribution to the document was relevant throughout the process.

The critical review of the PEFCR was done on the draft PEFCR v6.1, in which the representative product included the 3 products, copper, Multilayer (PEX or PE-RT/Aluminium/PEX or PE-RT) and PEX systems. The comments from the reviewers were fully answered and accepted for this version of the PEFCR.

Under these circumstances TEPPFA decided to continue the PEF pilot with the two plastic systems only. Consequently the PEFCR and the model were adjusted to remove all references to the copper system. All the requirements, scenarios, assumptions that existed in the draft PEFCR v6.1 remained unchanged, and only the results (benchmark, normalised and weighted results and the most relevant impact categories, lifecycle phases and processes) changed in line with the updated representative product. Considering this limited change to the core of the PEFCR, after reviewing the updated version with only the 2 plastic systems, the EC advised that no additional critical review was necessary.

Below the critical review panel report of the PEFCR is included, with all findings of the review process and the actions taken by the TS to answer the comments of the reviewers.

ANNEX 4 - Other Annexes

ANNEX 4.I – Representative product and PEF screening studies

The document describing the representative product of the PEF pilot hot and cold water piping systems in the building approved by the SC, as well as the background and results of the PEF screening studies can be downloaded from the PEF wiki page:

https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/Stakeholder+workspace%3A+PEFCR+pilot+Hot+and+cold+water+supply+pipes

ANNEX 4.II – Elements excluded from the reference flow and the system boundaries, as well as based on cut-off rules

The elements that are **excluded** from the reference flow and the system boundaries are listed below:

- **Insulation of the plastic piping system** for hot and cold water supply due to the following facts:
  - The construction products regulation mentions on page 1 point 4[33]: *"Member States have introduced provisions, including requirements, relating not only to safety of buildings and other construction works but also to health, durability, energy economy, and protection of the environment, economic aspects, and other important aspects in the public interest."(European Commission, 2011);*
  - This relates to individual national solutions about the insulation within the building structure, e.g. national laws, regulations or rules about the way of energy saving measures;
  - National design principles for pipe insulation have taken care about national climates. Therefore requirements for insulation thickness and thermal conductivity are not harmonised;
  - Therefore the pipe insulation is not covered, because regional and/or national aspects do not allow to create an average "value" for the pipe insulation across Europe.
- **Water meter and shut off valves** due to the following facts:
  - Water meters are mainly mandatory and have to fulfil various requirements in accordance to the modelling for equipment design (MED), but the dimensioning of the water meter is bound to the max possible volume flow, which is directly linked to the number of persons living in these flats.
  - The number and type of shut valves are bound to local, regional or national installation codes. Therefore an average amount and type could not be judged and is not mentioned.

Technical specifications:

- A range of specific standards and regulations are in place across the EU which cover the requirements for the performance of piping systems used for the supply of drinking water.
- Additional statutory requirements at member state level also apply to the health and hygiene aspects of all piping system materials which are in contact with drinking water.
- For the purposes of this PEFCR it is assumed that systems meet all the relevant performance requirements and have been approved for drinking water applications approprite for the markets in which they are sold. Accordingly confirmation of compliance with these requirements does not form part of the scope of the PEFCR.

[33] REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC

According to this PEFCR, the following life cycle stages/ processes are excluded based on the cut-off rule:

- The use stage of the piping system in the building;
- The dismantling of the piping system in the building after 50 years of reference service life time.

The reasons for exclusion of these life cycle stages are explained below:

- The ***use stage*** includes both the functioning and the maintenance. For all pipe systems considered in this PEFCR maintenance is not needed during the 50 years of reference service life time. The functioning of the piping system is product independent and it is not relevant to the product under study. In fact, the life span of the pipes is limited by the building life span and not by the design of the pipes or by their installation. Moreover, it was found that the heat loss is independent of the piping systems considered under the scope of this PEFCR. Full details on the reasons for excluding the use stage from the system boundaries can be found in Annex 4.III – Assumptions related to the exclusion of the use stageof this PEFCR;.
- The ***dismantling*** stage of the piping system after 50 years of reference service life time only generates a neglible impact and can therefore be excluded from the system boundaries. This conclusion has been drawn from the PEF screening studies and the PEF supporting studies.

Annex 4.III – Assumptions related to the exclusion of the use stage

Introduction

A Life Cycle Assessment from cradle to grave, as described in the PEFCR guidance, shall take into consideration all the life cycle stages of the system, including production / manufacturing of materials, transportation, installation, use stage and End-of-Life stage.

For hot and cold water supply plastic piping systems, the use stage looks like a relevant stage since at first sight it seems there is a heat loss through the pipe wall over 50 years. However after detailed investigations the TS has decided to exclude the use stage based on the following two results:

1. It was found that the heat loss is independent of the piping systems considered under the scope of this PEFCR. The rules from the TAB paper on the use stage (version 5.1) have been applied (including table 1 in that TAB paper describing the PEFCR guidelines for the use stage). Since the use stage of the installed piping systems for hot and cold water supply piping systems is product independent, this stages is excluded from the PEFCR model.
2. Each internal thermal loss within a building, including the heat transfer through the wall of the piping system contributes to maintain the temperature inside the thermal building envelope.

The details of the investigation which lead to the above mentioned results are presented below.

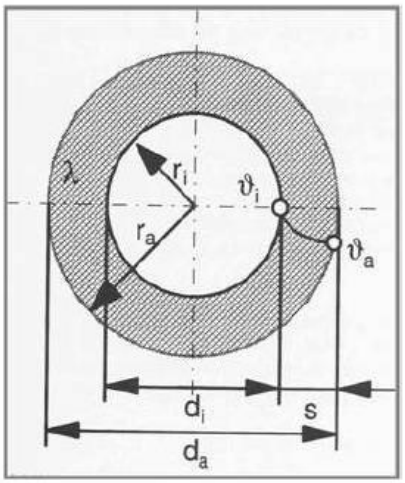
1) Heat loss through the pipe wall is independent of the piping system

The first driver that affects the thermal loses is the size of the pipe. Heat transfer increases with larger radius (e.g. surface). Further it is also affected by the material of the tube.

An additional insulation layer is a key parameter to the final thermal loses. The European standard EN 806 Part 2 "*Specification for installations inside buildings conveying water for human* consumption – Design (2005)" in clause 9 requires an insulation of water pipes, but does not give details about the type of the insulation to be used, the requirements being independent from the pipe material.

The German supplemental to the standard European EN 806-2, DIN 1988-200 „Code of practice for drinking water installations – Planning, components, apparatus, materials (2012) in table 9 sets clear requirements to wall thickness and to the λ-value of the insulation material.

The heat loss of the pipes, each with and without insulation, was calculated by the use of the following formula, where the parameters can be seen in the PEF Screening report (PEF screening report_Core_Figure 1: Transversal view through a pipe).



$$q = \left(\frac{1}{\frac{1}{h} + \frac{t}{k}}\right) \cdot A \cdot \Delta T$$

where

q = heat transfer rate (W)

h = heat transfer coefficient (W/(m^2·K))

t = wall thickness (m)

k = wall thermal conductivity (W/m·K)

A = area (m^2)

ΔT = difference in temperature.

Figure 9: Formula to calculate heat losses

The energy transfer from the fluid (water) to the ambient air through the pipe wall and insulation follows the formula given above. The formula below is the basis for the calculation program which was used to develop the formula in Figure 8.

$$Q_R = \frac{p * L * (\vartheta_m - \vartheta_l)}{\frac{1}{\alpha_i * d_i} + \frac{1}{2 * \lambda n} * \ln\left(\frac{d_{a,n}}{d_{i,n}}\right) + \cdots\cdots + \frac{1}{\alpha_a * d_a}}$$

Q_R	=	total heat flow (W)
q_R	=	specific heat flow over 1 m pipe length (W/m)
L	=	length of pipe (m)
ϑ_M	=	fluid temperature (°C)
ϑ_L	=	air temperature (°C)
α_i	=	heat transmission coefficient inner (W/(m^2*K))
α_a	=	heat transmission coefficient outer (W/(m^2*K))
d_i	=	inner diameter of pipe (m)
d_a	=	outer diameter of insulation cover (m)
λ_n	=	thermal conductivity of layer n (W/(m*K))
$d_{a,n}$	=	outer diameter of layer n (m)
$d_{i,n}$	=	inner diameter of layer n (m)

The formula used in figure 8 is a shortened version which already contains data for the heat transmission coefficient and the conductivity.

Sources for the formula above are:

1. Handbuch rohrleitungsbau - Günter Wossog - Vulkan Verlag, 2004

2. Wärmeabgabe von Raumheizflächen und Rohren - Bernd Glück - Verlag für Bauwesen, 1990

3. VDI Wärmeatlas – Autorengemeinschaft - Sringer Verlag, 2006, 10. Auflage

The formula is applied in the model available under:

http://www.schweizer-fn.de/berechnung/waerme/rohrisol/rohrisol_start.php.

Being aware that the real parameters of a hot water piping system inside building are very complex (variation of temperature and flow over time, dependent of the number and habit of the persons living in the apartments) the following realistic, but simplified parameters were chosen:

- insulation thickness 20 mm;
- thermal conductivity coefficient λ = 0,035 W/mK;
- T_{water} = 40°C;
- T_{room}= 21°C;
- λ_{Cu} = 380 W/mK;
- λ_{PE-X} = 0,35 W/mK;
- no water flow, no air flow.

The calculation results are shown in the table below:

Table 16: Results of calculation of heat losses during use stage

1) Pipes (d_i / s / d_{out}) with an inner diameter of ca. 12 mm:

ML Pipe	(12,0 / 2,0 / 16,0)	naked	10,91 W/m
ML Pipe	(12,0 / 2,0 / 16,0)	W ith insulation	2,89 W/m
PEX Pipe	(11,6 / 2,2 / 16,0)	naked	10,70 W/m
PEX Pipe	(11,6 / 2,2 / 16,0)	with insulation	2,89 W/m

2) Pipes (di / s / dout) with an inner diameter of ca. 20 mm:

ML Pipe	(20,0 / 2,5 / 25,0)	naked	15,40 W/m
ML Pipe	(20,0 / 2,5 / 25,0)	with insulation	3,71 W/m
PEX Pipe	(18,0 / 3,5 / 25,0)	naked	15,10 W/m
PEX Pipe	(18,0 / 3,5 / 25,0)	with insulation	3,71 W/m

The results indicate there is a big difference between a naked pipe and an insulated pipe. But there is no difference between Multilayer pipe and PEX pipe with or even without insulation.

2) Each internal thermal loss within a building, including the heat transfer through the wall of the piping system contributes to maintain the temperature inside the thermal building envelope

As perfectly outlined in the attached presentation the real heat loss occurs when heat leaves the building. For example this is the case when the heat transfers through the outer wall of the building or through an outer window or when hot water leaves the house through a drain.

A heat transfer inside a building contributes to the comfort temperature of the house.

When heat transfer occurs through the wall of the hot water piping systems considered in our PEFCR it is not a heat loss, but a contribution to the comfort temperature inside the building – all over Europe.

In conclusion, the Technical secretariat has decided based on the above outlined reasons in addition to the rules in the PEFCR guidelines for the use stage (Table 1 of the TAB paper on the use stage, version 5.1) to exclude the use stage for PEF studies on hot and cold water supply piping systems. This will simplify the PEFCR without affecting the results since it is proven that, the pipes material has a non-significant role in the heat loss of the system.

Annex 4.V – Background information on methodological choices taken during the development of the PEFCR

Information regarding the selection of the most relevant impact categories

The identification of the most relevant impact categories has been based on the normalised and weighted results of the representative product(s) as recalculated after the remodelling. At last three relevant impact categories had to be considered. The most relevant impact categories have been identified as all impact categories that cumulatively contribute to at least **80%** of the total environmental impact (excluding toxicity related impact categories). This had to start from the largest to the smallest contributions. The TS could have added more impact categories to the list of the most relevant ones but none could be deleted.

Information regarding the selection of the most relevant life cycle stages

Whilst the identification of the most relevant life cycle stages is not considered essential in terms of identifying data needs (primary versus semi-specific versus secondary), it could be relevant in terms of communication and supply chain management.

The following approach has been adopted:

Identification of the relevancy at the level of life cycle stages

The most relevant life cycle stages are the life cycle stages which together contribute to at least **80%** of any of the most relevant impact categories identified. This should start from the largest to the smallest contributions. The TS could have added more life cycle stages to the list of the most relevant ones but none could be deleted.

In order to guarantee a minimum level of harmonisation among different PEFCRs, the default life cycle stages shall be as a minimum the following:

- Material acquisition and pre-processing (including production of parts and unspecific components);
- Production of the main product;
- Product distribution and storage;
- Use stage (if in scope);
- End-of-life (including product, recovery / recycling, if in scope).

The right level to define most relevant life cycle stages has been seen in close relation to the definition of the Representative Product (RP). It is of primary importance that relevance thresholds are defined for every technology included in the Representative Product, even if the current market share of the technology is low. When choosing the level, we were careful not to leave something out (cut-off) and we investigated the relevance at the lowest possible level. In that sense the relevancy is not determined at the representative product level, but by aggregating all relevant life cycle stages at the individual level, being the PEX and ML system level individually.

Information regarding the selection of the most relevant processes

Each most relevant impact category shall be further investigated to identify the most relevant processes used to model each life cycle stage. The processes shall be modelled as disaggregated at level-1. Similar/identical processes taking place in different life cycle stages (e.g. transportation) shall be accounted for separately. The identification of the most relevant processes shall be done according to Table 17 below.

Table 17. 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

The most relevant processes are those that collectively contribute at least with **80%** to any of the most relevant impact categories identified. The TS can add more processes to the list of the most relevant ones but none can be delete.

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 metadata accompanying the data shall be analysed by the TS and used to identify the most relevant processes. If this is not possible, 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[34].

[34] In this last case, if an aggregated dataset is relevant, everything in it is automatically relevant

Cut-off rules

Any cut-off has been avoided in the screening study and supporting studies. However, based on the results of the screening study and if confirmed by the supporting study results, the PEFCR could identify and list the processes excluded from the modelling by applying the following rule:

- In case processes are excluded from the model this shall be done based on a 1% 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 1% cut-off order the processes starting from the less relevant to the most relevant one. The processes that in total account less than 1% of the environmental impact for each impact category may be excluded from PEF studies (starting from the less relevant). In case the pilot decides to apply the cut-off rule, the PEFCR shall list the processes that may be excluded based on the cut-off.

- Human toxicity-Cancer effect, Human toxicity-non Cancer effect and Freshwater Ecotoxicity shall not be taken into account when selecting processes that can be excluded based on the cut-off rule. In other words, it means that if a process accounts for less than 1% for all the impact categories with the only exception of toxicity-related ICs, this process can be cut-off.
- In case the processes identified following this procedure starting from the results of the screening study are not confirmed by the supporting studies, these cannot be excluded based on the cut-off rule.

Only the processes identified following this procedure starting from the results of the screening study and confirmed by the supporting studies may be listed in the PEFCR and excluded according to the cut off rule. No additional cut-offs are allowed for PEF studies in addition to those listed in the PEFCR.

Annex 4.VI – Stakeholders of the PEF pilot on hot and cold water supply plastic piping system in the building

Table 18: Overview of the stakeholders actively involved in the PEF pilot on hot and cold water supply plastic piping systems in the building by providing comments during stakeholder consultation phase as well as direct input to some specific aspects of the PEFCR

Stakeholder list PEF pipes	
Organisation	**Country**
Aurubis AG	Germany
BASF	Belgium
DG Environment	Belgium
DG Environment Ministry of public Health and Environment	Belgium
Ecoinnovazione srl	Italy
ENEA on behalf of the Italian Ministry of Environment	Italy
Eurima	Belgium
ECI (European Copper Institute)	Belgium
European Commission Joint Research Centre	Italy
maki Consulting GmbH	Germany
PlasticsEurope	France
Quantis	Switzerland
TEPPFA (The European Piping Pipes and Fittings Association)	Belgium
thinkstep (formerly PE International)	Germany
VITO (Flemish Institute for Technological Research)	Belgium