PRODUCT ENVIRONMENTAL FOOTPRINT CATEGORY RULES

Uninterruptible Power Supply (UPS)

Version: 1.7

September 22, 2016



Participating Organizations:

Link to Wikipage: https://webgate.ec.europa.eu/fpfis/wikis/pages/viewpage.action?pageId=61835546

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1 Introduction

The Product Environmental Footprint (PEF) Guide[1] developed by the European Commission 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.

This Product Environmental Footprint Category Rules (PEFCR) shall be used in parallel with the PEF Guide. Where the requirements in this PEFCR are in line with, but at the same time more specific than those of the PEF Guide, such specific requirements shall be fulfilled.

The use of the present PEFCR is optional for in-house PEF studies; it is recommended for external applications without comparison/comparative assertions, while it will be mandatory for external applications with comparisons/comparative assertions after the PEF pilot phase.

2 General information about the PEFCR

2.1 Technical Secretariat

This PEFCR was developed by a consortium of several UPS manufacturers, an EPD program operator specialized on electronic products and a LCA consultant within the EU EF pilot phase. The following table presents the members of the Technical Secretariat of the project:

Logo	Name	Activity	Website
Schneider Electric	Schneider Electric	UPS manufacturer	http://www.schneider-electric.com
EATON	EATON	UPS manufacturer	http://www.eaton.com
socomec	SOCOMEC	UPS manufacturer	http://www.socomec.com
legrand	Legrand	UPS manufacturer	http://www.legrand.com
CEMEP Gimélec	CEMEP	European trade association of UPS manufacturers represented by Gimelec	http://www.gimelec.org
PEP eco PASS PORT	PEP ecopassport	EPD programme operator of PEP ecopassport®	http://www.pep-ecopassport.org
SGS	SGS	LCA consultancy	http://www.sgs.com

Table 1: Members of the Technical Secretariat

2.2 Consultation and stakeholders

The procedure for the development of a PEFCR according to the "Guidance for the implementation of the EU PEF during the EF pilot phase" considers a number of steps that have been followed by this Technical Secretariat, namely:

- Definition of PEF product category and scope of the PEFCR

[1] http://ec.europa.eu/environment/eussd/pdf/footprint/PEF%20methodology%20final%20draft.pdf

- Definition of the product "model" based on representative product(s)
- PEF Screening
- PEFCR v.1.7
- PEFCR supporting studies
- Confirmation of the benchmark(s) and determination of performance classes
- Final PEFCR

A first physical consultation with stakeholders took place in February 2014 where the definition of PEF product category, the scope of PEFCR and the definition of the representative product were presented and commented.
The TS invited a wide range of stakeholders including SMEs, environmental organizations and consumer associations. In total, close to 80 representatives registered as stakeholders.

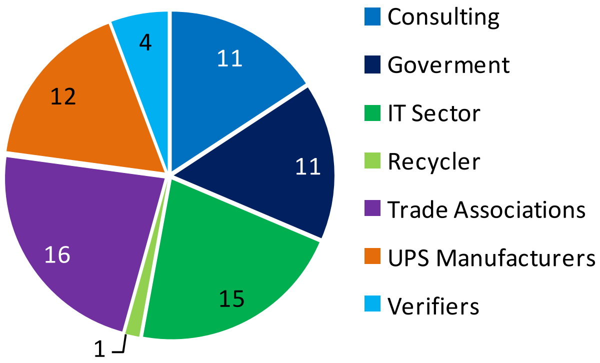


Figure 1: Stakeholder distribution

The document hereby constitutes the PEFCR, which is the deliverable required by the EU COM after the completion of the PEF Screening step (including the critical review of the PEF screening report and model by the European Commission and a neutral Review Panel).
This first PEFCR has been submitted to virtual consultation in April 2015 and this version includes the amendments made further to the comments made by the stakeholders.

2.3 Date of publication and expiration

- Version number: PEFCR version 1.7
- Date of publication/revision: 09 022 2016
- Date of expiration: 4 years after the date of publication

2.4 Geographic region

The PEFCR is valid for Europe 28 and EFTA countries.

2.5 Language(s) of PEFCR

The present original is in English (GB). It supersedes translated versions in case of conflicts.

2.6 Methodological inputs and compliance

This first PEFCR has been prepared in conformance with:

- European Commission, 2014, Environmental Footprint Pilot Guidance document, - Guidance for the implementation of the EU Product Environmental Footprint (PEF) during the Environmental Footprint (EF) pilot phase, v. 5.1, September 2015.

The Technical Secretariat identified an existing PCR that was developed and is currently used by some members of the technical secretariat. The corresponding PCR is a reference document from the PEP Ecopassport program. The PEP Ecopassport association is the program operator. The PCR V3 was recently published. It is completed with specific rules for UPS. The documents can be downloaded using the following link:

http://www.pep-ecopassport.org/create-a-pep/produce-a-lca/

The analysis of those documents was carried out in order to check the similarities and differences respect to the PEFCR Methodologies and recommendations. The conclusions of the analysis were presented by the UPS PEF TS to the EF Steering committee, who approved them.

The relevant methodological inputs from these existing PCRs were considered during the screening study and the preparation of this PEFCR.

3 PEFCR review and background information

3.1 PEFCR review panel

Name	Contact information	Affiliation
Chair		
Other members		
Other members		

3.2 Review requirements for the PEFCR document

3.3 Reasoning for development of PEFCR

The current PEFCR aims at providing means to evaluate the environmental impacts of UPS equipment used in the EU plus EFTA, applying a harmonised approach for any UPS manufacturer, in order to have the possibility to compare results.

A large number of UPS manufacturers are already engaged in an EPD program named PEP Ecopassport. An existing PCR was published in 2014 and the goal of this PEFCR is to align the practices with the requirements of the PEF guide.

3.4 Conformance with the PEFCR Guidance

This first PEFCR has been prepared in conformance with the PEF Guide and the Guidance Products v5.1.

4 PEFCR scope

4.1 Unit of analysis

Although there are different UPS sizes ranges only one unit of analysis was defined, as UPS commonly share the function, application and technology. Based on the definition of the representative product (see chapter 5) the unit of analysis was defined as follows:

To ensure the supply of power without interruption to equipment with load of 100 watts for a period of 1 year, including a backup time of 5 minutes during a power shortage.

This unit of analysis answers to the following questions:

- The function(s) / service(s) provided: "**what**": a UPS to ensure power supply to an electrical equipment
- The magnitude of the function or service: "**how much**": supply 100 W to the equipment for 5 minutes. 5 minutes is the most frequent UPS backup time for small and large UPSs.
- The amount of service provided over the life time: "**how long/ how often**": 1 year
- The expected level of quality: "**how well**": without interruption

The reference flow is the amount of product that satisfies the intended function as quantified by the functional unit.

In this screening study, the reference flow is defined as the "fraction of UPS" that is needed to fulfill the functional unit. It is calculated by the following formula:

$$fraction\ of\ UPS = \frac{1}{PO \times L} \times 100$$

Where:

- PO = output power of UPS in watts
- L = life time of UPS in years

Formula 1: Calculation of the reference flow

How to use this unit of analysis

- **Load**: Divide the load of the studied UPS to have a 100 W load. For instance, for a 3 kVA UPS, divide the impacts by 30.
- **Lifespan**: Divide the total impact of the product by the lifespan of the product in years to reduce it to 1 year. For instance, for a product < 1.5 kVA, divide the results by 5. The coefficients are given in Table 9.
- **Backup time**: The backup time is directly linked to the battery size. The only impacts that need to be adjusted are the impacts of the battery. For instance, a 10 min backup time UPS, the study shall consider the same UPS but with a battery configuration of 5 min. If such product is not available and the amount of battery is unknown, an approximation using Generic provided in this document must be done.

5 Representative product(s)

5.1 Category of products covered

The product category covered by this PEFCR is “Uninterruptible Power Supply” (UPS). The main use of a UPS is to provide backup time in case of power failure.

There are UPSs for private and professional use in different size ranges (see chapter 3). Basically, all types UPSs fulfill the same function and have the same components. In addition, they have the same application. However, they vary, for example, in size, used topologies and life time. Annex I gives some examples of different UPSs.

The following UPSs are excluded from the scope of this PEFCR:

- UPSs with no backup time
- Rotary UPSs
- UPSs for special application (e.g.):
    - UPSs exposed to extreme temperatures, excessive dust, moisture, vibration, flammable gasses, corrosive, or explosive atmospheres
    - UPSs in vehicles, on board of ships or aircrafts, in tropical countries, or at elevations higher than 1000m
    - UPSs in electrometrical applications with the UPS located within 1.5m of the patient contact
    - UPSs in systems classified as emergency power systems by an authority having jurisdiction

5.1.1 UPS definition

An **Uninterruptible Power Supply (UPS)** is a “combination of convertors, switches and energy storage devices (such as batteries) constituting a power system for maintaining continuity of load power in case of input power failure.”[2] It acts as an interface between the power mains and the sensitive applications. A UPS supplies the load with continuous, high quality electrical power regardless the status of the mains.

Power distribution systems, both public and private, theoretically supply electrical equipment with a sinusoidal voltage of fixed amplitude and frequency (e.g. 400Vrms, 50Hz on low voltage systems). In real-life conditions however, utilities indicate the degree of fluctuation around the rated values. Because digital equipment (computers, telecom systems, instruments, etc.) use microprocessors that operate at frequencies of several mega or even gigahertz, i.e. they carry out millions or even billions of operations per second, a disturbance in the electrical supply lasting just a few milliseconds can affect thousands or millions of basic operations. This results for instance in malfunctions or loss of data with dangerous (e.g. airports, hospitals) or costly consequences (e.g. loss of production).

UPS Technologies:

Most common UPS technologies are stand-by or backup UPSs, line interactive UPSs or online UPSs. Even if the architecture of the UPSs may vary, the main function remains the same.

[2] Definition from IEC 62040-3:2011.3.1.1

5.1.2 UPS size ranges

There are different UPS size ranges. They are defined based on the apparent output specified in kVA or W. In this project the following four UPS sizes ranges from the ErP Lot 27 are used:

- UPSs below 1.5 kVA
- UPSs between 1.5 kVA and 5.0 kVA
- UPSs between 5.1 kVA and 10 kVA
- UPSs between 10.1 kVA and 200 kVA.[3]

There are also larger UPSs, i.e. bigger than 200 kVA, but in most cases they are made of several smaller ones.

5.1.3 UPS components

UPSs generally contain the following components:

- transformers (if incorporated inside the UPS)
- electrolytic capacitors (if incorporated inside the UPS)
- semi-conductors: IGBT / THYRISTOR, etc.
- circuit boards
- housing
- fans and / or cooling systems
- switches
- relays
- breaker
- lead-acid battery, if included inside the UPS (In some specific cases, other types of batteries are used.)
- wires

5.1.4 UPS topologies

Depending on the protection to apply and the characteristic (voltage or frequency or both) that is it necessary to control, there are three different UPS topologies:

- At the **stand by topology**: voltage and frequency depends from the main, it is also the maximum energy saving mode (VFD). The normal mode of operation consists on supplying the load from the primary power source.
- The **line interactive topology** allows the voltage independence (VI), during the normal mode of operation the load is supplied with conditioned AC input power at the input frequency.
- The **double conversion topology** provides the highest power conditioning (VFI), output voltage and frequency are independent of input conditions.

The functioning of these topologies is shown in Annex II.

The topology has a high impact on the electricity consumption of the UPS. Typical UPSs´ architectures for different UPS sizes are given in Annex III.

[3] http://www.ecoups.org/assets/Lot-27-Task-5-Report-v1.pdf

Type	Size	Manufacturer	Model	Image
B2C	1 kVA – 10 kVA	Schneider Electric	Back UPS Pro	
			Smart UPS	
		Eaton	9PX	
		Legrand	DAKER	
			SMS	
			Nicky	
B2B	50 kVA – 200 kVA	Schneider Electric	Symetra PX	
		Eaton	93 PM	
		SOCOMEC	Delphys	

This part introduces the representative products which have been defined to calculate the environmental impacts of the batteries in each application.

5.1.5 Representative product as basis of the PEF screening study

A PEF analysis has been run on the representative products of each application: the screening study.

The objective of the screening is to pre-identify the following key information: - Most relevant life cycle stages; - Most relevant processes; - Preliminary indication about the most relevant life cycle impact categories; - Data quality needs; - Preliminary indication about the definition of the benchmark for the product category/subcategories in scope. For the screening study, one representative products have been defined, this representative product is virtual.

5.1.6 Assumptions regarding the production of raw and basic materials

Assumptions in regard with the production of raw and basic materials are summarized in the table below:

<table>
<tr><th>Parameter</th><th colspan="7">Assumption</th><th>Source</th></tr>
<tr><td>Blowing technique of the EPS contained in the packaging</td><td colspan="7">In the baseline scenario it is assumed that the EPS is blown with HFC-134a. As the production of HFC-134a has significant ozone depletion potential other EPS blowing techniques with HFC-152 and carbon dioxide are analysed in the sensitivity analysis.</td><td>conservative assumption</td></tr>
<tr><td>Origin of raw and basic materials</td><td colspan="7">As far as available global market mixes were applied to take the global supply chain of electronics into account.</td><td>Expert judgment</td></tr>
<tr><td rowspan="9">Processing of plastics contained in the BOM of the UPSs</td><td></td><td>Injection moulding</td><td>Blow moulding</td><td>Extrusion, plastic film</td><td>Foaming</td><td>Calendering</td><td>Thermofor-ming</td><td rowspan="9">Industry + expert assumptions</td></tr>
<tr><td>LDPE</td><td>80%</td><td>15%</td><td>5%</td><td>0%</td><td>0%</td><td>0%</td></tr>
<tr><td>HDPE</td><td>100%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td></tr>
<tr><td>PVC</td><td>0%</td><td>0%</td><td>0%</td><td>100%</td><td>0%</td><td>0%</td></tr>
<tr><td>ABS</td><td>100%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td></tr>
<tr><td>PA6</td><td>100%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td></tr>
<tr><td>PC</td><td>80%</td><td>0%</td><td>0%</td><td>0%</td><td>20%</td><td>0%</td></tr>
<tr><td>PMMA</td><td>100%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td></tr>
<tr><td>Epoxy</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>100%</td></tr>
<tr><td>Powder coating</td><td colspan="7">• 50% of the powder coating is used for aluminium parts
• 50% of the powder coating is used for steel parts</td><td>Industry + expert assumptions</td></tr>
<tr><td>Loss of material during processing</td><td colspan="7">A generic loss of 2% was assumed for all materials.</td><td>Industry + expert assumptions</td></tr>
<tr><td>Production region of components</td><td colspan="7">Global, mainly Asia</td><td>Industry + expert assumptions</td></tr>
</table>

Table 2: Assumptions regarding the production of raw and basic materials

5.1.7 Assumptions regarding the production of the main product

Assumptions that were taken for the assembly phase are summarized in the following table:

Parameter	Assumption	Source
Assembly location for small UPSs (groups 1 – 3)	Final assembly takes place in Asia.	Industry sources
Assembly location for large UPSs (group 4)	Final assembly takes place in Europe.	Expert judgment

Table 3: Assumptions regarding the assembly of UPSs

5.1.8 Assumptions in the distribution phase

Assumptions with regard to the distribution phase are specified in the table below:

Parameter	UPSs < 1.5 kVA	UPSs ≥1.5– 5 kVA	UPSs ≥5.1– 10 kVA	UPSs ≥10.1-200 kVA	Source
Needed palette space (p) for 1 UPS	0.015625	0.057240411	0.377510332	1	Expert judgment
Storage time (weeks)	2	2.5	3	4	Expert judgment
Transport distance (km)	19,000 km by ship and 1,000 km by lorry			0[4]	P.E.P. Association (2012)
Vehicle class	Lorry > 32t, EURO 4				Expert judgment
Loading factor and empty runs	The average loading factors and number of empty runs included in the ecoinvent datasets were applied as no specific data for the UPSs were available.				Spielmann et al. (2007)

Table 4: Assumptions regarding the UPS distribution

5.1.9 Assumptions in the use phase

The following assumptions were made for the use phase:

Parameter	UPSs < 1.5 kVA	UPSs ≥1.5– 5 kVA	UPSs ≥5.1– 10 kVA	UPSs ≥10.1-200 kVA	Source
Transport distance to the client (in km)	20	500	500	500	Expert judgment
Means of transportation	Passenger car	Van < 3.5 t	Van < 3.5 t	Lorry <16t	Expert judgment
Further needed processes for the installation	May need some equipment to carry the UPS and batteries from truck to final destination.			Travel of a professional to install the UPS of 500 pkm	Expert judgment
Electricity consumption (in kWh)	377.7	1,929.4	3,120.75	42,839.69	ErP Lot 27 (2013), confirmed with manufacturer-specific information
Average power output (in kVA)	0.54	2.87	6.25	94.5	ErP Lot 27 (2013), confirmed with manufacturer-specific information
Life time (in a)	5	8	10	15	P.E.P. Association (2014)

Table 5: Assumptions regarding the installation phase

[4] Large UPSs are assembled in Europe for the European market. They are produced just in time, so that the UPSs are only transported to the client (this transport is included in the use phase).

Further, for the maintenance of the UPSs within in the use phase the following assumptions were defined, the table below described the number of components that will have to be replaced during the life of the product.

UPS size	Typical lifetime in years	Components replaced during the use phase			
		Capacitor	Fan	Power supply	Battery
< 1.5 kVA	5	No maintenance			
≥ 1.5 kVA – 5 kVA	8	1	1	1	1
≥ 5.1 kVA – 10 kVA	10	1	2	1	1
≥ 10.1 kVA – 200 kVA	15	2	3	2	2

Table 6: Assumed maintenance frequencies - Source: P.E.P. Association (2014)

5.1.10 Assumptions in the end of life phase

Assumptions with respect to the end of life phase are listed in the table below:

<table>
<tr><th>Parameter</th><th colspan="7">Assumption</th><th>Source</th></tr>
<tr><td rowspan="8">EoL treatment of packaging waste</td><td rowspan="2"></td><td colspan="6">EoL treatment per fraction (in %)</td><td rowspan="8">EUROSTAT (2013)</td></tr>
<tr><td>Plastics</td><td>Ferro metals</td><td>Non-ferro metals</td><td>Paper</td><td>Cardboard</td><td>Wood</td></tr>
<tr><td>Re-use</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>Material recycling</td><td>25</td><td>94</td><td>94</td><td>68</td><td>68</td><td>36</td></tr>
<tr><td>Recovery</td><td>34</td><td>0</td><td>0</td><td>14</td><td>14</td><td>10</td></tr>
<tr><td>Incineration without recovery</td><td>0</td><td>0</td><td>0</td><td>13</td><td>13</td><td>48</td></tr>
<tr><td>Landfill</td><td>40</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td></tr>
<tr><td>Total</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td></tr>
<tr><td rowspan="9">EoL treatment of UPSs</td><td>UPS component</td><td colspan="6">Treatment</td><td></td></tr>
<tr><td>Entire UPS</td><td colspan="6">is 100% sent to WEEE compliant treatment</td><td>Assumption</td></tr>
<tr><td>Metal parts</td><td colspan="6">are melted</td><td rowspan="7">Interview with German recycling company</td></tr>
<tr><td>PWBs including ICs, diodes, ports, etc.</td><td colspan="6">are melted</td></tr>
<tr><td>Fan</td><td colspan="6">are dismantled manually and separated in metal parts, plastic parts</td></tr>
<tr><td>Power supply unit</td><td colspan="6">are shredded mechanically and separated in metal parts, plastic parts and PWBs</td></tr>
<tr><td>Plastic parts</td><td colspan="6">are shredded, sorted, and sold</td></tr>
<tr><td>Battery</td><td colspan="6">specific treatment</td></tr>
<tr><td>LCD module</td><td colspan="6">specific treatment</td></tr>
</table>

Table 7: Assumptions regarding the EoL phase

The representative product PEF results can be used to benchmark products having the same boundaries, same use phase and EoL scenarios, and similar assumptions for the background data (such as raw materials datasets, OEM components datasets, etc.

5.2 Product classification (NACE/CPA)

Based on the product category, provide the corresponding Classification of Products by Activity (CPA) (minimum two-digit, based on the latest CPA list version available). Where multiple production routes for similar products are defined using alternative CPAs, the PEFCR shall accommodate all such CPAs. Identify the sub-categories not covered by the CPA, if any

The Eurostat guidance indicates that the manufacture of UPS is covered by Prodcom class 27.90. A review of the codes for this class indicates there is no specific code associated with UPSs. The most potentially appropriate code, which covers electrical machines and apparatus, having individual functions is:

- **27.90.11.50**: Machines with translation or dictionary functions, aerial amplifiers and other electrical machines and apparatus, having individual functions, not specified or included elsewhere in HS 852 (excluding sunbeds, sunlamps and similar suntanning equipment)

In addition, a review of other Prodcom codes suggests that UPSs could also potentially be covered by the following code:

- **27.11.50.40**: Power supply units for telecommunication apparatus, automatic data-processing machines and units thereof

These definitions are very broad and will include products other than UPSs.

5.3 System boundaries – life-cycle stages and processes

As described in the PEF Guide, all processes and activities to be considered in the Resource Use and Emissions Profile shall be included in the screening step. Any exclusion of supply-chain stages will be explicitly justified and their influence on the final results will be discussed.

The system boundary is defined based on the cradle-to-grave principle. It includes all life cycle stages of the UPS from raw material extraction through processing, production, distribution, storage, to use and end of life treatment.

The **raw material acquisition and pre-processing phase** includes all processes needed for the provision of, for example, plastic granulates, metals casts, or printable paper, including mining processes, transports and processing. A global production mix was assumed as the production location for raw and basic materials, if available in the LCA database, the further processing of the raw and basic materials, as for instance, the bending of steel, the injection moulding of plastic granulates, or the production of electronic components is also covered in the life cycle phase.[5] The process location of these processes is Asia and Europe.

The **production of the main product** covers the final assembly of the UPSs. While the assembly of the small UPSs (≤ 10 kVA) takes places in Asia; the assembly of the large UPSs for the European market takes place in Europe.

In the **distribution phase** the small UPSs are transported to a retail store, the large UPSs are transported directly to the clients in Europe.

The **use phase** includes the installation of the UPSs, the use as well as the maintenance of the UPSs. For small UPSs no specific processes are necessary for the installation – the UPS is unpacked and plugged (plug-and-play). Large UPSs are installed by an expert, so that the travelling of the professional to the location of use is included in the product system. The use covers the electricity consumption of the plugged UPSs and their maintenance. That is the production and mounting of spare parts as well as disposal of replaced components. As the use phase takes place in the EU an average European electricity mix was used based on data available in the LCA database.

[5] Due to loops in the ecoinvent LCA database it was not always possible to group the processes in the product systems. Based on the origin of the main environmental impacts the processes were either considered in the group "production of raw and basic materials" or "production of UPS and packaging components".

The disposal of the packaging waste is also included in this life cycle stage. An average end of life scenario for EU 27 was defined based on statistics from EUROSTAT[6].

The **end of life phase** comprises the collection, sorting, transportation and treatment of the wasted UPSs, the metal parts of the UPSs are melted and the plastic parts of the UPSs are shredded. Printed Wiring Boards (PWBs) with mounted Integrated Circuits (ICs), diodes, capacitors, etc. are also melted as a whole. Some UPS components, as for example the Power Supply Unit (PSU) or fans, are shredded or manually dismantled and metal parts, plastic parts and PWBs are separated.

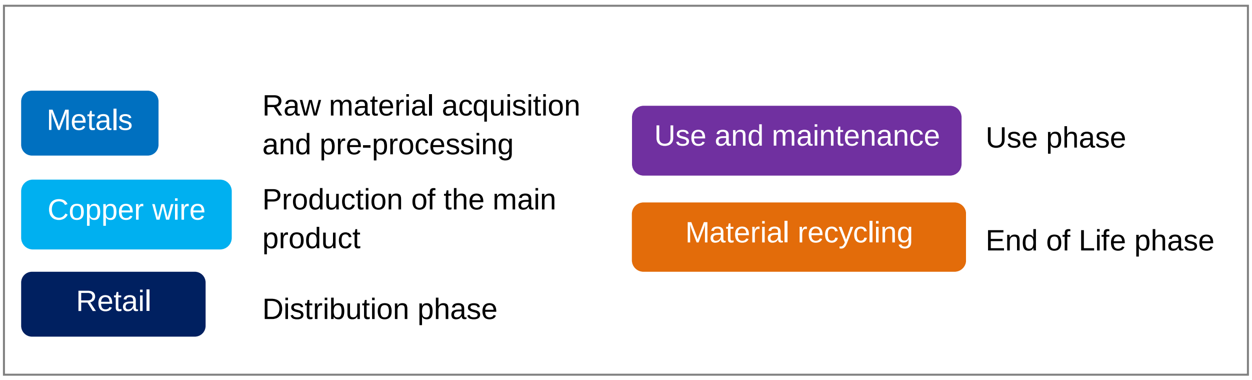
All processes in the product system were divided into foreground and background processes. Foreground processes are core processes in the product life cycle for which direct data access is available; background processes are those processes in the life cycle for which no direct access to information is possible. Due to the composition of the TS of the UPS pilot only the assembly of the UPSs is defined as foreground process, the UPS manufacturers do not produce the UPS components but purchase all parts and only final assembly is done by the manufacturers.

5.3.1 System diagram

Provide a system diagram clearly indicating the processes that are included in the product system. Provide a second diagram indicating the organizational boundary, to highlight those activities under the control of the organization, indicate with more detail the processes that are on the interface of the investigated product system (processes that are included) and other product systems (excluded processes) or the environment

Figure 1: Stakeholder distribution provides a global system boundary diagram. For a clearer view not all flows, materials and processes are illustrated, as for instance waste flows not directly linked to the UPSs or the packaging of the UPSs and transport processes.

Legend:



6 http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Packaging_waste_statistics

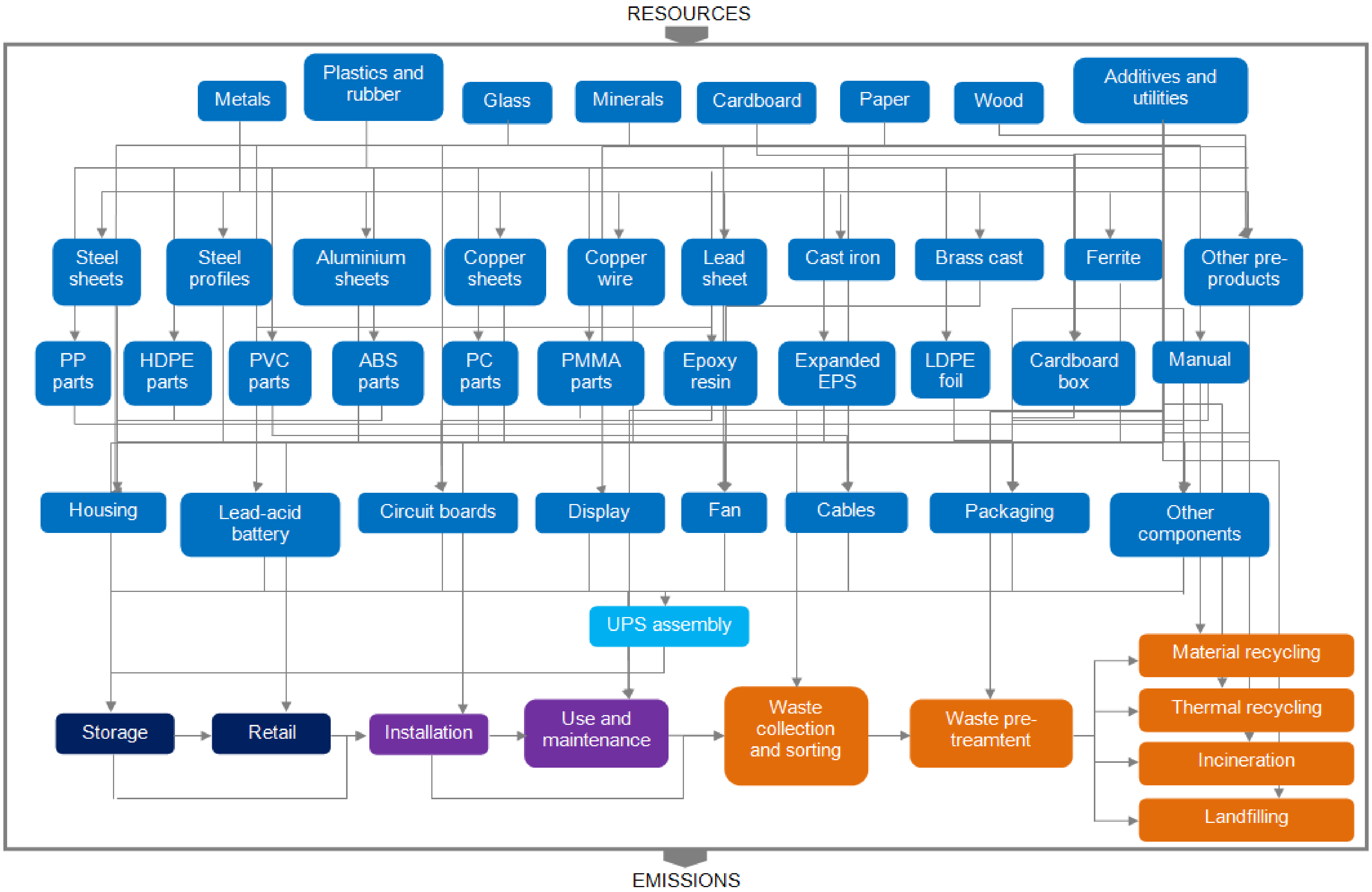


Figure 2: Stakeholder distribution

5.3.2 System boundaries - upstream processes/scenarios

The manufacturing of UPS consists of the assembly of parts and components usually sourced from suppliers. UPS manufacturers control the design and the assembly of the equipment. Upstream processes consist of the production of the raw material constituting the parts and components and the manufacturing of these parts and components. The parts and components are then shipped to the assembly location of the manufacturer.

The following diagram gives an overview of the organisation of the UPS supply chain:

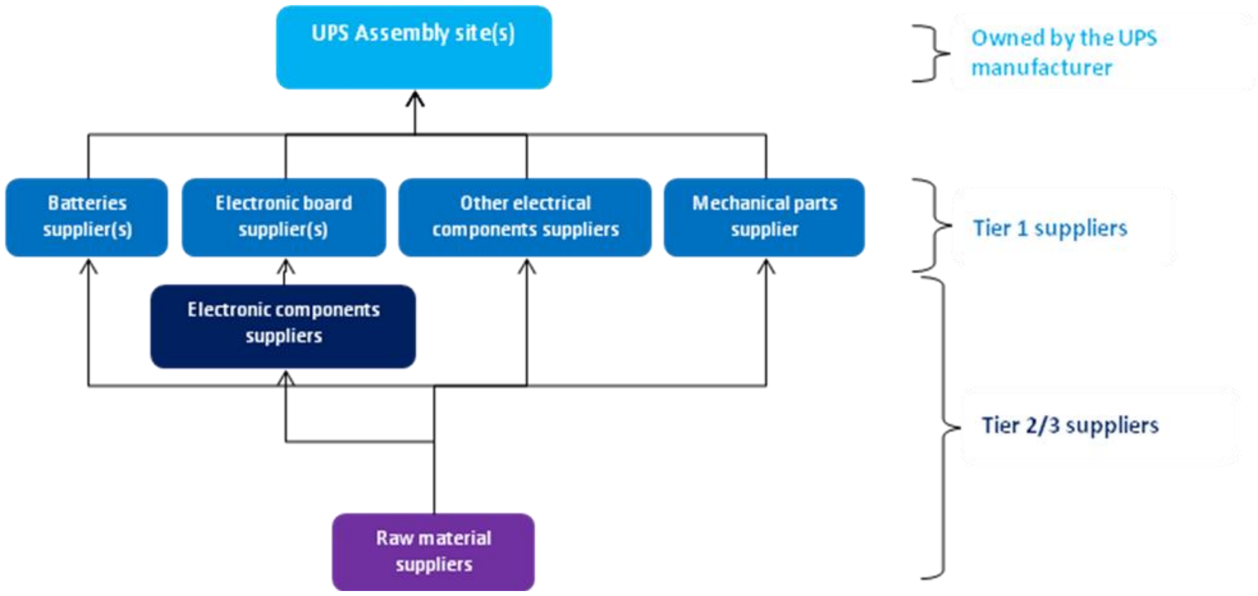


Figure 3: Overview of the supply chain of a UPS

The supply chain of electrical and electronic equipment such as UPS can involve several hundreds of suppliers and manufacturing locations (all tiers included). Some intermediate brokers of materials and components are usually involved. This multi stakeholders' chain reduces the likelihood of obtaining a complete mapping of the full supply chain. Usually the UPS manufacturers don't have any control on the operations of the suppliers, making the supply chain of each component included in a UPS very complex. If the company applying the PEFCR does not run a process and has no possibility to obtain (company) specific data for a process, then the manufacturer shall use PEF complaint/approved secondary data sources. Manufacturers shall list the activity data to be declared and the level of influence for each process in its supply chain. Use supply-chain specific PEF compliant datasets for electricity-mix and transport for sub-processes.

Figure 3 gives an example of the supply chain of a semiconductor used in a logic circuit board of a UPS. This graphic shows that only one component has multiple processes and components, adding to the complexity of the UPS's supply chain.

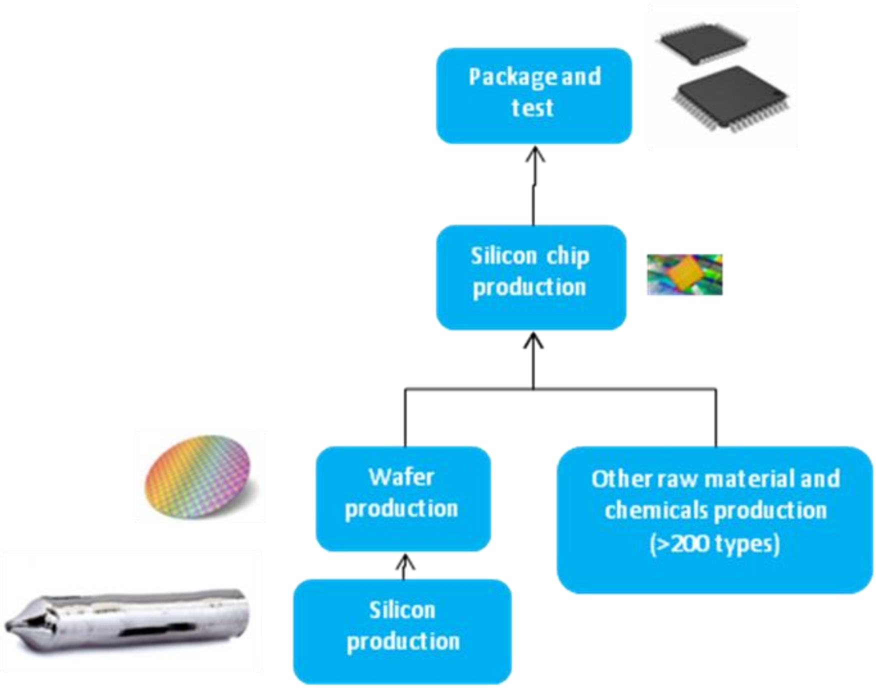


Figure 4: Overview of the supply chain of one component in composition of the UPS

The major upstream processes are listed below:

Raw material production phase

The raw material production phase includes the following processes:

- Production (extraction, treatment, transformation, etc.) and transportation of raw materials
- Manufacturing of parts (plastics, metals, packaging, etc.), electrical and electronic sub-assemblies (electronic boards, batteries,…) and utilities (electricity, detergents, etc.)

Manufacturing phase

The manufacturing phase includes the following processes:

- Production of components, sub-assemblies and utilities (heat, compressed air, etc.)
- Reuse of sub-assemblies from end of life UPSs
- Transport of components and sub-assemblies from the supplier's place of manufacturing to assembly site(s) on the producer's premises
- Manufacturing of the packaging
- Assembling of the UPS
- Transporting of the UPS from the assembly site to the producer's last logistic platform

5.3.3 System boundaries - downstream processes/scenarios

Distribution phase

The distribution phase includes the following processes:

- Transporting of UPS from the producer's logistic platform to the distributor or retailer
- Storage of the UPS
- Retail
- Transporting of the UPS from the distributor's site or retailer to the place of use

Installation phase

The installation phase includes the following processes:

- Installation of the UPS
- Use of a crane for large UPSs
- Presence of a professional for the installation of large UPSs

Use phase

The use phase of the UPS takes into account the operation of the product under normal conditions of use as well as the maintenance of the product as well as a reuse phase. The following processes are included in the use phase:

- Use of the UPS (electricity production and distribution)
- Reuse of the UPS (de-installation, transport to second user, second installation, reuse)
- Maintenance of the UPS during the entire life time (production and transport of spare parts and elements required for operating, servicing and maintaining the product, as specified by the manufacturer and not supplied with the product)

End of life

The end of life phase comprises the following processes:

- Transport from the user or reuser to the recycling and waste treatment facility
- Waste treatment (recycling, incineration, landfilling, etc.)

The minimum company-specific information to be collected by manufacturers includes:

- The energy consumed in the assembly of the UPS
- Transport of the final product to the distribution port or storage
- Product specific information (materials and manufacturing processes).

The most relevant processes shall cover the stages and information described in the table below.

Life cycle stage	Relevant processesData collected
Raw material and manufacturing	• Data of the materials of the components • International transport from production to Assembly plant Manufacturing loss for materials of at least largest mechanical components by weight
Assembly of final UPS	• Energy consumed in the assembly of the UPS
Distribution	Intracontinental transport of final UPS to storage or distribution port
Use + maintenance	Energy at the consumer and replacement parts
End of Life	Transport of decommissioned UPS to recycling facility Treatment of waste at recycling centers

Additional important processes shall include:

- Transport of manufacturing loss to treatment facilities
- Treatment of waste at recycling centers
- Transport of technician delivering or installing the UPS (add this process to distribution)
- Replacement parts transport and disposal treatment

5.4 Impact categories indicators

This section shall document the impact assessment method and tool used to run the assessment. The assessment method shall be selected based on the levels of classification from the ILCD handbook.

- Classification of the methods performed in the ILCD Handbook “Recommendations for Life Cycle Impact Assessment in the European context”, JRC, 2011 The recommended characterization models and associated characterization factors are classified into three levels according to their quality:

Level I	recommended and satisfactory
Level II	Recommended, but in need of some improvements
Level III	recommended, but to be applied with caution

The impact indicators can be reported in two groups, mandatory and optional. The required indicators are based on characterization of the results of supporting studies that show the dominant impacts are Climate Change, Ozone Depletion and Water Depletion.

Mandatory impact categories	Unit
Climate change	kg CO2 eq
Ozone depletion	kg CFC-11 eq
Water depletion	m^3 water eq

Table 8: List of required impact categories

Optional ILCD Impact Category	Unit
Human toxicity, cancer effects	CTUh
Human toxicity, non-cancer effects	CTUh
Particulate matter/Respiratory inorganics	kg PM2.5 eq.
Ionizing radiation, human health	kBq U^{235} eq. (to air)
Photochemical ozone formation, human health	kg NMVOC eq.
Acidification	mol H+ eq.
Eutrophication terrestrial	mol N eq.
Eutrophication freshwater	kg P eq.
Eutrophication marine	kg N eq.
Land use	kg C deficit
Ecotoxicity freshwater	CTUe
Resource depletion, mineral, fossils and renewables	kg Sb eq.

Normalization of the results is optional if the tools allow this step. If the results are normalized the mandatory indicators are the three listed below. In addition, the optional indicators of the table above can be reported.

- Human toxicity - carcinogenic effect
- Freshwater eutrophication
- Resource depletion- mineral, fossil

5.5 Additional environmental information

In addition to the calculation of the environmental footprint, it is recommended to include the following information about the product:

- Calculation of the recyclability of the equipment using the **IEC TR 62635:2012** "Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment

5.6 Assumptions/limitations

Availability of reliable data sets

Main limitation of the study is associated with the low availability of relevant data for electronic components and batteries in common databases like ELCD or Ecoinvent. Manufacturers will not be able to collect specific data for the production of these components; therefore the quality of the PEF will be a function of the availability of reliable inventories in LCA databases.

In order to overcome this limitation, it is recommended to use databases containing a more complete set of data for the production of electronic components such as the Gabi database, the EIME database or private data such as the SGS database.

This PEFCR includes a list of datasets that shall be used to model the product. The list includes primary and secondary modules from different sources (see Annex VIII). The list will enable the benchmark with the reference studies and increase the robustness of the life cycle assessment.

End of life formula

The EOL WG recommends a simplified end of life approach given the complexity of the composition of a UPS and the availability of end of life data. It is recommended to collect the following information that is readily available to manufcaturers:

The inputs and outputs associated with the following aspects shall be included in the end-of-life stage:

1. Required transportation to collect the end-of-life product and transport it from the installation site to the final treatment site.
2. Treatment processes (landfilling or incineration without waste-to-energy recovery), including depollution treatment of items (for example items covered by WEEE Directive 2012/19/EU) to be sent to special end-of-life product treatment centers, up to final treatment.

System expansion is not allowed at end-of-life stage (i.e. environmental benefits from energy recovering and recycling are excluded).

***NOTE**: The end-of-life of the product under study therefore corresponds to a disposal and/or storage process in the case of waste recovery.*

6 Resource use and emission profile

6.1 Screening step

A robust assessment shall have as much primary data that reflects the company operations and production of the product. The PEFCR indicates when primary data is mandatory and when secondary data can be used. The use of secondary data has been harmonized by providing amounts to be used for the assessment. These amounts are based on industry data. For the context of this PEFCR primary and secondary data are defined as follows:

Primary data	Primary data refers to specific processes within the supply chain of the company. Such data may take the form of activity data or direct elementary flows collected by the manufacturers via meter readings, direct monitoring, engineering models, or other methods to obtain site specific information. For instance the amount and type of metal contained in a UPS.
Secondary/ Generic data	Secondary data refers to non-process specific data within the supply chain of the company. These data are not directly measured, estimated, monitored from the supply chain but sourced from industry averages from commonly used LCA databases, LCA studies, articles and industry associations. In this particular case PEFCR provides product category data for typical activities of the industry to cover data gaps. For example the transport values in the PEFCR and datasets (see section 6.6)

6.2 Data Needs Matrix

Availability of data depends in many cases on the situation of the manufacturing of the product. There are instances in which data is not at all available to a manufacturer because parts are sourced from suppliers. To identify when data may not be available, the data needs matrix (Table 4) from the PEF Guideline v 5.1, shall be used to identify the level of data collection possible, the limitations and when secondary data sources can be used. All limitations and assumption shall be listed in the final report.

- Situation 1: the process is run by the company applying the PEFCR v 1.7
- 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.

Table 4 Data needs matrix

		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[7] (DQR ≤1.6).	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).
Situation 1: process run by the company applying the PEFCR	**Option 2**		Use default secondary dataset, in aggregated form (DQR ≤3.0)
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).	Use default secondary dataset, in aggregated form (DQR ≤4.0)
Situation 2: process not run by the company applying the PEFCR but with access to (company-)specific information	**Option 2**	Starting from the default secondary dataset provided in the PEFCR, 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. The newly created dataset shall have a DQR ≤3.0.	
Situation 3: process not run by the company applying the PEFCR and without access to (company)-specific	**Option 1**	Use default secondary dataset, in aggregated form (DQR ≤3.0)	

After identifying the data level situation, use the table below to guide your selection of data sets, whether primary or genric/secondary by life cycle stage and process. the The table below is a tool intended for the classification and qualification of primary and secondary data. This table shall be used to classify the data as primary or generic. In Annex IX, Background datasets, this PEFCR provides guidance on values and datasets to be used for the secondary/generic data (blue cell in table 4).

7 The underlying sub-processes shall be based on PEF-compliant secondary datasets.

Life Cycle Stage	Process	Material/Component			Manufacturing Process			Transportation			Justification/Comment
		Quantity	Type	Data source	Quantity	Type	Data source	Quantity	Type	Data source	
Productions of raw & basic materials	Included in subsequent stages										
Production of primary packaging	Material in composition	Primary	Primary	Generic	Generic	Generic	Generic	Generic	Generic	Generic	Does not contribute significantly to the impacts.
Production of second. & tertiary packaging		Excluded from the score									Does not contribute significantly to the impacts.
Production of materials used in UPS	Material in composition	Primary	Primary	Generic	Primary	Primary	Generic	Generic	Primary	Generic	Contributes significantly to the impacts.
Production of component	Printed Circuit Boards	Primary	Primary	Generic	Primary	Primary	Generic	Generic	Primary	Generic	Contributes significantly to the impacts. Not possible to collect specific data.
	Semiconductors	Primary	Primary	Generic	*Included in component*			*Included in component*			
	Batteries	Primary	Primary	Generic	*Included in component*			*Included in component*			
	Cables	Primary	Primary	Generic	*Included in component*			*Included in component*			
	Other	Primary	Primary	Generic	*Included in component*			*Included in component*			
Production of UPS	UPS assembly & customization	Primary	Primary	Generic	Primary	Primary	Generic				Does not contribute significantly to the impacts.
	Transport to distribution center							Primary	Primary	Generic	Does not contribute significantly to the impacts.
	Storage at distribution center	Excluded from the scope									Does not contribute significantly to the impacts.
Product Distribution	Transport to point of sale							Generic	Primary	Generic	Does not contribute significantly to the impacts.
	Consumer transport							Generic	Generic	Generic	Does not contribute significantly to the impacts.
Installation of UPS *(Only for large UPSs)*	Installation components	Primary	Primary	Generic	Generic	Primary	Generic	Primary	Primary	Generic	Only relevant for UPS > 5 kVA
	Installation processes				Generic	Primary	Generic	Generic	Primary	Generic	Only relevant for UPS > 5 kVA
Use of UPS	Electricity				Primary	Primary *	Generic				Contributes significantly to the impacts.
	Life span				Generic	Primary	Generic				Market life span to use as default value
	Replacement parts	Primary	Primary	Generic	Primary	Primary	Generic				Only relevant for large UPSs
End of Life of the product	Transport (waste collection)							Generic	Generic	Generic	Does not contribute significantly to the impacts. Not possible to collect specific data.
	Waste treatment (landfill. etc.)				Generic	Generic	Generic				

** i.e. Region of electricity production*

6.3 Data quality requirements

Data quality assessment of datasets can be performed preferably on all data (materials and processes) when information of Table 9: Data quality requirements (PEF Guide), table on next page, If the information is not available for all data, the assessment shall include at least the material and processes that the information on the six criteria is available.

When selecting datasets for the life cycle assessment it is important to keep in mind that data older than 10 years will provide poor data quality rating because data may be outdated, not cover the relevant impact indicators, or have significant technological differences compared to most recent data. Based on the Data quality requirements of Table 5, a complementary excel tool for this PEFCR was developed to facilitate rating of data sets (Annex XII and find the Quality Data Rating excel tool in the Wiki page).

The table organizes the processes and material based on life cycle phases and score the data based on the DQR of the PEF method Table 3, page 33. Processes shall only be rated once even if present multiple times in different life cycle stages. Materials assessed shall at least cover 95% of the weight of the product. Processes shall include manufacturing, distribution, electricity and disposal. After scoring each criteria based on the information in the software or database, the table in the Annex tabulates the results and generates the single score to be reported in this section. In particular, three parameters shall be adapted by the applicant: time representativeness, technological representativeness and geographical representativeness. All the other parameters in the DQR formula shall remain as quantified in the original data set.

The semi-quantitative assessment of the overall data quality of the dataset is calculated summing up the achieved quality rating for each of the quality criteria and dividing by the total number of criteria. The Data Quality Rating (DQR) goes from1 to 5 with 1 being the best quality. The semi-quantitative assessment of the overall data quality of the dataset requires the evaluation (and provision as metadata) of each single quality indicator. This evaluation shall be done according to formula of the PEF method [1]:

$$\text{DQR} = \frac{TiR + TeR + GR + C + P}{5} \qquad [1]$$

- DQR : Data Quality Rating of the dataset
- TeR: Technological Representativeness
- GR: Geographical Representativeness
- TiR: Time-related Representativeness
- C: Completeness;
- P: Precision/uncertainty;

Quality level		Complete -ness	Time representa-tiveness	Technology representativeness	Geographical representativeness	Precision/ uncertainty
Very good	1	> 90%	< 3 year-old data	data from technology under study	data from area under study	≤ 10%
Good	2	> 80 – 90%	3 – 5 year-old data	data from average technology-mix of the country in which the applied technology is included	average data from a larger area in which the area under study is included	10 – 20%
Fair	3	> 70 – 80%	5 – 10 year-old data	data from average technology-mix of the region or typical technology applied in the region	data from area with similar environmental legislation and production conditions	20 – 30%
Poor	4	> 50 – 70%	10 – 15 year-old data	average technology for similar products	data from area with different environmental legislation and production conditions	30 – 50%
Very poor	5	< 50 %	≥ 15 year-old data	other technology	data from area with very different environmental legislation and production conditions	> 50%

Table 9: Data quality requirements (PEF Guide)

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6.4 Requirements regarding foreground specific data collection

Foreground data refers to the information from the activities happening at the manufacturing sites owned by the manufacturer where parts for the UPS are produced plus the final assembly sites controlled by the company. The assembly phase accounts for a small portion of the overall impact categories. However, as it is common within UPS manufacturers it can be the only foreground process. Therefore, electricity consumed at the assembly location shall be reported and added to the electricity of manufacturing. The electricity can be allocated by weight.

6.5 Requirements regarding background generic data and data gaps

Background data shall cover processes and activities not controlled by manufacturers. These data include raw materials extraction, processing and manufacturing of the components supplied to the final assembly company. In addition, transport of components to the final assembly site, transport of technician to the user location and transport of the product to the recycling facility. Other activities covered under background data are the end of life treatment for generic material in the product (metals, plastic, inert, electronics and packaging).

6.6 Data gaps

This PEFCR provides a list of preferred secondary datasets for processes when no primary data is available. The chosen set shall follow the format of the table below. However, the choice of geographical location can vary according to the company situation. If there are additional data gaps for processes or materials that are not in the table below it is expected that manufacturers consult other sources of information to fill data gaps with industry averages, data from literature, other sources. Secondary datasets for the modelling shall be chosen from the tables in Annex IX.

6.7 Use stage

PEF Guidelines for the Use Phase

Analyse and declare separately the use phase following the instruction in this section.

Is the use stage process...?		Use stage processes	Actions taken by the TS:	
(ii) Product dependent?	(iii) Most relevant?		Modelling	Reporting
Yes	Yes	Electricity at consumer	Modelled as main function approach. Default data provided (total energy use).	In the PEF report

6.8 Use scenario

6.8.1 Operating profiles

The electricity consumption of a UPS is related to its load. To calculate the total electricity consumption of a UPS, it is required to know:

- The energy efficiency of the product at different load. These values are specific for each product.
- The typical usage profile of a UPS is shown in the table below:

UPS size	Topology	Proportion of time spent in each load			
		25%	50%	75%	100%
< 1.5 kVA	VFD	0.20	0.20	0.30	0.30
1.5 kVA – 5.0 kVA	VI or VFI	0.00	0.30	0.40	0.30
5.1 kVA – 10 kVA	VFD, VI or VFI	0.00	0.30	0.40	0.30
10.1 kVA – 200 kVA	VFD, VI or VFI	0.25	0.50	0.25	0.00

Table 10: Operating profiles for different UPSs
Source: Energy STAR® Program Requirements, Criteria Version 1.0

How to read the table: A UPS below 1.5 kVA is working 20% (0.2 in the table) of its time at 25% load, 20% of its time at 50% load, 30% of its time at 75% load and 30% of its time at 100% load.

6.8.2 Calculation of electricity consumption

As presented in chapter 0 numeral 5, UPSs can use different topologies. Some UPSs just have one operating mode (single mode) and some more sophisticated UPSs can have several operating modes and are able to switch between them during usage. The operating mode influences the electricity consumption of the UPS considerably. How to calculate the energy efficiency is explained in the following sub-chapters:

6.8.3 Energy efficiency calculation in case of a single mode UPS

To calculate the average efficiency of a UPS take the operating profile from Table 10: Operating profiles for different UPSs and the specific energy efficiency at these different loads (values are different for each UPS and each manufacturer). Then calculate the energy consumption using Equation 1:

$$\text{average efficiency} = [t]_{25\%}xEff_{25\%} + [t]_{50\%}xEff_{50\%} + [t]_{75\%}xEff_{\mathbf{75\%}} + [t]_{100\%}xEff_{100\%}$$

Equation 1: Calculation of energy efficiency for a single mode UPS

Where:

- $[t]_{25\%}$ is the amount of time the UPS is running at 25% load as indicated in Equation 1: Calculation of energy efficiency for a single mode UPS
- $xEff_{25\%}$ is the energy efficiency of the UPS at 25% load. Only the manufacturer knows this value.

If the equation 1 is entered in Table 11: Calculation of electricity consumption in single mode , it gives the following table:

UPS size	Topology	Equation 1 (average efficiency)
< 1.5 kVA	VFD	$0,2xEff_{25\%}+0,2xEff_{50\%}+0,3xEff_{75\%}+0,3xEff_{100\%}$
1.5 kVA – 5.0 kVA	VI or VFI	$0,3xEff_{50\%}+0,4xEff_{75\%}+0,3xEff_{100\%}$
5.1 kVA – 10 kVA	VFD, VI or VFI	$0,3xEff_{50\%}+0,4xEff_{75\%}+0,3xEff_{100\%}$
10.1 kVA – 200 kVA	VFD, VI or VFI	$0,25xEff_{25\%}+0,5xEff_{50\%}+0,25xEff_{75\%}$

Table 11: Calculation of electricity consumption in single mode

6.8.4 Energy efficiency calculation in case of a multimode UPS

Calculate the average efficiency according to equation 1 for both modes, then apply Equation 2:

$$\text{average efficiency} = 0{,}75\text{xEff1} + 0{,}25\text{xEff2}$$

Equation 2: Calculation of energy efficiency for a multimode UPS

Where:

- Eff1 is the average loading-adjusted efficiency in the lowest input dependency mode (i.e. VFI or VI), as calculated per Equation 1.
- Eff2 is the average loading-adjusted efficiency in the highest input dependency mode (i.e. VFD), as calculated per Equation 1.

6.9 Life Span

The life span of the UPS shall be defined based on the power output of the UPS as established in Table 12.

UPS size	Lifetime in years
< 1.5 kVA	5
1.5 kVA – 5.0 kVA	8
5.1 kVA – 10 kVA	10
10.1 kVA – 200 kVA	15

Table 12: Typical lifetimes of different UPSs
Source: UPS PCR from PEP ecopassport

6.10 Maintenance

The use stage includes all activities and products that are needed for a proper use of the product during its lifetime. Manufacturing, distribution and waste of materials needed for maintenance, repair or refurbishment (e.g. spare parts needed to repair the product, the coolant production and waste management due to losses). The waste of the product in use (e.g., food waste, packaging, or the product left at its end of use) is excluded from the use stage and is part of the end of life stage of the product.

Some UPSs may require to be maintained to reach the expected lifetime. A non-exhaustive list of typical UPS components to be maintained is:

- Electrolytic capacitors
- Fans
- Batteries if incorporated in the UPS
- PCB

The amount of each component needed during the lifetime of the UPS has to be taken into account in the life cycle assessment, as defined in the following table**:**

UPS size	Typical lifetime in years	Maintenance frequency			
		Capacitor	Fan	Power supply PCB	Lead-acid battery
< 1.5 kVA	5	No maintenance			
1.5 kVA – 5.0 kVA	8	1	1	1	1
5.1 kVA – 10 kVA	10	1	2	1	1
10.1 kVA – 200 kVA	15	2	3	2	2

Table 13: Maintenance frequency
Source: UPS PCR from PEP ecopassport

6.11 Transport scenarios

Transport-specific data should be taken into account for transportation stages (kilometres covered, types of transport). Data shall be justified and documented in the LCA report.

If no specific data are available, the following generic data shall be taken into consideration for all the stages, from manufacturing to end-of-life:

- International transport: 19,000 km by boat plus 1,000 km by lorry
- Intracontinental transport: 3,500 km by lorry
- Local transport: 1,000 km by lorry.

The LCI datasets in the ELCD database should be used for these scenarios:

- Lorry: the latest available version of the "Articulated lorry transport" dataset Euro 0, 1, 2, 3, 4 mix; 40 t total weight, 27 t max payload" dataset for "RER" location and non-parameterised; •
- Ship: The latest available version of the "Ocean-going container ship; technology mix; 27.500 dwt pay load capacity" dataset for "RER" location and non-parameterised. Any special means of transport necessary shall be taken into consideration.

Consumer transport (from retailer to consumer home) is excluded from the use stage and shall be included in the distribution stage: 500km by car "Car; for passenger transport; technology mix; petrol; RER"

6.12 End-of-life stage

The following treatment scenarios shall be considered for all elements during the life cycle and documented in the LCA report:

- The quantity going for treatment shall equal to the product weight as it is expected that the whole product is sent to the treatment facility where components will be dismantled.
- Product/material disposal processes (incineration without waste-to-energy recovery, landfill)

  If the product disposal treatment is known and/or the data are available, the impacts related to these processes shall be taken into account. The types of treatment used shall be described and documented in the LCA report.

  If distance data to the disposal site are not known, it shall be considered by default the transport by lorry of the considered product aver 1,000 km.
- Product/material recovery (reuse, recycling or incineration with waste-to-energy recovery).

  In this case, the end-of-life treatment does not lead to waste disposal. The stage ends in the storage of the materials, which obtain the status of end-of waste. Environmental benefits and loads relating to secondary material, secondary fuel or recovered energy going out the product system shall not be included.

Processes ending in waste storage shall be included in the scope of the analysis of the product that generates the waste.

Processes enabling stored resources to be used shall be included in the scope of the study of the product that uses the resources.

If distance data to the disposal site are not known, it shall be considered by default the transport by lorry of the considered product aver 1,000 km.

The system boundaries (and in particular the location of the stored materials) shall be clearly explained and documented in the LCA report.

If the treatment is unknown or the data are not available, it shall be considered by default the transport by lorry of the end-of-life product over 1,000 km and the disposal in landfill site by identified waste constituting material family. The following ELCD LCI dataset shall be used:

- Ferrous metals - Data set: Landfill of ferro metals (03.00.000) (source: Landfill of ferro metals; landfill including leachate treatment and without collection, transport and pretreatment; at landfill site),
- Plastics - Data set: Landfill of plastic waste (03.00.000) – (source: Landfill of plastic waste; landfill including landfill gas utilisation and leachate treatment and without collection, transport and pre-treatment; at landfill site),
- Inert waste - Data set: Landfill of glass/inert waste (03.00.000) – (source: Landfill of ferro metals; landfill including leachate treatment and without collection, transport and pre-treatment; at landfill site).

Table 14: Required Data sets

The datasets for the modelling of the life cycle of the product shall be selected from the table below. Any dataset not in this table and use in the design, shall be identified in the report, including its source, year and location and reason to use a module outside the indicated set of this PEFCR.

Required Data Set	Source	Year	Location
Materials production			
Acrylonitrile-Butadiene-Styrene granulate (ABS);production mix, at plant	ELCD 3.2	2006	RER
Aluminium sheet;primary production;production mix, at plant;aluminium semi-finished sheet product, including primary production, transformation and recycling	ELCD 3.2	2011	RER
Copper wire;technology mix;consumption mix, at plant;cross section 1 mmy	ELCD 3.2	2009	EU-15
Lead primary and secondary mix ;technology mix;production mix, at producer;primary 46% / secondary 54%	ELCD 3.2	2011	EU-27
Steel hot dip galvanized	ELCD 3.2	2005	GLO
Polypropylene, granulate	Ecoinvent		ROW
Polyethylene, high density, granulate	Ecoinvent		ROW
Processes			
Injection moulding {RoW}| processing | Alloc Def	Ecoinvent	Recent	GLO
Blow moulding {RoW}| production | Alloc Def	Ecoinvent	Recent	GLO
Extrusion, plastic film {RoW}| production | Alloc Def	Ecoinvent	Recent	GLO
Thermoforming, with calendering {RoW}| production | Alloc Def	Ecoinvent	Recent	GLO
Calendering, rigid sheets {RoW}| production | Alloc Def	Ecoinvent	Recent	GLO
Solder, paste, Sn95.5Ag3.9Cu0.6, for electronics industry {GLO}|	Ecoinvent	Rece	GLO

		nt	
Extrusion of aluminium; technology mix, at plant; RER	CODDDE	Rece nt	RER
Bending of steel parts; from pre-shaped materials; technology mix, at plant; NE	CODDDE	Rece nt	RER
Electronics			
Capacitor, tantalum-, for through-hole mounting {GLO}| market for | Alloc Def	Ecoinvent	Rece nt	GLO
Capacitor, electrolyte type, > 2cm height {GLO}| market for | Alloc Def	Ecoinvent	Rece nt	GLO
Capacitor, film type, for through-hole mounting {GLO}| market for | Alloc Def	Ecoinvent	Rece nt	GLO
Integrated circuit, logic type {GLO}| production | Alloc Def	Ecoinvent	Rece nt	GLO
LCD module, at plant/GLO	Ecoinvent	Rece nt	GLO
Light emitting diode {GLO}| production | Alloc Def	Ecoinvent	Rece nt	GLO
Connector, PCI bus, at plant/GLO	Ecoinvent	Rece nt	GLO
Diode, glass-, for surface-mounting {GLO}| production | Alloc Def	Ecoinvent	Rece nt	GLO
Printed wiring board, for surface mounting, Pb free surface {GLO}| production | Alloc Def	Ecoinvent	Rece nt	GLO
Resistor, SMD type, surface mounting, at plant/GLO	Ecoinvent	Rece nt	GLO
Resistor, metal film type, through-hole mounting, at plant/GLO	Ecoinvent	Rece nt	GLO
Power supply unit, at plant/CN	Ecoinvent	Rece nt	CN
Packaging			
Pine wood;timber;production mix, at saw mill;40% water content		Rece nt	DE
Paper; production mix, at plant; with deinking, 100% recycled, from wastepaper; RER	CODDE	Rece nt	
Packaging film, LDPE, at plant/RER U	CODDE	Rece nt	
Corrugated board, recycling fibre, double wall, at plant/RER U	CODDE	Rece nt	
Extrusion, plastic film/RER U	CODDE	Rece nt	
PET film (production only)	CODDE	Rece nt	
Replacement parts			
Lead-acid battery	Ecoinvent	Rece nt	
Lead acid battery, valve regulated; production mix, at plant; GLO	CODDE	Rece nt	GLO
Transport			
Articulated lorry transport;Euro 0, 1, 2, 3, 4 mix;40 t total weight, 27 t max payload	ELCD database 3.2	Rece nt	RER
Lorry transport;Euro 0, 1, 2, 3, 4 mix;22 t total weight, 17,3 t max payload	ELCD database 3.2	Rece nt	RER
Small lorry transport;Euro 0, 1, 2, 3, 4 mix;7,5 t total weight, 3,3 t max payload	ELCD database 3.2	Rece nt	RER
Container ship ocean;technology mix;27.500 dwt pay load capacity	ELCD database 2.0	Rece nt	RER
Rail transport;technology mix, electricity driven, cargo-GLO	ELCD database 2.0	Rece nt	GLO
Rail transport;technology mix, diesel driven, cargo-RER	ELCD database 2.0	Rece nt	RER
Electricity grid mix 1kV-60kV;AC;consumption mix, at consumer;1kV - 60kV	ELCD database 3.0	Rece nt	EU
End of Life			

Landfill of ferro metals;landfill including leachate treatment and without collection, transport and pre-treatment;at landfill site	ELCD database 2.0	Recent	EU-27
Landfill of glass/inert waste;landfill including leachate treatment and without collection, transport and pre-treatment;at landfill site	ELCD database 2.0	Recent	EU-27
Landfill of municipal solid waste;landfill including landfill gas utilisation and leachate treatment, without collection, transport and pre-treatment;FR, GB, IE, FI, NO technology mix, at landfill site	ELCD database 2.0	Recent	EU-27
Landfill of paper waste;landfill including landfill gas utilisation and leachate treatment and without collection, transport and pre-treatment;at landfill site	ELCD database 2.0	Recent	EU-27
Landfill of plastic waste;landfill including landfill gas utilisation and leachate treatment and without collection, transport and pre-treatment;at landfill site	ELCD database 2.0	Recent	EU-27
Landfill of untreated wood;landfill including landfill gas utilisation and leachate treatment and without collection, transport and pre-treatment;at landfill site	ELCD database 2.0	Recent	EU-27
Waste incineration of ferro metals;average European waste-to-energy plant, without collection, transport and pre-treatment;at plant	ELCD database 2.0	Recent	EU-27
Waste incineration of glass/inert material;average European waste-to-energy plant, without collection, transport and pre-treatment;at plant	ELCD database 2.0	Recent	EU-27
Waste incineration of glass/inert material;average European waste-to-energy plant, without collection, transport and pre-treatment;at plant	ELCD database 2.0	Recent	EU-27
Waste incineration of municipal solid waste (MSW);average European waste-to-energy plant, without collection, transport and pre-treatment;at plant	ELCD database 2.0	Recent	EU-27
Waste incineration of plastics (unspecified) fraction in municipal solid waste (MSW);average European waste-to-energy plant, without collection, transport and pre-treatment;at plant	ELCD database 2.0	Recent	EU-27

6.13 Requirements for multifunctional products and multiproduct processes allocation

Not applicable for this product category

7 Benchmark and classes of environmental performance

Benchmarking was completed for comparison of the outcomes of the supporting studies against the screening studies. The benchmark confirmed that the application of the PEFCR resulted in results comparable to the reference/screening study.

The environmental performance shall be developed based on the Commissions guidance, it was not done for the supporting studies.

8 Interpretation

The information in this section shall be a succinct understanding of the accuracy of the results to determine if they meet the goal of the study. This can be accomplished by identifying the data inputs with significant contribution to each impact category, evaluating the sensitivity of these significant data, assessing the completeness & consistency of the data and study, and drawing conclusions and recommendations based on a clear understanding of the conditions to conduct the LCA and the influence in the results.

9 Reporting, Disclosure and Communication

Use the official PEF template for the reporting of the study.

9.1 PEF external communication report

This report is a short version of the study without confidential information. Remove section 5 or provide non-confidential information that informs about the product and modify the outcomes of the assessment as needed. The results shall specify the life cycle impacts, the most relevant life cycle phase, the most significant impact categories, the most relevant processes and elementary flows.

9.2 PEF performance tracking report

To be developed

9.3 PEF Declaration

As a reminder from guidance section 3.14.3. “The PEF profile can be communicated through a PEF declaration which is intended to be either publicly available or not.” and “the characterised results for all impact categories shall be available to the public through freely accessible information sources.”

The PEF declaration is designed to be communicated in a B2B context.

The PEF declaration shall be based on a specific PEF study covering all the life cycle stages.

The PEF declaration shall contain the information described in the following sections regarding:

- General information
- Constituent materials
- Additional environmental information
- Environmental impacts

NOTE: The Company is free to use the template and graphics according to internal marketing guidelines.

9.4 General information

Name of the document

The term “PEF declaration” shall be included in the declaration.

Information regarding the document

The information shall include:

- The date of publication and the validity period,
- The identification of the applicable "PEF Guidance" document and its version,
- The identification of the applicable "Product Environmental Footprint Category Rules" (PEFCR) document and its version,
- The text: "The PEFCR review was conducted by an expert panel chaired by <name and organisation of the chair of the review panel>" ,
- The text: "The content of this PEF declaration cannot be compared with content based on another life cycle assessment method",
- The verification text: "Independent verification of the declaration and data, according to PEF Guide specifications from the European Commission.",
- The verifier’s name and organisation.

Information regarding the company publishing the PEF declaration

The information shall include:

- The company details (name, web site),
- The details of a legal contact in the company (e.g. create a specific email address).

Product and methodology

The PEF declaration shall indicate:

- The name of the product ,
- An illustration of the product,
- Information that unambiguously identifies the product: trade reference, etc.,
- The functional unit used to draw up the PEF study ,
- Intended use of the product,
- Where appropriate:
    - The product category to which the product belong,
    - The list of eligible entities.

9.5 Constituent materials

- The total mass of the product, packaging and additional elements supplied with the product by the manufacturer shall be indicated.
- For the following categories, indicate their distribution in percentage of the total mass of the product, packaging and elements supplied with the product:
    - Plastics,
    - Metals,
    - Others.
- Materials can be also further listed by material groups or by base materials as defined in IEC 62474 in its latest edition:
    - Example of material groups: copper and alloys, thermoplastics,
    - Example of base materials: copper, zinc, lead, polycarbonate, talc, dye.
- Beyond appearing in 15 material groups or basic materials, they shall also be listed under "Miscellaneous".
- Distribution data for materials shall be expressed as a % of the product mass with 1 digit after the decimal point and ranked in descending order of mass if it is presented in the form of a table.
- The materials shall cover the entire reference product, packaging and elements supplied with the product.
- The value of substances and materials with a mass lower than 0.1 % shall be given as "<0.1%".
- Plastics can be identified in conformity with the relevant current standards.
- Some components (e.g.: electronic circuit boards, cells and batteries,…) can be listed with their mass in the material balance without a description of the constituent materials, except for hazardous substances such as those listed in the following sections.

9.6 Additional environmental information

General

Certain relevant aspects should be specified in the PEF declaration:

- Additional environmental information shall be specific, accurate and not misleading. They shall be based on information that is substantiated and verified, in accordance with the requirements of ISO 14020 and ISO 14021, clause 5.

- Additional environmental information shall only be related to environmental issues. It may include data on product performance, if environmentally significant. Information and instructions on product safety unrelated to the environmental performance of the product shall not be part of a PEF declaration.
- Although the additional information cannot generally be related to a functional unit, it shall be provided for the same product as the product to which the environmental part of the PEF declaration applies.
- All additional environmental information shall be justified and documented in the LCA report and readily available on request and verifiable if it is disclosed:
- Where relevant, references shall be made to recognized measurement methods defined in PEFCR or to the standards in force.
- By default, measurement methods used to justify the additional environmental information shall rely on test report documented in LCA report.

Manufacturing

Actions to reduce the environmental impact of manufacturing activities such as any environmental management systems or a regulatory monitoring device can be mentioned, with a statement on where an interested party may find details of the system.

The additional environmental information may include information on absence or level of presence of a material that is considered of environmental significance in certain areas [see ISO 14020 and ISO 14021, 5.7 (r)]. It shall not refer to the absence of substances or features that are not or have never been associated with the product category.

The hazardous substances specified in the various regulations (REACH, RoHS, etc.) or standards (IEC 62474, etc.) in force in the countries concerned and used in the composition of the reference flow can be mentioned as additional information.

For example, the following hazardous substances specified in the RoHS Directive can be declared when present in the homogeneous materials of the product:

- Lead,
- Mercury,
- Cadmium,
- Hexavalent chromium,
- Polybrominated biphenyl (PBB) ,
- Polybrominated diphenyl ether (PBDE).

If the quantity of a hazardous substance is indicated, it shall be expressed as specified by the regulations in force.

Distribution

Actions to reduce the environmental impact of the distribution stage such as the establishment of specific logistic processes can be mentioned.

Installation

Actions to reduce the environmental impact of the installation process can be mentioned.

Use

Actions to reduce product pollution and its impact on the environment according to the characteristics of the product and consistent with the product use can be mentioned.

The following aspects can be provided, when relevant:

- Instructions and limits for efficient use,
- Noise level, when considered by the applicable standards,

- Electromagnetic emissions, when considered by the applicable standards.

A product may reduce, through its main function, the environmental impact of a system with which it interacts or it monitors.

In this case, claimed environmental impact reduction may be mentioned in the use phase section in the PEF declaration and shall be clearly calculated, justified and documented in the LCA report.

End of life

Actions to reduce the end-of-life impact of the product on the environment should be mentioned, such as participation in recycling or recovery programs, provided that details of these programs are readily available to the purchaser or user and contact information is provided.

For products submitted to end-of-life treatment regulations, the presence and mass of any components or subassemblies that have to be sent to specific treatment centres should be mentioned (e.g. Directive 2012/19/EU on Waste Electrical and Electronic Equipment).

The quality of design of the product with respect to end of life can be mentioned. In this case, it can be measured with a recyclability rate indicator. The recyclability rate represents the recycling potential of the product in terms of its design: technology and input materials. The recycling method and potential values shall be compatible with the relevant standards. Document IEC/TR 62635 should be used for electrical and electronic equipment. Other methods shall be mentioned and documented in the PEF declaration and justified in the LCA report.

9.7 Environmental impacts

The PEF declaration shall specify:

- The table of environmental impacts in numerical values, expressed in the corresponding units with three significant figures (and in option as a percentage) for all the environmental impact categories, for each stage of the life cycle, and the total for each indicator of the complete life cycle assessment,
- The name and version of the LCA software and database,
- The product category and the use scenario specifying:
    - The expected service life time,
    - The description of the product use scenario,
- Where appropriate, the applicable product standards,
- For the installation phase, the installation elements taken into account,
- The product maintenance scenario and the consumables used during the expected service life time of the product,
- Information on the geographical and technological representativeness of the PEF declaration,
- The energy model used to determine the impacts of the manufacturing, installation, use and end-of-life stages.

NOTE: For a given indicator, a life cycle stage can be considered to be negligible if it represents less than 0.01% of the total life cycle of the reference flow. In this case, it shall be shown as 0* in the environmental impacts table for this stage and this indicator and "represents less than 0.01% of the total life cycle of the reference flow" shall be inserted under the table.

10 Reference literature

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11 Supporting information for the PEFCR

11.1 Open stakeholder consultations

[A link to a web-page]

11.2 PEFCR Review Report

11.3 Additional requirements in standards not covered in PEFCR

[If a PEFCR is designed to be compliant with more than one standard, list requirements for any claim that intends to be compliant with these standards]

11.4 Cases of deviations from the default approach

[Where deviations from the default approach (as given in the PEF or in this PEFCR) is made, justification, results, interpretation and recommendation to the European Commission and the PEF-practitioner should be included.]

12 List of annexes

12.1 Annex I – Examples of UPS types

UPS size	Life time (in years)	EU-27 Sales (in Million units)	Market share (in %)
< 1.5 kVA	5	0.99	69.23
≥ 1.5 kVA – 5 kVA	8	0.40	27.97
≥ 5.1 kVA – 10 kVA	10	0.03	2.10
≥ 10.1 kVA – 200 kVA	15	0.01	0.70
		1.43	**~ 100%**

The **stand by topology**: is the maximum energy saving mode (VFD). The normal mode of operation consists on supplying the load from the primary power source.

The **line interactive topology** allows the voltage independence (VI), during the normal mode of operation the load is supplied with conditioned AC input power at the input frequency.

The **double conversion topology** provides the highest power conditioning (VFI), output voltage and frequency are independent of input conditions.

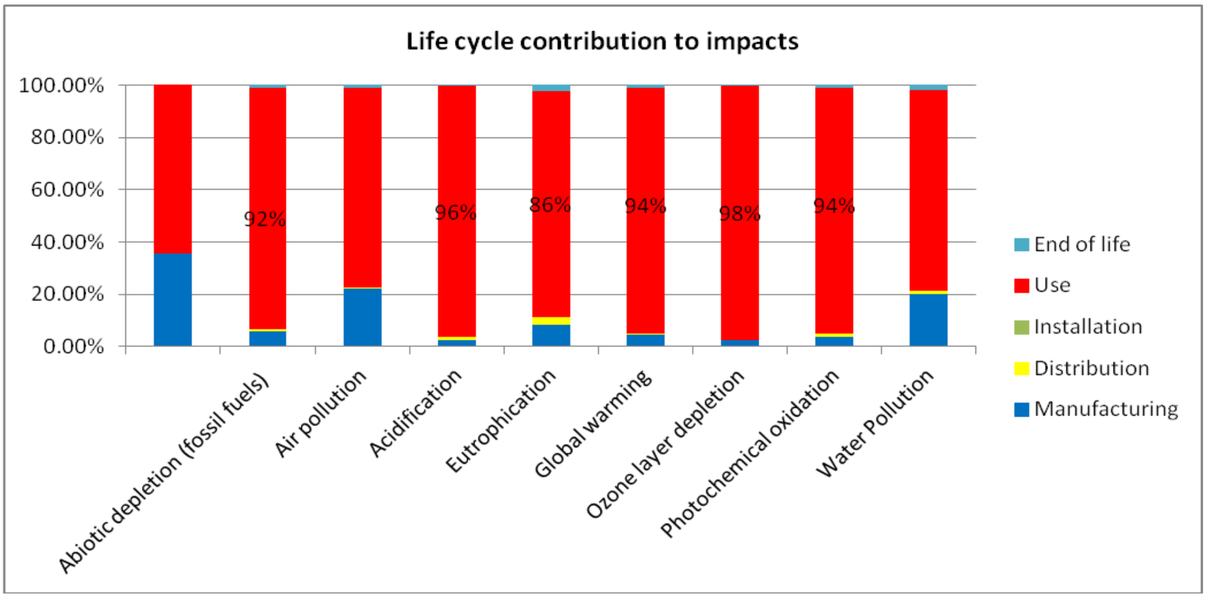
Type	Size	Manufacturer	Model	Image
B2C	1 kVA – 10 kVA	Schneider Electric	Back UPS Pro	
			Smart UPS	
		Eaton	9PX	
		Legrand	DAKER	
			SMS	

12.2 Annex II – Supporting studies

Four PEF supporting studies were carried out in compliance with the latest version of the PEF guide - Version 5.0 (August 2015) and with current PEFCR V 1.7. The studies were performed on UPS of 3kVA, 10kVA and 200 kVA. The PEFCR generic data harmonized the studies if no distribution data is available, sets up a use phase scenario with data sometimes unknown for manufactures that scenario considers transport of the product, transport of the technician, energy consumption and life time. In addition, the PEFCR list of generic secondary datasets guided the selection of modules while doing the life cycle assessment. The studies support the conclusions of the screening study v 2.3 in that the outcomes shows the same life cycle impact dominates, the same processes and components. The difference is in few elementary flows that changed based on the dataset and tool used for the assessment. In general the results of the studies and the screening report are similar.

Use of the PEFCR to identify dominant life cycle phase and impacts

The result of applying the PEFCR shows that for the four UPS products, small and large size, the use phase is the dominant life cycle phase.



This outcome demonstrates that the rules of the UPS PEFCR can be applied to a diverse range of UPS. The outcomes of the assessment of all UPS products showed that climate change and water resource depletion were the most relevant impact categories. Depending on the size of the product water depletion could be higher for small size UPS and climate change larger for big size UPS. Note that not all impact indicators were available for the assessment of all four products, given the different indicators in the assessment tools. As the assessment tools are out of the control of the manufacturers less than 50% of the indicators were assessed for 3 of the four studies. Considering the limitation on impact categories, it is unknown If other indicators would change the outcomes of the most significant environmental impacts.

For all products, manufacturing phase dominated abiotic depletion regardless of the difference in datasets. Thought the modules selection somewhat influenced the percentage contribution, it did not change the percentage more than 1%.

Normalization was not applied for all studies as not all the tools allow this step in the assessment. Only users of SimaPro normalized the results using the PEF normalization factors. For the remaining studies, the results were presented by the highest contribution or result of the assessment.

12.2.1 Use of the PEFCR to identify contributing processes and elementary flows

Contributing processes were selected for all life cycle phases, sometimes similar processes where identified for different stages but with a different percentage contribution, the results were reported by life cycle phase. A summary table of the main process contributing to each life cycle phase sorted from the most dominant phase to the least significant, showed electricity and energy sources dominate process contribution. The same procedure applies to contribution from elementary flows, which were identified by life cycle phase plus reported by highest to lowest elementary contribution.

12.2.2 Complementing analysis

The hot spot analysis reported contributions from components and processes with more than 50% contribution to impacts. The results for the studies showed that electricity and electronics are the main hot spots. Following closely was end of life treatment of batteries.

The uncertainty analysis was only completed for one study that used the results straight from the software assessment tool. The usefulness of this step is unclear because the tool's procedure to report uncertainty in unclear. To minimize uncertainty, data quality assessment was performed using an excel tool that allows rating the data quality by using recorded data information and expert judgement. This is a more efficient way of determining uncertainty and identifying data quality issues. The results showed that for materials, data is at least 10 years old though it has a large sample size. In the case of electronics data is as old as 6 years but depending on the software tool there can be more or less data available for the data source assessment. In general, the studies use datasets of good quality though older.

12.2.3 Comparative Benchmark

The environmental performance benchmark can help double check the assessment results and the significance of the environmental impacts against reference point. If the indicators and tool to perform the life cycle assessment are the same for the reference product and the study, the results are expected to be similar and the benchmark can then be useful. It was less significant for the studies that could only compare 50-% of the indicators against the expected set of impacts. The benchmark of the product assessing the full set of indicators showed that there is a significant difference between the percentage contribution of the reference product (from the screening study) and the product under assessment for human toxicity indicators, marine eutrophication and particulate matter. For the studies for which the full set of expected indicators was not available, the benchmark was done by taking the difference between the same indicators of the corresponding product of the screening study and the actual product assessed.

12.2.4 Comparative Benchmark

The end of life assessment was an alternative to the formula recommended by the PEF Guideline. The supporting studies reported difficulty in collecting end of life data for all the parameters of the formula for all the main materials of the product. End of life data is out of manufacturers reach, making the use of the formula useless. All pilots followed the recommendation of the screening of a simplified approach that used data available to manufacturers. The alternative approach demonstrated that the information used for the Screening study was readily available to manufacturers.

12.3 Annex III – Benchmark and classes of environmental performance

To be developed

12.4 Annex IV – Upstream scenarios (optional)

12.5 Report describing upstream scenarios and processes as a result of the 1st virtual consultation.

12.6 Annex V – Downstream scenarios (optional)

12.7 Report describing downstream scenarios and processes as a result of the 1st virtual consultation.

12.8 Annex VI – Table 15 Normalisation factors

ILCD Impact Category	Unit	EC-JRC EU27 (2010), per person	EC-JRC Global (2010 or 2013), per person	PROSUITE Global (2010 or 2000), per person
		1.1	1.2	1.3
Climate change	kg CO_2 eq.	9.22E+03	7.07E+03	8.10E+03
Ozone depletion	kg CFC-11 eq.	2.16E-02	1.22E-02	4.14E-02
Human toxicity, cancer effects	CTUh	3.69E-05	1.24E-05	5.42E-05
Human toxicity, non-cancer effects	CTUh	5.33E-04	1.55E-04	1.10E-03
Particulate matter/Respiratory inorganics	kg PM2.5 eq.	3.80E+00	5.07E+00	2.76E+00
Ionizing radiation, human health	kBq U^{235} eq. (to air)	1.13E+03	2.41E+02	1.33E+03
Photochemical ozone formation, human health	kg NMVOC eq.	3.17E+01	4.53E+01	5.67E+01
Acidification	mol H+ eq.	4.73E+01	5.61E+01	4.96E+01
Eutrophication terrestrial	mol N eq.	1.76E+02	1.64E+02	1.15E+02
Eutrophication freshwater	kg P eq.	1.48E+00	6.54E+00	6.20E-01
Eutrophication marine	kg N eq.	1.69E+01	3.04E+01	9.38E+00
Land use	kg C deficit	7.48E+04	5.20E+06	2.36E+05
Ecotoxicity freshwater	CTUe	8.74E+03	3.74E+03	6.65E+02
Resource depletion water	m^3 water eq.	8.14E+01	6.89E+01	2.97E+01
Resource depletion, mineral, fossils and renewables	kg Sb eq.	1.01E-01	1.93E-01	3.13E-01

12.9 Annex VII – Table 16 Weighting factors

		WEIGHTING APPROACHES/TYPES/METHODS													
		SINGLE SCORE METHODS							**MULTIPLE INDICATORS METHODS - NO NORMALIZATION**						
		Distance to target					**Damage oriented**	**Panel-based**	**Damage oriented**			**Damage oriented (2 AoPs and 2 midpoint)**			
		Policy targets			**Planetary boundaries**		**Mid-to-endpoint**		**3 Endpoint indicators (Human health, Ecosystem health, Resource)**			**2 Endpoint indicators (Human health, Ecosystem health) and 2 Midpoint indicators (Water Depletion, Resource Depletion)**			
									based on: Ponsioen & Goedkoop 2015			**based on: Humbert 2015**			
		Castellani et al. 2015 WFsA	**Castellani et al. 2015 WFsB**	**EDIP 2003**	**Tuomisto et al. 2012**	**Bjørn&Hauschild 2015**	**Ponsioen& Goedkoop 2015**	**Huppes et al. 2012**	**Human health**	**Ecosystems**	**Resources**	**Human health**	**Ecosystems**	**Resources**	**Water scarcity**
	Spreadsheet	**2.A.1**	**2.A.1**	**2.A.2**	**2.A.3**	**2.A.4**	**2.A.5**	**2.A.6**	**2.B.1**	**2.B.1**	**2.B.1**	**2.B.2**	**2.B.2**	**2.B.2**	**2.B.2**
ILCD Impact Category	**Unit**	**dimensionless (%)**							**[DALY]**	**[species.year]**	**[US$/kg]**	**[DALY]**	**[species.year]**	**[kg Sb eq.]**	**[m3 eq.]**
Climate change	kg CO_2 eq.	7.1%	5.4%	2%	10%	25%	44%	23.2%	9.28E-07	4.57E-09	NA	2.55E-07	3.67E-09	NA	NA
Ozone depletion	kg CFC-11 eq.	6.4%	4.9%	87%	8%	1%	0%	3.6%	5.31E-04	NA	NA	1.05E-03	NA	NA	NA
Human toxicity, cancer effects	CTUh	6.9%	5.2%	2%	NA	NA	1%	6.5%	1.25E+01	NA	NA	1.30E+01	NA	NA	NA
Human toxicity, non-cancer effects	CTUh	6.2%	4.7%	2%	NA	NA	4%	4.1%	2.70E+00	NA	NA	1.30E+00	NA	NA	NA
Particulate matter/Respiratory inorganics	kg PM2.5 eq.	7.4%	5.6%	NA	NA	NA	8%	6.6%	7.00E-04	NA	NA	1.80E-03	NA	NA	NA
Ionizing radiation, human health	kBq U^{235} eq. (to air)	6.1%	4.6%	NA	NA	NA	0%	6.5%	7.94E-08	NA	NA	2.10E-08	NA	NA	NA
Photochemical ozone formation, human health	kg NMVOC eq.	7.8%	5.9%	2%	NA	34%	0%	5.4%	3.90E-08	NA	NA	1.28E-06	NA	NA	NA
Acidification	mol H+ eq.	7.2%	5.5%	2%	8%	1%	0%	4.2%	NA	3.72E-09	NA	NA	9.29E-11	NA	NA
Eutrophication terrestrial	mol N eq.	7.0%	5.3%	2%	28%	1%	0%	2.3%	NA	0.00E+00	NA	NA	1.59E-08	NA	NA
Eutrophication freshwater	kg P eq.	6.2%	4.7%	1%	7%	9%	0%	2.3%	NA	5.62E-08	NA	NA	2.75E-08	NA	NA
Eutrophication marine	kg N eq.	6.9%	5.2%	2%	28%	1%	0%	2.3%	NA	0.00E+00	NA	NA	2.28E-12	NA	NA
Land use	kg C deficit	6.4%	5.3%	NA	6%	25%	19%	10.2%	NA	8.88E-09	NA	NA	1.66E-09	NA	NA
Ecotoxicity freshwater	CTUe	6.1%	5.1%	0%	NA	2%	0%	10.9%	NA	1.08E-12	NA	NA	4.32E-13	NA	NA
Resource depletion water	m^3 water eq.	6.1%	29.6%	NA	5%	1%	3%	5.1%	1.14E-06	2.35E-08	9.60E-01	NA	NA	NA	1.00
Resource depletion, mineral, fossils and renewables	kg Sb eq.	6.1%	3.0%	0%	NA	NA	19%	6.9%	NA	NA	4.52E+04	NA	NA	1.00	NA

12.10 Annex VIII – Foreground data

12.10.1 Table 17 Overview of the types of data sources to be used in the PEF

Life Cycle Stage	Process	Material/Component			Manufacturing Process			Transportation			Justification/Comment
		Quantity	Type	Data source	Quantity	Type	Data source	Quantity	Type	Data source	
Productions of raw & basic materials	Included in subsequent stages										
Production of primary packaging	Material in composition	Primary	Primary	Table 11	Primary	Table 11	Table 11	Section 6.7	Section 6.7	Section 6.7	Does not contribute significantly to the impacts.
Production of second. & tertiary packaging		Excluded from the score									Does not contribute significantly to the impacts.
Production of materials used in UPS	Material in composition	Primary	Primary	Table 11	Primary	Primary	Table 11	Section 6.7	Primary	Section 6.7	Contributes significantly to the impacts.
Production of component	Printed Circuit Boards	Primary	Primary	Table 11	Primary	Primary	Table 11	Section 6.7	Primary	Section 6.7	Contributes significantly to the impacts. Not possible to collect specific data.
	Semiconductors	Primary	Primary	Table 11	*Included in component*			*Included in component*			
	Batteries	Primary	Primary	Table 11	*Included in component*			*Included in component*			
	Cables	Primary	Primary	Table 11	*Included in component*			*Included in component*			
	Other	Primary	Primary	Table 11	*Included in component*			*Included in component*			
Production of UPS	UPS assembly & customization	Primary	Primary	Table 11	Primary	Primary	Table 11				Does not contribute significantly to the impacts.
	Transport to distribution center							Primary	Primary	Section 6.7	Does not contribute significantly to the impacts.
	Storage at distribution center	Excluded from the scope									Does not contribute significantly to the impacts.
Product Distribution	Transport to point of sale							Table 12	Primary	Section 6.7	Does not contribute significantly to the impacts.
	Consumer transport							Section 6.7	Generic	Section 6.7	Does not contribute significantly to the impacts.
Installation of UPS *(Only for large UPSs)*	Installation components	Table 12	Primary	Table 11	Table 12	Primary	Table 11	Primary	Primary	Section 6.7	Only relevant for UPS > 5 kVA
	Installation processes				Table 12	Primary	Table 11	Section 6.7	Primary	Section 6.7	Only relevant for UPS > 5 kVA
Use of UPS	Electricity				Primary	Primary *	Table 11				Contributes significantly to the impacts.
	Life span				Table 12	Primary	Table 11				Market life span to use as default value
	Replacement parts	Primary	Primary	Table 11	Primary	Primary	Table 11				Only relevant for large UPSs
End of Life of the product	Transport (waste collection)							1000km	Lorry	Section 6.8	Does not contribute significantly to the impacts. Not possible to collect specific data.
	Waste treatment (landfill. etc.)				Section 6.8	Section 6.8	Section 6.8				

** i.e. Region of electricity production*

Parameter	UPSs < 1.5 kVA	UPSs ≥1.5– 5 kVA	UPSs ≥5.1– 10 kVA	UPSs ≥10.1-200 kVA	Source
Transport distance to the client (in km)	20	500	500	500	Expert judgment
Means of transportation	Passenger car	Van < 3.5 t	Van < 3.5 t	Lorry <16t	Expert judgment
Further needed processes for the installation	May need some equipment to carry the UPS and batteries from truck to final destination.			Travel of a professional to install the UPS of 500 pkm	Expert judgment
Electricity consumption (in kWh)	377.7	1,929.4	3,120.75	42,839.69	ErP Lot 27 (2013), confirmed with manufacturer-specific information
Average power output (in kVA)	0.54	2.87	6.25	94.5	ErP Lot 27 (2013), confirmed with manufacturer-specific information
Life time (in a)	5	8	10	15	P.E.P. Association (2014)

Table 17**: Generic data use phase**

12.11 Annex X – EOL formula application

$$\left(1-\frac{R_1}{2}\right)\times E_V+\frac{R_1}{2}\times E_{recycled}+\frac{R_2}{2}\times\left(E_{recyclingEoL}-E^*_V\times\frac{Q_S}{Q_P}\right)+\frac{R_3}{2}\times\left(E_{ER}-LHV\times X_{ER,heat}\times E_{SE,heat}-LHV\times X_{ER,elec}\times E_{SE,elec}\right)+$$

Note: This Annex only demonstrates the attempt to use the EOL formula but the difficulty of implementing that formula in the assessment of a UPS. This section only shows the work done to try to use the formula and the examples of how is was apply to just a few materials.

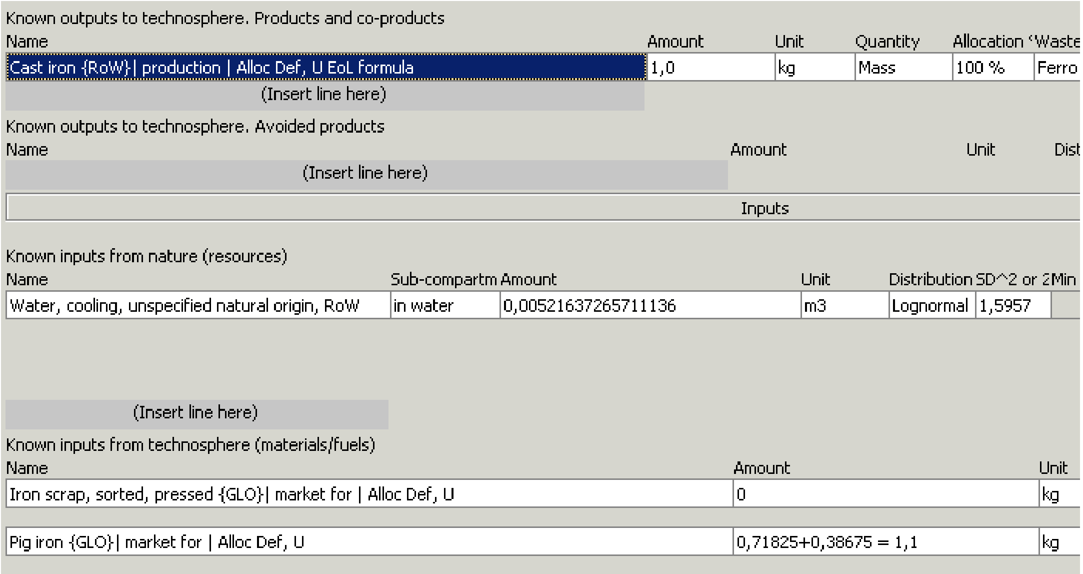
Implementation of the EOL formula shall be done using product specific data for values of R2, R3, LHV, Qs/QP, XER_heat or XER_elec. If all values/data are known the EOL formula can be applied manually to the largest materials by weight. The limitation of manual implementation is the formula will be applied to a few single materials without accounting for the various input resources that are contained in that material.

If the values are unknown the formula can be applied to the model created in the software by implementing the formula in each module. The limitation is that a material contains multiple resources for which the formula shall be applied. In addition there are resources that already include recycled content and that is not identified in the modules. This PEFCR applied the formula to a metal material for demonstration of how to use of the formula.

Example: Cast iron

1. Open "Cast iron {GLO}| market for | Alloc Def, U" and check iron inputs. 2 iron inputs are found:
   a. Cast iron {RER}| production | Alloc Def, U
   b. Cast iron {RoW}| production | Alloc Def, U

2. Open “Cast iron {RER}| production | Alloc Def, U” and “Cast iron {RoW}| production | Alloc Def, U” and check iron inputs. 2 iron inputs are found:
    a. Pig iron {GLO}| market for | Alloc Def, U
    b. Iron scrap, sorted, pressed {GLO}| market for | Alloc Def, U
3. Copy both processes and change amounts for iron inputs:



Known outputs to technosphere. Products and co-products

Name	Amount	Unit	Quantity	Allocation	Waste
Cast iron {RoW}| production | Alloc Def, U EoL formula	1,0	kg	Mass	100 %	Ferro
(Insert line here)					

Known outputs to technosphere. Avoided products

Name	Amount	Unit	Dist
(Insert line here)			

Inputs

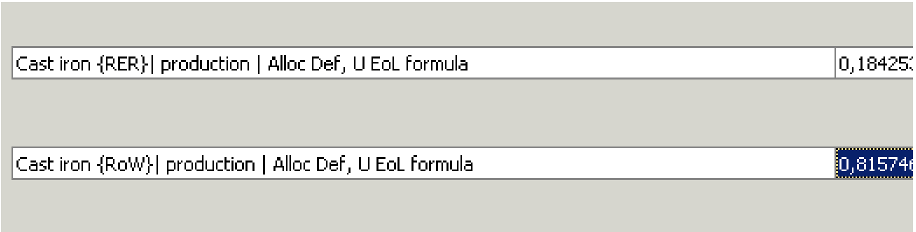
Known inputs from nature (resources)

Name	Sub-compartm	Amount	Unit	Distribution	SD^2 or 2	Min
Water, cooling, unspecified natural origin, RoW	in water	0,00521637265711136	m3	Lognormal	1,5957	
(Insert line here)						

Known inputs from technosphere (materials/fuels)

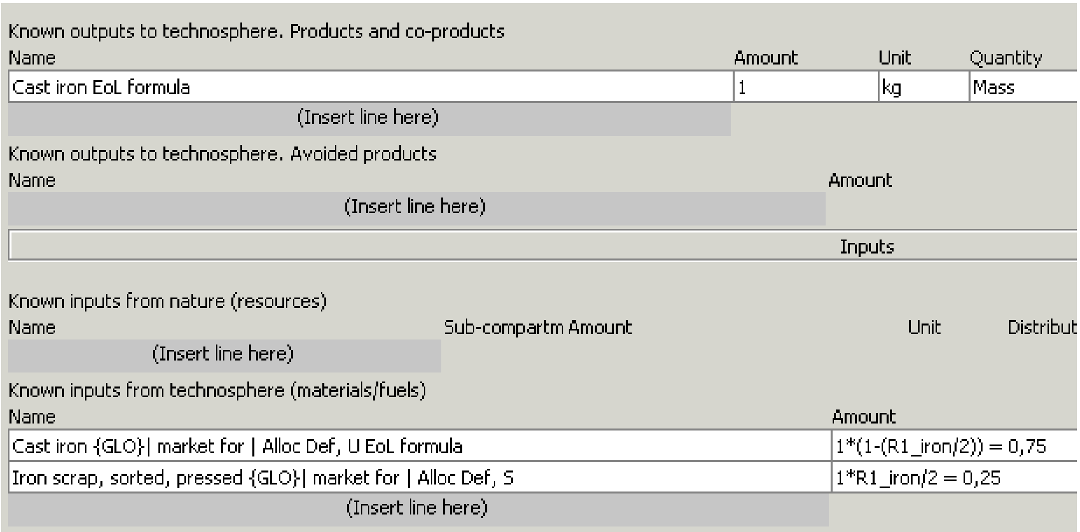
Name	Amount	Unit
Iron scrap, sorted, pressed {GLO}| market for | Alloc Def, U	0	kg
Pig iron {GLO}| market for | Alloc Def, U	0,71825+0,38675 = 1,1	kg

- Copy “Cast iron {GLO}| market for | Alloc Def, U” and change inputs:



Cast iron {RER}| production | Alloc Def, U EoL formula	0,18425
Cast iron {RoW}| production | Alloc Def, U EoL formula	0,81574

- Change cast iron input process for UPS:



Known outputs to technosphere. Products and co-products

Name	Amount	Unit	Quantity
Cast iron EoL formula	1	kg	Mass
(Insert line here)			

Known outputs to technosphere. Avoided products

Name	Amount
(Insert line here)	

Inputs

Known inputs from nature (resources)

Name	Sub-compartm	Amount	Unit	Distribut
(Insert line here)				

Known inputs from technosphere (materials/fuels)

Name	Amount
Cast iron {GLO}| market for | Alloc Def, U EoL formula	1*(1-(R1_iron/2)) = 0,75
Iron scrap, sorted, pressed {GLO}| market for | Alloc Def, S	1*R1_iron/2 = 0,25
(Insert line here)	

- Use of different EoL treatment processes (combination of incineration, landfill, material recycling, etc) are only possible with the use of “waste scenarios”. Waste scenarios can only be used by product stages, e.g. assemblies, not by processes. Therefore, for each material for which the EoL formula needs to be applied a separate assembly has to be defined.

- To implement the EoL formula unit processes have to be used. However, there is a process network of 10.000 processes for ecoinvent v3 and the calculation of results is very slow (several minutes per calculation).
- Analyse the impact of the EoL. For the Cast iron example the EOL impact is so small that the processes are still not fully visible with a cut-off of 0,05%, but with a lower cut-off the networks becomes unclear.

If manual application is chosen the following data can be used if not primary values are known. Values not in table shall be calculated.

Parameter	Assumption							Source
Scenarios		EoL treatment per fraction (in %)						EUROSTAT (2013)
		Plastics	Ferro metals	Non-ferro metals	Paper	Cardboard	Wood	
	Re-use	1	1	1	0	0	1	
	Material recycling	25	94	94	68	68	36	
	Recovery	34	0	0	14	14	10	
	Incineration without recovery	0	0	0	13	13	48	
	Landfill	40	5	5	5	5	5	
	Total	**100**	**100**	**100**	**100**	**100**	**100**	
EoL treatment of UPSs	**UPS component**	**Treatment**						
	Entire UPS	is 100% sent to WEEE compliant treatment						Assumption
	Metal parts	are melted						Interview with German recycling company
	PWBs including ICs, diodes, ports, etc.	are melted						
	Fan	are dismantled manually and separated in metal parts, plastic parts						
	Power supply unit	are shredded mechanically and separated in metal parts, plastic parts and PWBs						
	Plastic parts	are shredded, sorted, and sold						
	Battery	specific treatment						
	LCD module	specific treatment						
	Quality $_{metals*}$	1						
	Quality $_{plastics*}$	0.4						

EOL formula implementation in the PEF screening studies, Technical Helpdesk, March 2016

12.12 Annex XI – Background information on methodological choices taken during the development of the PEFCR

The methodology developed is intended to facilitate the use of a PEFCR broadly in industry. In addition the supporting studies are provided with a format that can be continuously used for different product just completing the chart with new results and analysis. The main guide was the PEF Guideline provided by the EPF Program, the PEP Ecopassport approach for the end of life, the selection of datasets based on quality and completion and report mechanisms to help fill in charts with sets of results for multiple products becoming a template internal use.

12.13 Annex XII – Data Quality Assessment Tool

Data Quality Assessment Tool

12.14 Annex XIII- Charts for reporting of the assessment results

Example of table for Bill of Materials

Bill of Materials			
Material family	Material declared	Total	%
Metal	Aluminum	x	%
	Copper	x	%
	Steel	x	%
Packaging	Paper	x	%
	Polyethylene film	x	%
	Wood	x	%
	ABS Acrylonitrile Butadiene Styrene	x	%
Plastics	Diverse Thermossetting Plastics	x	%
	PA Polyamide	x	%
	PC Polycarbonate	x	%
	PPS Polyphenylene sulfure	x	%
Various	Cables and connectors	x	%
	Elastomer	x	%
	Electrolytic capacitor	x	%
	Electronic cards	x	%
	LCD screen	x	%
Assemblies	Missing data	x	0.00%
	Total	x	

Example of table for Main process contribution to impacts

Impact indicators	Process contributing to impacts	≥80%	Other
Abiotic depletion (elements)	Lead acid battery, valve regulated; production mix, at plant; GLO		64%
	Electricity Mix; AC; consumption mix, at consumer; < 1kV; EU-27		32%
Abiotic depletion (fossils)	Electricity Mix; AC; consumption mix, at consumer; < 1kV; EU-27	88%	
Air pollution	Lead acid battery, valve regulated; production mix, at plant; GLO		14%
	Electricity Mix; AC; consumption mix, at consumer; < 1kV; EU-27		47%
Acidification	Electricity Mix; AC; consumption mix, at consumer; < 1kV; EU-27	94.4%	
Eutrophication	Electricity Mix; AC; consumption mix, at consumer; < 1kV; EU-27	80%	
Global Warming	Electricity Mix; AC; consumption mix, at consumer; < 1kV; EU-27	91%	
Ozone layer depletion	Electricity Mix; AC; consumption mix, at consumer; < 1kV; EU-27	95%	
Photochemical oxidation	Electricity Mix; AC; consumption mix, at consumer; < 1kV; EU-27	92%	
Water Pollution	Lead acid battery, valve regulated; production mix, at plant; GLO		10%
	Electricity Mix; AC; consumption mix, at consumer; < 1kV; EU-27	56%	

Example of table for Flows contribution to impacts

Impact category	Flow category	Elementary flow	Contribution to impact category result (in %)
Abiotic depletion (elements)	Resources from ground	lead	97
	Total		**97**
Abiotic depletion (fossils)	Resources from ground	hard coal	**34.50**
	Resources from ground	natural gas	**29.97**
	Resources from ground	brown coal	**20**
	Total		**85.18**

Example of table for benchmark

	Total characterized impacts		Raw material and manufacturing			Distribution			Use phase			EoL phase		
Impact category	Benchmark	Product	Benchmark	Product	Difference	Benchmark	Product	Difference	Benchmark	Product	Difference	Benchmark	Product	Difference
Climate change	26.945	%	1.81%	%	3%	0%	%	0%	93%	%	5%	-0.06%	%	1%
Ozone depletion	1.34E-06	%	4.92%	%	-3%	0%	%	0%	44%	%	51%	-0.14%	%	0%
Water resource depletion	1.463	%	49.26%	%	-29%	0%	%	1%	7%	%	46%	-3.39%	%	80%

13 Goal of the study

13.1 Intended application and target audience

The intended application of the screening study is the development of the PEFCR for UPSs. As described in the PEF Guide, the objective of the screening steps is to obtain an approximate estimation of each environmental impact for the default EF impact categories.