Product Environmental Footprint Category Rule

- The product category for which the PEFCR is valid: IT equipment (Storage)
- Version number: 1.2
- Date of publication: February 2020 (original publication date: 20 April 2018)
- Date of expiration: 31 December 2021

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Acronyms

Acronyms from PEF guide

ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie
B2B	Business to Business
B2C	Business to Consumer
BSI	British Standards Institution
CF	Characterisation Factor
CFCs	Chlorofluorocarbons
CPA	Statistical Classification of Products by Activity
DQR	Data Quality Rating
EIA	Environmental Impact Assessments
ELCD	European Reference Life Cycle Database
EF	Environmental Footprint
EMAS	Eco-Management and Audit Schemes
EMS	Environmental Management Schemes
EoL	End-of-Life
EPD	Environmental Product DeclarationEN L 124/56 Official Journal of the European Union 4.5.2013
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
ILCD	International Reference Life Cycle Data System
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature and Natural Resources
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LCT	Life Cycle Thinking
NACE	Nomenclature Générale des Activités Economiques dans les Communautés Européennes
OEF	Organisation Environmental Footprint
PAS	Publicly Available Specification
PCR	Product Category Rule
PEFCR	Product Environmental Footprint Category Rule
WRI	World Resources Institute
WBCSD	World Business Council for Sustainable Development

Acronyms from PEFCR Guidance

AF	Allocation Factor
AR	Allocation Ratio
B2B	Business to Business
B2C	Business to Consumer
BoC	Bill of Components
BoM	Bill of Materials
BP	Bonne Pratique

CF	Characterization Factor
CFF	Circular Footprint Formula
CFF-M	Circular Footprint Formula – Modular form
CMWG	Cattle Model Working Group
CPA	Classification of Products by Activity
DC	Distribution Centre
DMI	Dry Matter Intake
DNM	Data Needs Matrix
DQR	Data Quality Rating
EA	Economic Allocation
EC	European Commission
EF	Environmental Footprint
EI	Environmental Impact
EoL	End-of-Life
FU	Functional Unit
GE	Gross Energy intake
GR	Geographical Representativeness
GHG	Greenhouse Gas
GWP	Global Warming Potential
HD	Helpdesk
ILCD	International Reference Life Cycle Data System
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
JRC	Joint Research Centre
LCDN	Life Cycle Data Network
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LT	Lifetime
NDA	Non Disclosure Agreement
NGO	Non-Governmental Organisation
NMVOC	Non-methane volatile compounds
P	Precision
PCR	Product Category Rules
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
RF	Reference Flow
RP	Representative Product
SB	System Boundary
SC	Steering Committee
SMRS	Sustainability Measurement & Reporting System
SS	Supporting study
TAB	Technical Advisory Board
TeR	Technological Representativeness
TiR	Time Representativeness
TS	Technical Secretariat
UNEP	United Nations Environment

UUID	Universally Unique Identifier

PEFCR specific acronyms

BOM	Bill of materials
CD-ROM	Compact disk read only memory
CFP	Carbon Footprint of Products
CV	Coefficient of variation
DTR	Draft technical report
EoL	End-of-Life
EPD	Environmental Product Declaration
ETSI	European Telecommunications Standards Institute
FR	Failure rate
GHG	Greenhouse gas
ICT	Information and communication technology
IEC	International Electrochemical Commission
IT	Information technology
ITU	International Telecommunication Union
SNIA	Storage Networking Industry Association
PCB	Printed circuit board
PCR	Product Category Rules
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
RAID	Redundant array of independent disks
SD	Standard deviation
TB	Terabyte
TR	Technical report
TS	Technical secretariat

Definitions

Definitions from PEF guide

(a) Product Environmental Footprint (hereinafter PEF) method: general method to measure and communicate the potential life cycle environmental impact of a product as laid down in Annex II.

(b) Organisation Environmental Footprint (hereinafter OEF) method: general method to measure and communicate the potential life cycle environmental impact of an organisation as laid down in Annex III.

(c) Product Environmental Footprint: result of a Product Environmental Footprint study based on the Product Environmental Footprint method.

(d) Organisation Environmental Footprint: result of an Organisation Environmental Footprint study based on the Organisation Environmental Footprint method.

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

(f) Communication of life cycle environmental performance: any disclosure of life cycle environmental performance information, including to business partners, investors, public bodies or consumers.

(g) Organisation: a company, corporation, firm, enterprise, authority or institution, or part or combination thereof, whether incorporated or not, public or private, that has its own functions and administrations.

(h) Scheme: for-profit or not-for-profit initiative taken by private companies or an association thereof, by a public-private partnership or by non-governmental organisations that requires the measurement or communication of life cycle environmental performance.

(i) Industrial association: organisation representing private companies that are members of the organisation or private companies belonging to a sector at local, regional national or international level.

(j) Financial community: all actors providing financial services (including financial advice), including banks, investors and insurance companies.

(k) Life cycle data: life cycle information of a specified product, organisation or other reference. It covers descriptive metadata and quantitative life cycle inventory as well as life cycle impact assessment data.

(l) Life cycle inventory data: quantified inputs and outputs for a product or organisation throughout its life cycle, either specific (directly measured or collected) or generic (not directly measured or collected, average) data. [incomplete]

Definitions from PEFCR Guidance

Activity data - This term refers to information which is associated with processes while modelling Life Cycle Inventories (LCI). In the PEF Guide it is also called “non-elementary flows”. The aggregated LCI results of the process chains that represent the activities of a process, are each multiplied by the corresponding activity data[1] and then combined to derive the environmental footprint associated with a process (See Figure 1.1). Examples of activity data include quantity of kilowatt-hours of electricity used, quantity of fuel used, output of a process (e.g. waste), number of hours equipment is operated, distance travelled, floor area of a building, etc. In the context of PEF the amounts of ingredients from the bill of material (BOM) shall always be considered as activity data.

Aggregated dataset - This term is defined as a life cycle inventory of multiple unit processes (e.g. material or energy production) or life cycle stages (cradle-to-gate), but for which the inputs and outputs are provided only at the aggregated level. Aggregated datasets are also called "LCI results", “cumulative inventory” or “System processes” datasets. The aggregated dataset can have been aggregated horizontally and/or vertically. Depending on the specific situation and modelling choices a "unit process" dataset can also be aggregated. See Figure 1.1[2].

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

[2] Source: UNEP/SETAC “Global Guidance Principles for LCA Databases"

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

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

Bill of materials – A bill of materials or product structure (sometimes bill of material, BOM or associated list) is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture an end product.

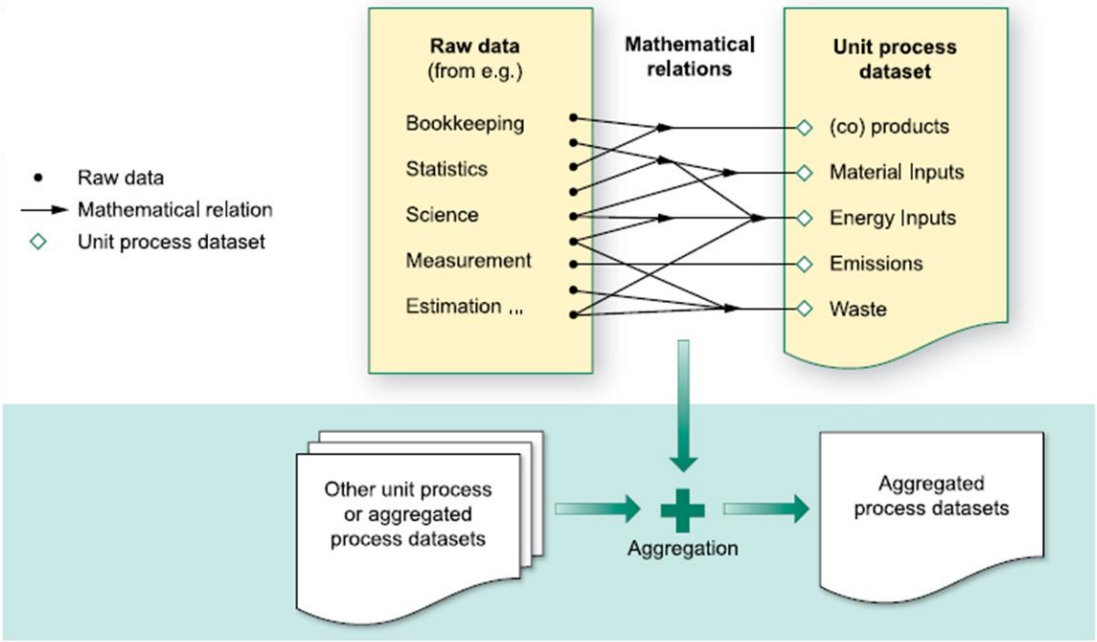

Figure 1.1: Definition of a unit process dataset and an aggregated process dataset

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

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

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

Company-specific data – it refers to directly measured or collected data representative of activities at a specific facility or set of facilities. It is synonymous to "primary data".

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

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

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

Direct elementary flows - All emissions and resource use (also named elementary flows) that arise directly in the context of a process. Examples are emissions from a chemical process, or fugitive emissions from a boiler directly onsite. See Figure 1.2.

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

EF communication vehicles - It includes all the possible ways that can be used to communicate the results of the EF study to the stakeholders. The list of EF communication vehicles includes, but it is not limited to, label, environmental product declarations, green claims, website, infographics, etc.

EF report - Document that summarises the results of the EF study. For the EF report the template provided as annex to the PECFR Guidance shall be used. In case the commissioner of the EF study decides to communicate the results of the EF study (independently from the communication vehicle used), the EF report shall be made available for free through the commissioner's website. The EF report shall not contain any information that is considered as confidential by the commissioner, however the confidential information shall be provided to the verifier(s).

EF study - Term used to identify the totality of actions needed to calculate the EF results. It includes the modelisation, the data collection, and the analysis of the results.

Electricity tracking[3] **-** Electricity tracking is the process of assigning electricity generation attributes to electricity consumption.

Elementary flow - Material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation.

[3] https://ec.europa.eu/energy/intelligent/projects/en/projects/e-track-ii

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

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

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

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

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

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

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

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

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

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

Output flows – product, material or energy flow that leaves a unit process. Products and materials include raw materials, intermediate products, co-products and releases (ISO 14040:2006).

Partially disaggregated dataset - A dataset with an LCI that contains elementary flows and activity data, and that only in combination with the complementing aggregated datasets that represent the activities yields a complete aggregated LCI data set. We refer to a partially disaggregated dataset at level 1 in case the LCI contains elementary flows and activity data, while at least some of the complementing sub-processes are in their aggregated form (see an example in Figure 1.2). The underlying sub-processes should be based on EF-compliant secondary datasets (if available).

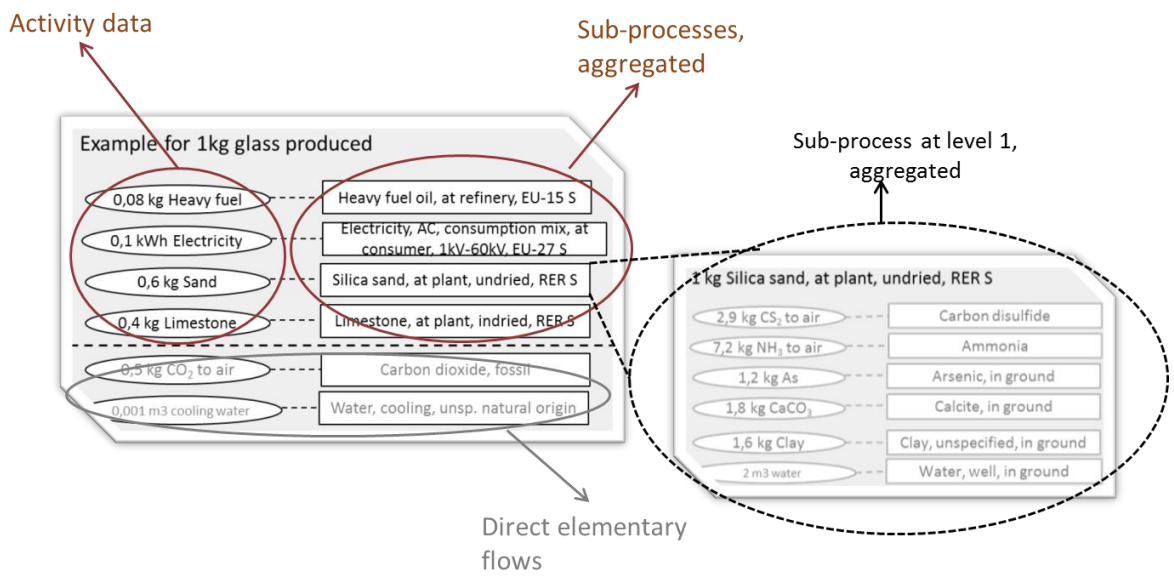

Figure 1.2: An example of a partially aggregated dataset, at level 1.

The activity data and direct elementary flows are to the left, and the complementing sub-processes in their aggregated form are to the right. The grey text indicates elementary flows

PEFCR Supporting study – the PEF study done on the basis of a draft PEFCR. It is used to confirm the decisions taken in the draft PEFCR before the final PEFCR is released.

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

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

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

Practitioner of the EF study - Individual, organisation or group of organisations that performs the EF study in accordance with the EF Guide, EF Guidance and the relevant PEFCR if available. The practitioner of the EF study can belong to the same organisation as the commissioner of the EF study (adapted from ISO 14071/2014, point 3.6).

Primary data[4] - This term refers to data from specific processes within the supply-chain of the company applying the PEFCR. Such data may take the form of activity data, or foreground elementary flows (life cycle inventory). Primary data are site-specific, company-specific (if multiple sites for a same product) or supply-chain-specific. Primary data may be obtained through meter readings, purchase records, utility bills, engineering models, direct monitoring, material/product balances, stoichiometry, or other methods for obtaining data from specific processes in the value chain of the company applying the PEFCR. In this Guidance, primary data is synonym of "company-specific data" or "supply-chain specific data".

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

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

Product Environmental Footprint Category Rules (PEFCRs) – Product category-specific, life-cycle-based rules that complement general methodological guidance for PEF studies by providing further specification at the level of a specific product category. PEFCRs help to shift the focus of the PEF study towards those aspects and parameters that matter the most, and hence contribute to increased relevance, reproducibility and consistency of the results by reducing costs versus a study based on the comprehensive requirements of the PEF guide.

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

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

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

Sample - A sample is a subset containing the characteristics of a larger population. Samples are used in statistical testing when population sizes are too large for the test to include all possible members or

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

observations. A sample should represent the whole population and not reflect bias toward a specific attribute.

Secondary data[5] - refers to data not from specific process within the supply-chain of the company applying the PEFCR. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third-party life-cycle-inventory database or other sources. Secondary data includes industry-average data (e.g., from published production data, government statistics, and industry associations), literature studies, engineering studies and patents, and can also be based on financial data, and contain proxy data, and other generic data. Primary data that go through a horizontal aggregation step are considered as secondary data.

Sub-population - In this document this term indicates any finite or infinite aggregation of individuals, not necessarily animate, subject to a statistical study that constitutes an homogenous sub-set of the whole population. Sometimes the word "stratum" can be used as well.

Sub-processes - those processes used to represent the activities of the level 1 processes (=building blocks). Sub-processes can be presented in their (partially) aggregated form (see Figure 1.2).

Sub-sample - In this document this term indicates a sample of a sub-population.

Supply-chain - refers to all of the upstream and downstream activities associated with the operations of the company applying the PEFCR, including the use of sold products by consumers and the end-of-life treatment of sold products after consumer use.

Supply-chain specific - it refers to a specific aspect of the specific supply-chain of a company. For example the recycled content value of an aluminium can produced by a specific company.

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

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

Verification report - Documentation of the verification process and findings, including detailed comments from the *Verifier(s)*, as well as corresponding responses from the *commissioner of the EF study.* This document is mandatory, but it can be confidential. However, it shall be signed, electronically or physically, by the *verifier or in case of a* verification panel, by the lead verifier.

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

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

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

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

PEFCR specific definitions

- "Printed Circuit" refers to a circuit consisting of printed wiring, and printed parts and/or mounted parts. [JISC 5603; IEC 194(1998)]

- "Printed Circuit Board" refers to a board on which a printed circuit is formed. [JISC 5603; IEC 194(1998)]

- "Printed Wiring" refers to wiring or its technologies that enable a printed conductor pattern to be formed, based on a given circuit design to establish connections between parts, on the surface, or the surface and the internal, of an insulated substrate. [JISC 5603; IEC 194(1998)]

- "Printed Wiring Board" refers to a board on which a printed wiring is formed. [JISC 5603; IEC 194(1998)]

- "Housing (or Shelf)" refers to a modular enclosure for storage devices such as disks and tapes. [2013 SNIA Dictionary]

- “Measurement” and "Actual Measurement" refers to performing a direct measurement of processes, as well as collecting measured values related to processes through an interview with, or a questionnaire survey of, economic operators.

- “Measured value” and "Actual Measured Value" refers to the results from an actual measurement, which includes those derived from design values, scaling, aggregation or other mathematical processing.

1 Introduction

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

For all requirements not specified in this PEFCR the applicant shall refer to the documents this PEFCR is in conformance with (see chapter 2.7).

The compliance with the present PEFCR is optional for PEF in-house applications, whilst it is mandatory whenever the results of a PEF study or any of its content is intended to be communicated.

Terminology: shall, should and may

This PEFCR uses precise terminology to indicate the requirements, the recommendations and options that could be chosen when a PEF study is conducted.

- The term “shall” is used to indicate what is required in order for a PEF study to be in conformance with this PEFCR.
- The term “should” is used to indicate a recommendation rather than a requirement. Any deviation from a “should” requirement has to be justified when developing the PEF study and made transparent.
- The term “may” is used to indicate an option that is permissible. Whenever options are available, the PEF study shall include adequate argumentation to justify the chosen option.

2 General information about the PEFCR

2.1 Technical secretariat

Name of the organization	*Type of organization*	*Name of the members*	*Participation since*
Fujitsu Limited	Manufacturer	Yoshiko SHINOMURA Satoru ARIHARA	November, 2013
Hitachi, Ltd.	Manufacturer	Osamu NAMIKAWA Takaaki KUMAZAWA	November, 2013
NEC corporation	Manufacturer	Noriyuki NAKAYAMA	November, 2013
Toshiba Corporation	Manufacturer	Michio IKEDA Norio TAKEYAMA	November, 2013
Japan Business Council in Europe (JBCE)	Trade association	Akihito NAKAI Shinya SASAKI	January, 2014
Japan Electrical Manufacturers’ Association (JEMA) of Japan's 4EE Industries	Industry	Kiyoshi SAITO Chisako MAEDA	November, 2013
Japan Environmental Management Association for Industry (JEMAI)	Program owner	Masayuki KANZAKI Ken YAMAGISHI	November, 2013

National Institute of Advanced Industrial Science and Technology (AIST)	Research association	Kiyotaka TAHARA	November, 2013
Mizuho Information & Research Institute, Inc.	Consultant	Masahiko SHIBATA Yasushi FURUSHIMA Hiroyuki UCHIDA	November, 2013

2.2 Consultations and stakeholders

1) Physical Consultation

- Opening and closing date: 6, March 2014
- Number of comments received: 16
- Names of organizations that have provided comments: Huawei, Alcatel Lucent, Bureau Veritas[incomplete]
- Link to the wiki page: https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/Stakeholder+workspace%3A+PEFCR+pilot+IT+equipment

The subject of the physical consultation was the analysis of existing PCRs and the scope definition:

- Product category of PEFCR : IT equipment, Storage
- Product classification (NACE/CPA) : NACE/CPA Code: 26.20.2, Storage units and other storage

2) 1st Virtual Consultation

- Opening and closing date: From 24 July to 24 August 2015
- Number of comments received: 53
- Names of organizations that have provided comments: Bureau Veritas CODDE, EC, DG Environment, Ericsson AB, Federal Public Service Health, Food chain Safety and Environment Directorate-general for Environment - Department of Product Policy and Chemical Substances - Product policy, Huawei, Technical Helpdesk, thinkstep AG,
- Link to the wiki page: https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/Stakeholder+workspace%3A+PEFCR+pilot+IT+equipment

3) 2nd Virtual Consultation

- Opening and closing date: From 26, September to 24, October 2016
- Number of comments received: 59

- Names of organizations that have provided comments: EC, DG Environment, maki Consulting GmbH, PEF metal sheet
- Link to the wiki page: https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/Stakeholder+workspace%3A+PEFCR+pilot+IT+equipment

2.3 Review panel and review requirements of the PEFCR

The members of the review panel for draft PEFCR are:

Name of the member	***Affiliation***	***Role***
Prof. Atsushi INABA	Kogakuin University	Chair
Prof. Norihiro ITSUBO	Tokyo city University	Member(LCA expert)
Dr. Katsuyuki NAKANO	Japan environmental management association for industry	Member(LCA expert)

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

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

The detailed review report is provided in Annex 3 of this PEFCR.

2.4 Review statement

This PEFCR has been developed in compliance with Version 6.3 of the PEFCR Guidance, and with the PEF Guide adopted by the Commission on 9 April 2013.

The representative product correctly describes the average product(s) sold in Europe for the product group in scope of this PEFCR.

PEF studies carried out in compliance with this PEFCR would reasonably lead to reproducible results and the information included therein may be used to make comparisons and comparative assertions under the prescribed conditions (see chapter on limitations).

2.5 Geographic validity

This PEFCR is valid for products in scope sold/consumed in the European Union + EFTA. Each PEF study shall identify its geographical validity listing all the countries where the product object of the PEF study is consumed/sold with the relative market share. In case the information on the market for the specific product object of the study is not available, Europe +EFTA shall be considered as the default market, with an equal market share for each country.

2.6 Language

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

2.7 Conformance to other documents

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

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

3 PEFCR scope

The scope of this PEFCR is storage subsystems equipped with hard disk drives as storage devices. The definition of the

2014 SNIA Dictionary is used, where storage subsystems are defined as an integrated collection of:

a) storage controllers and/or host bus adapters,
b) storage devices such as disk drives, CD-ROM drives, tape drives, and libraries, and
c) any required control software, which provides storage services to one or more computers.

This PEFCR covers the following storage subsystems, according to the categorization of SNIA Emerald™ [6]:

[6] SNIA Emerald™ Power Efficiency Measurement Specification, Version 2.0.2

- Online categories 2, 3, 4, 5, and 6
- Near Online categories 2, 3, 5, and 6

The scope in this document also includes storage subsystems that provide interfaces other than block-mode access.

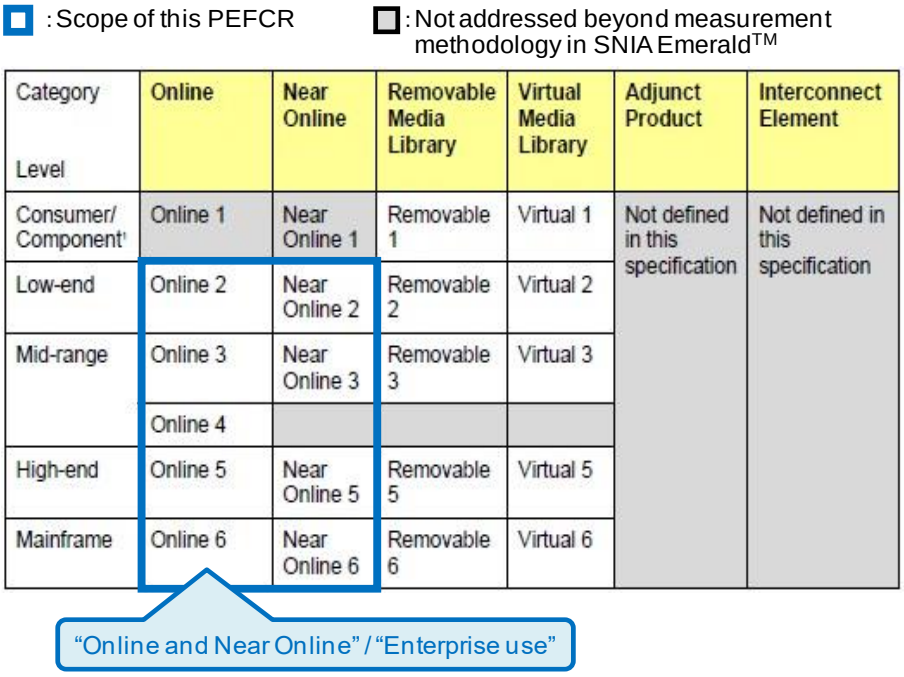

Figure 3.2. The scope of storage subsystems, categorized in SNIA Emerald™

The following products are out of scope:

- server,
- network equipment, and
- other IT equipment.

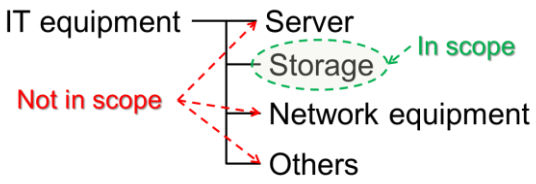

Figure 3.1. The scope of PEFCR

This PEFCR does not define any product sub-categories. A single virtual representative product is used as a basis for the analysis.

3.1 Product classification

The CPA code for the products included in this PEFCR is 26.20.2 Storage units and other storage devices.

3.2 Representative product(s)

A virtual product with the average EU-sales weighted characteristics of existing technologies was considered as a representative product. The average configurations were estimated as follows (see Annex 4 for a detailed description of the definition processes):

- Total capacity is 102TB;
- HDD of 3.5 inch (7200rpm, 4TB) and 2.5 inch (10,000rpm, 0.9TB) are used;
- Total capacity of 3.5 inch HDDs is the same as that of 2.5 inch HDDs;
- RAID level may be set on the basis of product policies by each company;
- Controllers and disk enclosure shall be included in the system boundary;
- Rack shall be excluded from the system boundary.

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

3.3 Functional unit and reference flow

The FU is "A storage subsystem providing one terabyte of formatted capacity to be suited for the needs of the purchasing customer for one year".

Table 3.3 defines the key aspects used to define the FU.

Table 3.3. ***Key aspects of the FU***

What?	Storage subsystems: Storage subsystems are defined in the 2014 SNIA Dictionary as an integrated collection of: a) storage controllers and/or host bus adapters, b) storage devices such as disk drives, CD-ROM drives, tape drives, and libraries, and c) any required control software, which provides storage services to one or more computers.
How much?	1 terabyte of formatted capacity
How well?	Ensuring capacity to be suited for the needs of the purchasing customer
How long?	1 year

In SNIA Emerald™ Power Efficiency Measurement Specification, formatted capacity is defined as the total amount of bytes available to be written after a system or device has been formatted for use, e.g., by an object store, file system, or block services manager.

The FR (Failure Rate) to ensure the capacity shall be taken into account. PEF practitioners shall include the environmental impacts of, e.g., magnetic disk drive as service parts to PEF studies, according to the FR.
A lifetime of 5 years shall be taken into account as the period to ensure capacity[7]. Company-specific lifetime may be used when supported by evidence.

The reference flow is the amount of product needed to fulfil the defined function and shall be measured in terabyte・year. All quantitative input and output data collected in the study shall be calculated in relation to this reference flow.

The reference flow shall be calculated through the formula below[8]:

$$\frac{Life\ Cycle\ Inventory}{Capacity[TB]\cdot Lifetime[year]}$$

Example for the calculation of the reference flow:

If the Life Cycle Inventory is 50 kg-CO_2, the capacity is 100TB, and the lifetime is 5 years, the reference flow is 0.1kg-CO_2/TB・year.

3.4 System boundary

Figure 3.4.1 presents the system diagram. The development of control software is not included in the system boundary.

[7] The default lifetime of 5 years is defined considering that legal durable years for IT equipment are set as 5 years in Japan, the average economic lifetime is estimated at 5-7 years, and average technical lifetime as 7-10 years in the discussions at ENTR Lot 9, http://www.ecodesign-servers.eu/documents.
[8] Inappropriate comparisons may occur as long-life products tend to have larger environmental impacts than short-life products due to the length of the use phase. The lifetime of the product was introduced into the reference flow in addition to formatted capacity to reflect correctly the impact of long-life products.

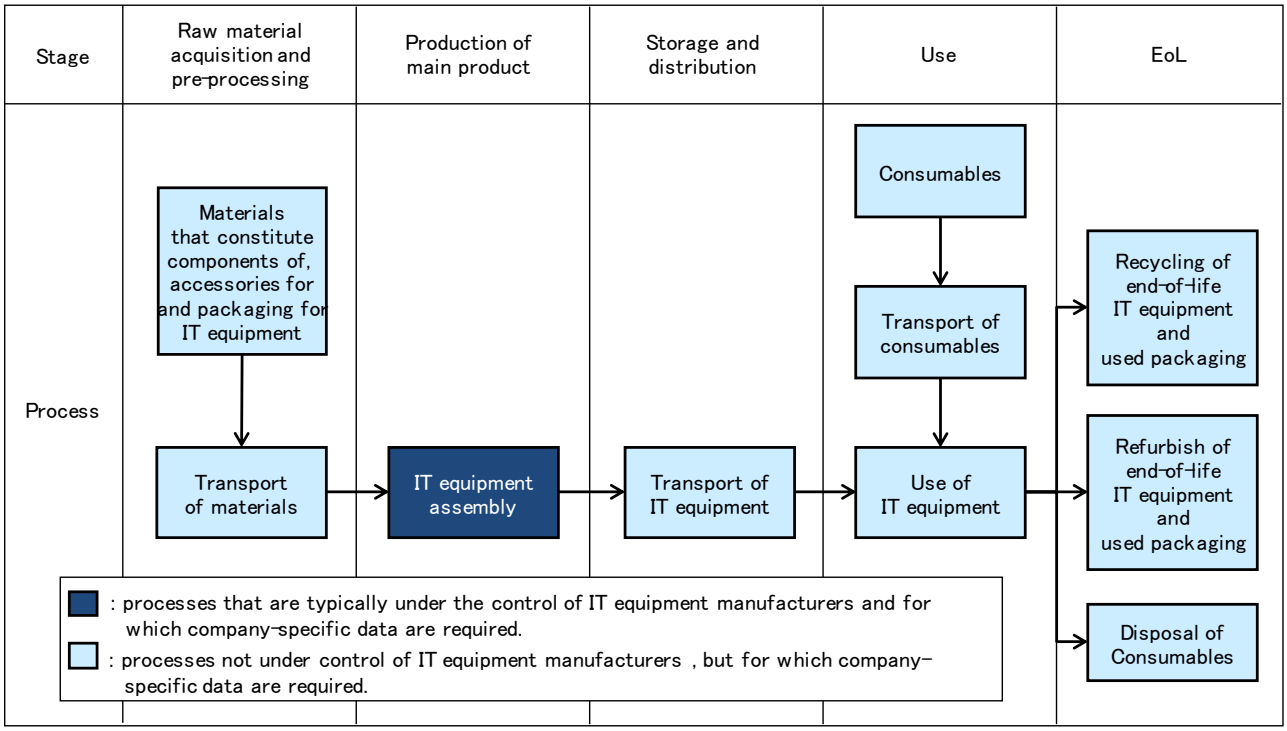

Figure 3.4.1 System diagram

The following life cycle stages and processes shall be included in the system boundary:

Table 3.4.2. Life cycle stages

Life cycle stage	***Short description of the processes included***
Raw material acquisition and pre-processing	- Materials that constitute components of, accessories for, and packaging for IT equipment - Transport of materials
Production of main product	-IT equipment assembly
Storage and distribution	-Transport of IT equipment
Use	- Use of IT equipment - Consumables - Transport of consumables
EoL	- Recycling of end-of-life IT equipment and used packaging - Refurbishment of end-of-life IT equipment - Disposal of consumables

According to this PEFCR, no further cut-off is applicable.

Each PEF study done in accordance with this PEFCR shall provide in the PEF study a diagram indicating the organizational boundary, to highlight those activities under the control of the organization and those falling into Situation 1, 2 or 3 of the data need matrix.

3.5 EF impact assessment

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

Table 3.5. List of the impact categories to be used to calculate the PEF profile

Impact category	***Indicator***	***Unit***	***Recommended default LCIA method***
Climate change	Radiative forcing as Global Warming Potential (GWP100)	kg $CO_{2\ eq}$	Baseline model of 100 years of the IPCC (based on IPCC 2013)
~~- Climate change - biogenic~~[9]			
~~- Climate change – land use and land transformation~~			
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 $_{eq}$	Steady-state ODPs 1999 as in WMO assessment
Human toxicity, cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al, 2008)
Human toxicity, non-cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al, 2008)
Particulate matter	Impact on human health	disease incidence	UNEP recommended model (Fantke et al 2016)
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq U^{235} $_{eq}$	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC $_{eq}$	LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe
Acidification	Accumulated Exceedance (AE)	mol H^+ $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P $_{eq}$	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N $_{eq}$	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe

[9] The sub-impact categories 'Climate change - biogenic' and 'Climate change - land use and land transformation' shall not be reported separately because their contribution to the total climate change impact, based on the benchmark results, is less than 5% each.

Impact category	*Indicator*	*Unit*	*Recommended default LCIA method*
Ecotoxicity, freshwater*	Comparative Toxic Unit for ecosystems (CTU_e)	CTUe	USEtox model, (Rosenbaum et al, 2008)
Land use	• Soil quality index[10] • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Dimensionless (pt) • kg biotic production[11] • kg soil • m^3 water • m3 groundwater	• Soil quality index based on LANCA (EC-JRC)[12] • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010)
Water use**	User deprivation potential (deprivation-weighted water consumption)	m^3 world $_{eq}$	Available WAter REmaining (AWARE) Boulay et al., 2016
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb $_{eq}$	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002

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

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

The full list of normalization factors and weighting factors are available in Annex 1 - List of EF normalisation factors and weighting factors.

The full list of characterization factors (EC-JRC, 2017a) is available at this link
http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtm

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

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

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

3.6 Limitations

- Resource use, fossil and Resource use, minerals and metals are the dominating impact category when applying the method "ADP crustal content/ultimate reserves" and current normalisation factors for assessing minerals and metals. This outcome shall be interpreted with caution. The ADP crustal content/ultimate reserves is considered as an intermediate recommendation. The European Commission, in cooperation with industry, should develop a new method moving from a depletion to a dissipation model to better quantify the potential for conservation of resources.
- The TS for IT equipment believes that PEF studies are usable for disclosing environmental information. It remains to be seen to what extent the comparison of results based on different PEF studies carried out in compliance with this PEFCR will lead to meaningful results.
- The default parameters of the circular footprint formula are average values for Europe.
- Datasets representing "ROW" are used as proxy for steel and stainless steel instead of "GLO".
- Datasets representing "EU-28+EFTA" are used as proxy for copper, PET, HDPE, PP, PVC, corrugated board, LDPE, Expanded PP instead of "GLO".
- Datasets representing "EU-28+3" are used as proxy for glass, wood, paper instead of "GLO".
- The dataset of "Kraft paper" is used as proxy for E*v in CFF of corrugated board and paper.
- The dataset of "waste incineration of inert material" is used as proxy for E_{ER}-LHV×$X_{ER,heat}$×$E_{SE,heat}$-LHV×$X_{ER,elec}$×$E_{SE,elec}$ in CFF of glass.

4 Summary of most relevant impact categories, life cycle stages and processes

The most relevant impact categories, life cycle stages, and processes were specified based on the weighted results (see Chapter 7.1 for the results of representative products and Annex 1 for the weighting factors).

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

- Climate change (Total)
- Resource use, minerals and metals
- Resource use, fossils
- Particulate matter/Respiratory inorganics

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

- Raw material acquisition and pre-processing
- Use
- End of life

The contribution of the use stage to climate change, particulate matter/respiratory inorganics and resource use, fossils is more than 50%. Therefore, most relevant processes for these impact categories are presented both separately for the use stage and for other life cycle stages (see table 4.1).

Table 4.1. List of the most relevant processes(contribution of the use stage ≥ 50%)

Impact category	*Processes(use stage)*	*Processes(without use stage)*
Climate Change (Total)	Use of IT equipment	"HDD-3.5inch/HDD-2.5inch" in Raw material acquisition and pre-processing stage
		"Printed circuit board" in Raw material acquisition and pre-processing stage
		"Power supply unit" in Raw material acquisition and pre-processing stage
		"Steel" in Raw material acquisition and pre-processing stage
		The processes related to $E_{recyclingEoL}$ of "Printed circuit board" in EoL stage
		The processes related to E*v of "Steel" in EoL stage
Particulate matter/Respiratory inorganics	Use of IT equipment	"HDD-3.5inch/HDD-2.5inch" in Raw material acquisition and pre-processing stage
		"Printed circuit board" in Raw material acquisition and pre-processing stage
		"Power supply unit" in Raw material acquisition and pre-processing stage
		"Steel" in Raw material acquisition and pre-processing stage
		"Transport of materials/Ship" in Raw material acquisition and pre-processing stage
		The processes related to $E_{recyclingEoL}$ of "Printed circuit board" in EoL stage
		The processes related to E*v of "Steel" in EoL stage
Resource use, fossils	Use of IT equipment	"HDD-3.5inch/HDD-2.5inch" in Raw material acquisition and pre-processing stage
		"Printed circuit board" in Raw material acquisition and pre-processing stage
		"Power supply unit" in Raw material acquisition and pre-processing stage

Impact category	*Processes(use stage)*	*Processes(without use stage)*
		"Steel" in Raw material acquisition and pre-processing stage
		"IT equipment assembly" in Production of main product stage
		The processes related to $E_{recyclingEoL}$ of "Printed circuit board" in EoL stage

The contribution of the use stage to resource use, minerals and metals is less than 50%. The most relevant processes for this impact category are listed in Table 4.2.

Table 4.2. List of the most relevant processes(contribution of the use stage < 50%)

Impact category	*Processes*
Resource use, minerals and metals	"HDD-3.5inch/HDD-2.5inch" in Raw material acquisition and pre-processing stage
	"Printed circuit board" in Raw material acquisition and pre-processing stage
	"Power supply Unit" in Raw material acquisition and pre-processing stage
	"Copper" in Raw material acquisition and pre-processing stage
	"Copper" in EoL stage
	"Printed circuit board" in EoL stage

5 Life cycle inventory

All newly created processes shall be EF-compliant.

In case sampling is needed, it shall be conducted as specified in this PEFCR. However, sampling is not mandatory and any applicant of this PEFCR may decide to collect the data from all the plants or farms, without performing any sampling.

5.1 List of mandatory company-specific data

The applicant shall collect company-specific data for the following processes:

A) Raw material acquisition and pre-processing

(1) Materials that constitute components of, accessories for, and packaging for IT equipment(mass of materials)

- HDD - 3.5 inch
- HDD - 2.5 inch
- Printed circuit board
- Power supply unit
- Other electronics
- Steel
- Stainless
- Aluminium
- Copper
- ABS
- PET
- HDPE
- PP
- PC
- Nylon 6
- PVC
- PMMA
- Other plastics
- Glass
- Corrugated cardboard
- Wood
- Paper
- LDPE
- Expanded PP

With regard to HDD - 3.5 inch and HDD - 2.5 inch, when data is collected as "piece" it shall be converted to "kg" based on 0.63kg/piece. (These HDDs are assembled in production phase before shipment therefore these are different from the consumables in use phase.)

(2) Transport of components of, accessories for, and packaging for IT equipment

- Transport of materials from production site of the materials to the production site where the assembly takes place (mass transported)

B) Production of main product

- IT equipment assembly (energy consumption)

C) Storage and distribution

- Transport of IT equipment products from production sites to consumers (mass transported)

D) Use

- Use of IT equipment (energy consumption)

- Consumables (mass of materials, when data is collected as "piece" it shall be converted to "kg" based on 0.63kg/piece)
- Transport of consumables from their production sites to consumers (mass transported)

E) EoL

- Recycling of end-of-life IT equipment products and used packaging(mass of material)
- Refurbishment of end-of-life IT equipment products(mass of material)

The details are described in an excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "5.1 company-specific data " for the list of all company-specific data to be collected. The excel file is available at this link
http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm
The specific data for a time period of the last one year, or any period of time equivalent to the last one year, shall be used.

In case sampling is needed it shall be conducted as follows:

- Sub-populations shall be identified in consideration of geographical distribution of companies/sites, technologies involved, and production capacity of the companies/sites#
- The size of sub-samples at sub-population level shall be defined based on the number of companies/sites involved in the sub-population. The required sub-sample size is calculated by the following formula:

  $$\boldsymbol{n_{SS} = \sqrt{n_{SP}}}$$

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

- The user of the PEFCR shall report the ratio(%) of the number of companies/sites considered.

For example, the applicant shall collect the activity data and use sub-processes listed in following table for "Use of IT equipment."

Table 5.1. Data collection requirements for use of IT equipment – example

Requirements for data collection purposes			**Requirements for modelling purposes**								**Remarks**
Activity data to be collected	*Specific requirements (e.g. frequency, measurement standard, etc)*	*Unit of measure*	*Default dataset to be used*	*Dataset source (i.e. node)*	*UUID*	*TiR*	*TeR*	*GR*	*P*	*DQR*	
Inputs:											

Power consumption of products	Measurement of the average power of the Ready Idle Test (PARI(7200)) as established by the SNIA Emerald™ Program.	W	Electricity grid mix 1kV-60kV AC, technology mix consumption mix, at consumer 1kV - 60kV	http://lcdn.thinkstep.com/Node/	34960d4d-af62-43a0-aa76-adc5fcf57246	1	1	1	2	1.3	
Outputs: Not applicable											

See excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "5.1 company-specific data" for the list of all company-specific data to be collected.

5.2 List of processes expected to run by the company

There are some processes expected to be run by the company in addition to those listed under 5.1. The following processes are expected to be run by the company applying the PEFCR.

The default data may be used for the following processes when PEF applicant can't collect/measure company-specific data.

A)Raw material acquisition and pre-processing

- Transport of materials from production site of the materials to the production site where the assembly takes place(transport mode, distance, utilisation ratio); see Table 5.2 for data collection

Table 5.2: Data to be used in case the transport is run by the company and specific data is used

Process name		***Unit of measurement (output)***	***Transport mode***	***Default (per FU)***			***Default dataset***	***Most relevant [Y/N]***
				Distance	***Utilisation ratio***	***Empty return***		
TRANSPORT OF MATERIALS FROM PRODUCTION SITE OF THE MATERIALS TO THE PRODUCTION SITE WHERE THE ASSEMBLY TAKES PLACE	For suppliers located within Europe:	tkm	Truck	Company specific data	Company specific data	Company specific data	Company specific data	Y
			Train	Company specific data	Company specific data	n.a.	Company specific data	
			ship	Company specific data	Company specific data	n.a.	Company specific data	

B) Storage and distribution

- Transport of IT equipment products from production sites to consumers(transport mode, distance, utilisation ratio); see Table 5.2 for data collection

D) Use

- Use of IT equipment (life time)
- Consumables (failure rate)
- Transport of consumables from their production sites to consumers (transport mode, distance, utilisation ratio); see Table 5.2 for data collection

E) EoL

- Recycling of end-of-life IT equipment products and used packaging (parameters of CFF)
- Refurbishment of end-of-life IT equipment products (parameters of CFF)

The details for the processes to be expected in situation1 are described in an excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory - Life cycle inventory.xlsx", sheet named "5.2 processes run by company".

5.3 Data gaps

Datasets are not available for the processes listed in Table 5.3.1 below. These processes are excluded from this PEFCR.

Table 5.3.1 Data gaps in datasets

Stage	Process
Raw material acquisition	Battery
EoL	$E_{recyclingEoL}$ of following materials -Glass -Wood
	E_V* of following materials -platinum used in HDD - 3.5 inch -platinum used in HDD - 2.5 inch -platinum used in Power Supply Unit
	Battery

For the processes listed in Table 5.3.2 below, the applicant shall use an EF-compliant dataset, if available, following the rules in chapter 5.6. If no such dataset is available, applicants may use the proxies listed in table 5.3.2, which were also used for calculating the representative product.

Table 5.3.2 Proxy of datasets

Stage	Process	Entry-level ILCD compliant proxy datasets
EoL	$E_{recyclingEoL}$ of the following materials -ABS	Recycling of polypropylene (PP) plastic UUID 47a967ec-a648-4ede-afb6-23a2289baef9

	-PET -HDPE -PC -Nylon 6 -PVC -PMMA -LDPE -Expanded PP -Other Plastics	
	$E_{recyclingEoL}$ of following materials -Corrugated board -Paper	Testliner(2015) UUID a0c91472-04d8-4293-acf5-0ec97a514bfd

5.4 Data quality requirements

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

$$\mathrm{DQR} = \frac{\overline{\mathrm{Te_R}} + \overline{\mathrm{G_R}} + \overline{\mathrm{Ti_R}} + \overline{\mathrm{P}}}{4} \qquad \text{[Equation 1]}$$

where TeR is the Technological-Representativeness, GR is the Geographical-Representativeness, TiR is the Time-Representativeness, and P is the Precision/uncertainty. The representativeness (technological, geographical and time-related) characterises to what degree the processes and products selected are depicting the system analysed, while the precision indicates the way the data is derived and related level of uncertainty.

The next chapters provide tables with the criteria to be used for the semi-quantitative assessment of each criterion. If a dataset is constructed with company-specific activity data, company -specific emission data and secondary sub-processes, the DQR of each shall be assessed separately.

5.4.1 Company-specific datasets

The score of criterion P cannot be higher than 3 while the score for TiR, TeR, and GR cannot be higher than 2 (the DQR score shall be ≤1.6). The DQR shall be calculated at the level-1 disaggregation, before any aggregation of sub-processes or elementary flows is performed. The DQR of company-specific datasets shall be calculated as following:

1) Select the most relevant sub-processes and direct elementary flows that account for at least 80% of the total environmental impact of the company-specific dataset, listing them from the most contributing to the least contributing one.

2) Calculate the DQR criteria TeR, TiR, GR and P for each most relevant process and each most relevant direct elementary flow. The values of each criterion shall be assigned based on Table 5.4.1

2.a) Each most relevant elementary flow consists of the amount and elementary flow naming (e.g. 40 g carbon dioxide). For each most relevant elementary flow, evaluate the 4 DQR criteria named $Te_{R\text{-}EF}$, $Ti_{R\text{-}EF}$, $G_{R\text{-}EF}$, P_{EF} in NOTE: in case the newly developed dataset has most relevant processes filled in by non-EF compliant datasets (and thus without DQR), then these datasets cannot be included in step 4 and 5 of the DQR calculation. (1) The weight of step 3 shall be recalculated for the EF-compliant datasets only. Calculate the environmental contribution of each most-relevant EF compliant process and elementary flow to the total environmental impact of all most-relevant EF compliant processes and elementary flows, in %. Continue with step 4 and 5. (2) The weight of the non-EF compliant dataset (calculated in step 3) shall be used to increase the DQR criteria and total DQR accordingly. For example:

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

Table .4.1. It shall be evaluated for example, the timing of the flow measured, for which technology the flow was measured and in which geographical area.

2.b) Each most relevant process is a combination of activity data and the secondary dataset used. For each most relevant process, the applicant of the PEFCR calculates the DQR as a combination of the 4 DQR criteria for activity data and the secondary dataset: (i) Ti_R and P shall be evaluated at the level of the activity data (named $Ti_{R\text{-}AD}$, P_{AD}) and (ii) Te_R, Ti_R and G_R shall be evaluated at the level of the secondary dataset used (named $Te_{R\text{-}SD}$, $Ti_{R\text{-}SD}$ and $G_{R\text{-}SD}$). As Ti_R is evaluated twice, the mathematical average of $Ti_{R\text{-}AD}$ and $Ti_{R\text{-}SD}$ represents the Ti_R of the most relevant process.

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

- Process 1 carries 30% of the total dataset environmental impact. The contribution of this process to the total of 80% is 37.5% (the latter is the weight to be used).
- Process 1 carries 50% of the total dataset environmental impact. The contribution of this process to the total of 80% is 62.5% (the latter is the weight to be used).

4) Calculate the Te_R, Ti_R, G_R and P criteria of the newly developed dataset as the weighted average of each criterion of the most relevant processes and direct elementary flows. The weight is the relative contribution (in %) of each most relevant process and direct elementary flow calculated in step 3.

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

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

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

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

Table 5.4.1. How to assess the value of the DQR criteria for datasets with company-specific information

	P_{EF} and P_{AD}	$Ti_{R\text{-}EF}$ and $Ti_{R\text{-}AD}$	$Ti_{R\text{-}SD}$	$Te_{R\text{-}EF}$ and $Te_{R\text{-}SD}$	$G_{R\text{-}EF}$ and $G_{R\text{-}SD}$
1	*Measured/calculated and externally verified*	*The data refers to the most recent annual administration period with respect to the EF report publication date*	*The EF report publication date happens within the time validity of the dataset*	*The elementary flows and the secondary dataset reflect exactly the technology of the newly developed dataset*	*The data(set) reflects the exact geography where the process modelled in the newly created dataset takes place*
2	*Measured/calculated and internally verified, plausibility checked by reviewer*	*The data refers to maximum 2 annual administration periods with respect to the EF report publication date*	*The EF report publication date happens not later than 2 years beyond the time validity of the dataset*	*The elementary flows and the secondary dataset is a proxy of the technology of the newly developed dataset*	*The data(set) partly reflects the geography where the process modelled in the newly created dataset takes place*
3	*Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer*	*The data refers to maximum three annual administration periods with respect to the EF report publication date*	*Not applicable*	*Not applicable*	*Not applicable*

	P_{EF} and P_{AD}	$Ti_{R\text{-}EF}$ and $Ti_{R\text{-}AD}$	$Ti_{R\text{-}SD}$	$Te_{R\text{-}EF}$ and $Te_{R\text{-}SD}$	$G_{R\text{-}EF}$ and $G_{R\text{-}SD}$
4-5	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*

5.5 Data needs matrix (DNM)

All processes required to model the product and outside the list of mandatory company-specific (listed in section 5.1) shall be evaluated using the Data Needs Matrix (see Table 5.5.1). The DNM shall be used by the PEFCR applicant to evaluate which data is needed and shall be used within the modelling of its PEF, depending on the level of influence the applicant (company) has on the specific process. The following three cases are found in the DNM and are explained below:

1. **Situation 1**: the process is run by the company applying the PEFCR
2. **Situation 2**: the process is not run by the company applying the PEFCR but the company has access to (company-)specific information.
3. **Situation 3**: the process is not run by the company applying the PEFCR and this company does not have access to (company-)specific information.

Table 5.5.1. Data Needs Matrix (DNM)[13] . *Disaggregated datasets shall be used.

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

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

5.5.1 Processes in situation 1

For each process in situation 1 there are two possible options:

- The process is in the list of most relevant processes as specified in the PEFCR or is not in the list of most relevant process, but still the company wants to provide company specific data (option 1);

- The process is not the list of most relevant processes as specified in the PEFCR and the company prefers to use a secondary dataset (option 2).

Situation 1/Option 1

For all processes run by the company and where the company applying the PEFCR uses company specific data. The DQR of the newly developed dataset shall be evaluated as described in section 5.4.1.

Situation 1/Option 2

For the non-most relevant processes only, if the applicant decides to model the process without collecting company-specific data, then the applicant shall use the secondary dataset listed in the PEFCR together with its default DQR values listed here.

If the default dataset to be used for the process is not listed in the PEFCR, the applicant of the PEFCR shall take the DQR values from the metadata of the original dataset.

5.5.2 Processes in situation 2

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

- The company applying the PEFCR has access to extensive supplier-specific information and wants to create a new EF-compliant dataset[14] (Option 1);
- The company has some supplier-specific information and want to make some minimum changes (Option 2).
- The process is not in the list of most relevant processes and the company prefers to use a secondary dataset (option 3).

Situation 2/Option 1

For all processes run by the company and where the company applying the PEFCR uses company specific data. The DQR of the newly developed dataset shall be evaluated as described in section 5.4.1.

Situation 2/Option 2

Company-specific activity data for transport are used and the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets are substituted starting from the default secondary dataset provided in the PEFCR.

Please note that, the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required.

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

The applicant of the PEFCR shall make the DQR values of the dataset used context-specific by re-evaluating Te_R and Ti_R, using the table(s) provided in this PEFCR. The criteria G_R shall be lowered by 30%[15] and the criteria P shall keep the original value.

Situation 2/Option 3

For other processes, the applicant may use the corresponding secondary dataset listed in the PEFCR together with its DQR values.

If the default dataset to be used for the process is not listed in this PEFCR, the applicant of the PEFCR shall take the DQR values from the original dataset.

Table 5.5.2. How to assess the value of the DQR criteria when secondary datasets are used.

	TiR	*TeR*	*G_R*
1	*The EF report publication date happens within the time validity of the dataset*	*The technology used in the EF study is exactly the same as the one in scope of the dataset*	*The process modelled in the EF study takes place in the country the dataset is valid for*
2	*The EF report publication date happens not later than 2 years beyond the time validity of the dataset*	*The technologies used in the EF study is included in the mix of technologies in scope of the dataset*	*The process modelled in the EF study takes place in the geographical region (e.g. Europe) the dataset is valid for*
3	*The EF report publication date happens not later than 4 years beyond the time validity of the dataset*	*The technologies used in the EF study are only partly included in the scope of the dataset*	*The process modelled in the EF study takes place in one of the geographical regions the dataset is valid for*
4	*The EF report publication date happens not later than 6 years beyond the time validity of the dataset*	*The technologies used in the EF study are similar to those included in the scope of the dataset*	*The process modelled in the EF study takes place in a country that is not included in the geographical region(s) the dataset is valid for, but sufficient similarities are estimated based on expert judgement.*
5	*The EF report publication date happens later than 6 after the time validity of the dataset*	*The technologies used in the EF study are different from those included in the scope of the dataset*	*The process modelled in the EF study takes place in a different country than the one the dataset is valid for*

5.5.3 Processes in situation 3

When a process is not run by the company applying the PEFCR and the company does not have access to company-specific data, there are two possible options:

[15] In situation 2, option 2 it is proposed to lower the parameter G_R by 30% in order to incentivize the use of company specific information and reward the efforts of the company in increasing the geographic representativeness of a secondary dataset through the substitution of the electricity mixes and of the distance and means of transportation.

- It is in the list of most relevant processes (situation 3, option 1)
- It is not in the list of most relevant processes (situation 3, option 2)

Situation 3/Option 1

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

Situation 3/Option 2

For the non-most relevant processes, the applicant shall use the corresponding secondary dataset listed in the PEFCR together with its DQR values.

If the default dataset to be used for the process is not listed in the PEFCR, the applicant of the PEFCR shall take the DQR values from the original dataset.

5.6 Which datasets to use?

The secondary datasets to be used by the applicant are those listed in this PEFCR. Whenever a dataset needed to calculate the PEF-profile is not among those listed in this PEFCR, then the applicant shall choose between the following options (in hierarchical order):

- Use an EF-compliant dataset available on one of the following nodes:
  - http://eplca.jrc.ec.europa.eu/EF-node
  - http://lcdn.blonkconsultants.nl
  - http://ecoinvent.lca-data.com
  - http://lcdn-cepe.org
  - https://lcdn.quantis-software.com/PEF/
  - http://lcdn.thinkstep.com/Node
- Use an EF-compliant dataset available in a free or commercial source;
- Use another EF-compliant dataset considered to be a good proxy. In such case this information shall be included in the "limitation" section of the PEF report.
- Use an ILCD-entry level-compliant dataset that has been modelled according to the modelling requirements included in the Guidance version 6.3. In such case this information shall be included in the "limitations" section of the PEF report.
- Use an ILCD-entry level-compliant dataset. In such case this information shall be included in the "data gap" section of the PEF report.

5.7 How to calculate the average DQR of the study

In order to calculate the average DQR of the EF study, the applicant shall calculate separately the TeR, TiR, GR and P for the EF study as the weighted average of all most relevant processes, based on their relative

environmental contribution to the total single score (excluding the 3 toxicity-related ones). The calculation rules explained in chapter 5.4 shall be used.

5.8 Allocation rules

Allocation is allowed for the electricity used for the assembly of IT equipment.

5.9 Electricity modelling

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

The following electricity mix shall be used in hierarchical order:

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

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

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

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

Note: for the use stage, the consumption grid mix shall be used.

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

Set of minimal criteria to ensure contractual instruments from suppliers:

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

A contractual instrument used for electricity modelling shall:

1. Convey attributes:
    - Convey the energy type mix associated with the unit of electricity produced.
    - The energy type mix shall be calculated based on delivered electricity, incorporating certificates sourced and retired on behalf of its customers. Electricity from facilities for which the attributes have been sold off (via contracts or certificates) shall be characterized as having the environmental attributes of the country residual consumption mix where the facility is located.
2. Be a unique claim:
    - Be the only instruments that carry the environmental attribute claim associated with that quantity of electricity generated.
    - Be tracked and redeemed, retired, or cancelled by or on behalf of the company (e.g. by an audit of contracts, third-party certification, or may be handled automatically through other disclosure registries, systems, or mechanisms).
3. Be as close as possible to the period to which the contractual instrument is applied.

Modelling 'country-specific residual grid mix, consumption mix':

Datasets for residual grid mix, per energy type, per country and per voltage have been purchased by the European Commission and are available in the dedicated node (http://lcdn.thinkstep.com/Node/). In case the necessary dataset is not available, an alternative dataset shall be chosen according to the procedure described in section 5.8. If no dataset is available, the following approach may be used:

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

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

  These data may be found in the publications of the International Energy Agency (IEA).
- Available LCI datasets per fuel technologies in the node. The LCI datasets available are generally specific to a country or a region in terms of:

- Fuel supply (share of resources used, by import and / or domestic supply),
- Energy carrier properties (e.g. element and energy contents)
- Technology standards of power plants regarding efficiency, firing technology, flue-gas desulphurisation, NOx removal and de-dusting.

Allocation rules:

Table 5.9.1. ***Allocation rules for a single location with multiple products.***

Process	***Physical relationship***	***Modelling instructions***
IT equipment assembly	When the amount of electricity used for the assembly of IT equipment is calculated with allocation, following formula shall be used: $$\textbf{Electricity measured for whole factory} \times \frac{\textbf{Man-hours to produce the product under assessment}}{\textbf{Total man-hours of whole factory which is the same site and same terms as for electricity that was measured}}$$ The electricity shall be measured from whole factory. Man-hours shall be used as an allocation factor.	Electricity used for the assembly of IT equipment includes electric power used for production facilities, air conditioning, and lighting. The amount of such energy used is proportional to man-hours.

Table 5.9.2. ***Allocation rules for multiple locations.***

Process	***Physical relationship***	***Modelling instructions***
IT equipment assembly	Not applicable	The amount of electricity from multiple sites shall be averaged and the dataset of the average EU residual consumption mix (EU-28 +3) shall be used
Use of IT equipment	Not applicable	The dataset of average EU consumption mix (EU-28+3) shall be used.

If the consumed electricity comes from more than one electricity mix, each mix source shall be used in terms of its proportion in the total kWh consumed. For example, if a fraction of this total kWh consumed is coming from a specific supplier a supplier-specific electricity mix shall be used for this part. See below for on-site electricity use.

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

a. The production (and related electricity consumption) of a product occurs in a separate site (building), the energy type physical related to this separated site may be used.
b. The production (and related electricity consumption) of a product occurs in a shared space with specific energy metering or purchase records or electricity bills, the product specific information (measure, record, bill) may be used.
c. All the products produced in the specific plant are supplied with a public available PEF study. The company who wants to make the claim shall make all PEF studies available. The allocation rule applied shall be described in the PEF study, consistently applied in all PEF studies connected to the site and verified. An example is the 100% allocation of a greener electricity mix to a specific product.

On-site electricity generation:

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

- No contractual instruments have been sold to a third party: the own electricity mix (combined with LCI datasets) shall be modelled.
- Contractual instruments have been sold to a third party: the 'country-specific residual grid mix, consumption mix' (combined with LCI datasets) shall be used.

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

- If possible, apply subdivision.
- Subdivision applies both to separate electricity productions or to a common electricity production where you can allocate based on electricity amounts the upstream and direct emissions to your own consumption and to the share you sell out of your company (e.g. if a company has a wind mill on its production site and export 30% of the produced electricity, emissions related to 70% of produced electricity should be accounted in the PEF study.
- If not possible, direct substitution shall be used. The country-specific residual consumption electricity mix shall be used as substitution[16].
- Subdivision is considered as not possible when upstream impacts or direct emissions are closely related to the product itself.

5.10 Climate change modelling

The impact category ‘climate change’ shall be modelled considering three sub-categories:

1. Climate change – fossil: This sub-category includes emissions from peat and calcination/carbonation of limestone. The emission flows ending with '(fossil)' (e.g., 'carbon dioxide (fossil)'' and 'methane (fossil)') shall be used if available.

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

2. Climate change – biogenic: This sub-category covers carbon emissions to air (CO_2, CO and CH_4) originating from the oxidation and/or reduction of biomass by means of its transformation or degradation (e.g. combustion, digestion, composting, landfilling) and CO_2 uptake from the atmosphere through photosynthesis during biomass growth – i.e. corresponding to the carbon content of products, biofuels or aboveground plant residues such as litter and dead wood. Carbon exchanges from native forests[17] shall be modelled under sub-category 3 (incl. connected soil emissions, derived products, residues). The emission flows ending with '(biogenic)' shall be used.

   A simplified modelling approach shall be used when modelling the foreground emissions. Only the emission 'methane (biogenic)' is modelled, while no further biogenic emissions and uptakes from atmosphere are included. When methane emissions can be both fossil or biogenic, the release of biogenic methane shall be modelled first and then the remaining fossil methane.

   Credits from biogenic carbon storage shall not be modelled, as the product life cycle or part of the life cycle does not have a carbon storage beyond 100 years.

3. Climate change – land use and land transformation: This sub-category accounts for carbon uptakes and emissions (CO_2, CO and CH_4) originating from carbon stock changes caused by land use change and land use. This sub-category includes biogenic carbon exchanges from deforestation, road construction or other soil activities (incl. soil carbon emissions). For native forests, all related CO_2 emissions are included and modelled under this sub-category (including connected soil emissions, products derived from native forest[18] and residues), while their CO_2 uptake is excluded. The emission flows ending with '(land use change)' shall be used.

   For land use change, all carbon emissions and removals shall be modelled following the modelling guidelines of PAS 2050:2011 (BSI 2011) and the supplementary document PAS2050-1:2012 (BSI 2012) for horticultural products. PAS 2050:2011 (BSI 2011): Large emissions of GHGs can result as a consequence of land use change. Removals as a direct result of land use change (and not as a result of long-term management practices) do not usually occur, although it is recognized that this could happen in specific circumstances. Examples of direct land use change are the conversion of land used for growing crops to industrial use or conversion from forestland to cropland. All forms of land use change that result in emissions or removals are to be included. Indirect land use change refers to such conversions of land use as a consequence of changes in land use elsewhere. While GHG emissions also arise from indirect land use change, the methods and data requirements for calculating these emissions are not fully developed. Therefore, the assessment of emissions arising from indirect land use change is not included.

[17] Native forests – represents native or long-term, non-degraded forests. Definition adapted from table 8 in Annex V C(2010)3751 to Directive 2009/28/EC.

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

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

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

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

- the earliest year in which it can be demonstrated that the land use change had occurred; or
- on 1 January of the year in which the assessment of GHG emissions and removals is being carried out.

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

1. where the country of production is known and the previous land use is known, the GHG emissions and removals arising from land use change shall be those resulting from the change in land use from the previous land use to the current land use in that country (additional guidelines on the calculations can be found in PAS 2050-1:2012);
2. where the country of production is known, but the former land use is not known, the GHG emissions arising from land use change shall be the estimate of average emissions from the land use change for that crop in that country (additional guidelines on the calculations can be found in PAS 2050-1:2012);
3. where neither the country of production nor the former land use is known, the GHG emissions arising from land use change shall be the weighted average of the average land use change emissions of that commodity in the countries in which it is grown.

Knowledge of the prior land use can be demonstrated using a number of sources of information, such as satellite imagery and land survey data. Where records are not available, local knowledge of prior land use can be used. Countries in which a crop is grown can be determined from import

statistics, and a cut-off threshold of not less than 90% of the weight of imports may be applied. Data sources, location and timing of land use change associated with inputs to products shall be reported.

Soil carbon storage shall not be modelled, calculated and reported as additional environmental information.

The sum of the three sub-categories shall be reported. The sub-categories 'Climate change – biogenic' and 'Climate change – land use and land transformation' shall not be reported separately.

5.11 Modelling of wastes and recycled content

The waste of products used during the manufacturing, distribution, retail, the use stage or after use shall be included in the overall modelling of the life cycle of the organisation. Overall, this should be modelled and reported at the life cycle stage where the waste occurs. This section gives guidelines on how to model the End-of-Life of products as well as the recycled content.

The Circular Footprint Formula is used to model the End-of-Life of products as well as the recycled content and is a combination of "material + energy + disposal", i.e.:

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

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

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

With the following parameters:

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

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

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

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

Q_p: quality of the primary material, i.e. quality of the virgin material.

R_1: it is the proportion of material in the input to the production that has been recycled from a previous system.

R_2: it is the proportion of the material in the product that will be recycled (or reused) in a subsequent system. R2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R2 shall be measured at the output of the recycling plant.

R_3: it is the proportion of the material in the product that is used for energy recovery at EoL.

$E_{recycled}$ (E_{rec}): specific emissions and resources consumed (per the functional unit) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.

$E_{recyclingEoL}$ (E_{recEoL}): specific emissions and resources consumed (per the functional unit) arising from the recycling process at EoL, including collection, sorting and transportation process.

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

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

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

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

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

$X_{ER,heat}$ and $X_{ER,elec}$: the efficiency of the energy recovery process for both heat and electricity.

LHV: Lower Heating Value of the material in the product that is used for energy recovery.

6 Life cycle stages

6.1 Raw material acquisition and pre-processing

(1) Materials that constitute components of, accessories for, and packaging for IT equipment

The applicant shall collect the mass of materials through actual measurement for each process listed in Table 6.1.1 and excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.1 Raw materials." With regard to HDD - 3.5 inch and HDD - 2.5 inch, when data is collected as "piece" it shall be converted to "kg" based on 0.63kg/piece.

The applicant shall use default datasets listed in Table 6.1.1 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "-6.1 Raw materials."

The activity data for a time period of the last one year, or any period of time equivalent to the last one year, shall be used.

Table 6.1.1. ***Raw material acquisition and processing –materials – example (capitals indicate those processes expected to be run by the company)***

Process name		*Default*	*UUID*	*Default DQR*	No

	Unit of measu-rement (output)	*R_1*	*Amount per FU*	*Dataset*	*Dataset source*		*P*	*TiR*	*GR*	*TeR*	
PRINTED CIRCUIT BOARD	kg	0	Mandatory company-specific information	Populated Printed wiring board (PWB) (8-layer); via the subtractive method (as opposed to additive method); production mix, at plant; 8-layer	http://lcdn.thinkstep.com/Node/	3b2e60de-2e05-4761-9c0d-06fb9320db9f	2	2	2	2	Y

See excel file named “PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx”, sheet named ”6.1 Raw materials" for the list of all processes to be included in this stage.

The following exclusions shall be considered in the collection of activity data:

- Racks on which housings (or shelves) are stored are not included.
- The mass of heat radiation fins on a printed circuit board shall not be included in the mass of the printed circuit board but included in relevant materials.

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

(2) Transport of components of, accessories for, and packaging for IT equipment

The applicant shall collect the mass of components of, accessories for, and packaging for IT equipment through actual measurement for the processes listed in Table 6.1.2. and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx”, sheet named ”6.1 Raw materials transport."

The applicant should collect the following activity data through actual measurement for the processes listed in Table 6.1.2. and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx”, sheet named ”6.1 Raw materials transport.":

- Transport mode
- Distance per transport mode
- Utilisation ratios for truck transport

The applicant shall use default datasets listed in Table 6.1.2 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx”, sheet named ”6.1 Raw materials transport.”

The activity data for a time period of the last one year, or any period of time equivalent to the last one year, shall be used.

Where transport mode, distance per transport mode, and utilization ratios are not collected through actual measurement, the default data in Table 6.1.2 and the excel file named "PEFCR for IT equipment version 1.1

- Life cycle inventory.xlsx", sheet named "6.1 Raw materials transport" shall be used. The sum of all transport modes provided shall be included.

Table 6.1.2. ***Transport (capitals indicate those processes expected to be run by the company)***

Process name		*Unit of measurement (output)*	*Transport mode*	*Default (per FU)*			*Default dataset*	*Dataset source*	*UUID*	*Default DQR*				*Most relevant [Y/N]*
				Distance	*Utilisation ratio*	*Empty return*				*P*	*TiR*	*GR*	*TeR*	
TRANSPORT OF MATERIALS FROM PRODUCTION SITE OF THE MATERIALS TO THE PRODUCTION SITE WHERE THE ASSEMBLY TAKES PLACE	For suppliers located within Europe:	tkm	Truck	130 km	64%	included	Articulated lorry transport, Euro 4, Total weight >32 t (without fuel)	http://lcdn.thinkstep.com/Node/	938d5ba6-17e4-4f0d-bef0-481608681f57	2	1	1	1	N
			Train	240 km	n.a.	n.a.	Freight train, average (without fuel)	http://lcdn.thinkstep.com/Node/	02e87631-6d70-48ce-affd-1975dc36f5be	2	1	1	1	
			ship	270 km	n.a.	n.a.	Barge technology mix	http://lcdn.thinkstep.com/Node/	4cfacea0-cce4-4b4d-bd2b-223c8d4c90ae	2	1	1	1	

* The applicant of this PEFCR shall always check the utilisation ratio applied in the default dataset and adapt it accordingly.

In case it is unknown whether the supplier is located within or outside Europe, the applicant shall assume that the supplier is located outside Europe.

If the producers' country of origin is known, the applicant may determine the adequate distance for ship and airplane using http://www.searates.com/services/routes-explorer or https://co2.myclimate.org/en/flight_calculators/new.

Modelling the recycled content (if applicable)

The following formula is used to model the recycled content:

$$(1 - \mathrm{R_1})\mathrm{E_V} + \mathrm{R_1} \times \left(\mathrm{AE_{recycled}} + (1 - \mathrm{A})\mathrm{E_V} \times \frac{\mathrm{Q_{Sin}}}{\mathrm{Q_p}}\right)$$

The R_1 values applied shall be supply-chain or default as provided in the table above, in relation with the DNM. Material-specific values based on supply market statistics are not accepted as a proxy. The applied R_1 values shall be subject to PEF study verification.

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

- The supplier information (through e.g., statement of conformity or delivery note) shall be maintained during all stages of production and delivery at the converter;
- Once the material is delivered to the converter for production of the end products, the converter shall handle information through their regular administrative procedures;
- The converter for production of the end products claiming recycled content shall demonstrate through his management system the [%] of recycled input material into the respective end product(s).
- The latter demonstration shall be transferred upon request to the user of the end product. In case a PEF profile is calculated and reported, this shall be stated as additional technical information of the PEF profile.
- Company-owned traceability systems can be applied as long as they cover the general guidelines outlined above.

Raw material acquisition and pre-processing of copper is modelled with two separate datasets, which are for the virgin material and the recycled content. Materials other than copper are modelled with a single dataset for each material (mixture of virgin material and recycled content).

6.2 Manufacturing

The applicant should collect the amount of electric power through actual measurement for the processes listed in Table 6.2 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.2 Manufacturing."

The applicant shall use default datasets listed in Table 6.2 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.2 Manufacturing."

Electricity is considered to be the only energy used for assembling products. Electricity used for production facilities, air conditioning, and lighting shall be included.

Data on the amount of electricity used may also be collected through allocation as presented in section 5.8. In that case, the allocation factor shall be derived from actual measurement.

Where the assembly of products that are part of the same equipment is undertaken in several production sites, the data for all production sites shall be used.

Where the same assembly processes are undertaken in multiple production sites, data of some production sites shall be sampled in a manner of sampling procedure prescribed in section 5.1.

The activity data for a time period of the last one year, or any period of time equivalent to the last one year, shall be used.

Table 6.2. ***Manufacturing (capitals indicate those processes expected to be run by the company)***

Name of the process	*Unit of measure-ment (output)*	*Default amount per FU*	*Default dataset to be used*	*Dataset source*	*UUID*	*Default DQR*				*Most relevant process [Y/N]*
						P	Ti_R	G_R	Te_R	
IT EQUIPMENT ASSEMBLY	kWh	mandatory company-specific information	Electricity grid mix 1kV-60kV AC, technology mix consumption mix, at consumer 1kV - 60kV	http://lcdn.thinkstep.com/Node/	34960d4d-af62-43a0-aa76-adc5fcf57246	2	1	1	1	N

See the excel file named “PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx”, sheet named ”6.2 Manufacturing" for the list of all processes to be included in this stage.

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

The waste of products used during the manufacturing shall be set as 0, considering that it is not generated.

6.3 Distribution stage

The transport from factory to final client (including consumer transport) shall be modelled within this life cycle stage. The final client is defined as companies who use the IT equipment.

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

The products of IT equipment are assumed to be transported directly from the factory to the final client. The applicant shall collect the mass of components of, accessories for, and packaging for IT equipment through actual measurement for each process listed in Table 6.3 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx”, sheet named ”6.3 Distribution."

-The applicant should collect the following activity data through actual measurement for each process listed in Table 6.3 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx”, sheet named ”6.3 Distribution."

- Transport mode

- Distance per transport mode
- Utilization ratios for truck transport

The applicant shall use default dataset listed in Table 6.3 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.3 Distribution."

The activity data for a time period of the last one year, or any period of time equivalent to the last one year, shall be used.

Where transport mode, distance per transport mode, and utilization ratios are not collected through actual measurement, the default data in Table 6.3 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.3 Distribution" shall be used. The sum of all transport modes provided shall be included.

Table 6.3. *Distribution – example (capitals indicate those processes expected to be run by the company)*

Process name		***Unit of measurement (output)***	***Default (per FU)***				***Default dataset***	***Dataset source***	***UUID***	***Default DQR***				***Most relevant [Y/N]***
			Transport mode	***Distance***	***Utilisation ratio***	***Empty return***				*P*	Ti_R	G_R	Te_R	
TRANSPORT OF IT EQUIPMENT PRODUCTS FROM PRODUCTION SITES TO CONSUMERS	Local supply chain	tkm	Truck	1200 km	64%	Inclu-ded	Articulated lorry transport, Euro 4, Total weight >32 t (without fuel)	http://lcdn.thinkstep.com/Node/	938d5ba6-17e4-4f0d-bef0-481608681f57	2	1	1	1	N

See the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.3 Distribution" for the list of all processes to be included in this stage.

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

The waste of products during the distribution and retail shall be set at 0 considering that waste of products is not generated.

6.4 Use stage

(1) Use of IT equipment

The amount of electricity used by IT equipment is calculated by the following equation:

$$amount\ of\ electricity\ used\ by\ IT\ equipment = power\ consumption\ of\ product \times operating\ time\ per\ year \times life\ time\ of\ product$$

The applicant shall collect the following activity data through actual measurement:

- Power consumption of products (PA_{RI}), which is the average power of the Ready Idle Test ($PA_{RI}(7200)$) as established by the SNIA Emerald™ Program.

The applicant shall use the default data in Table 6.4.1 for the operating time per year.

The applicant should use 5 years as the default data as shown in Table 6.4.1 for the lifetime of the product. The applicant may use another value, if it is supported by evidence (e.g. the maintenance period exceeds five years). The reference flow is calculated using lifetime as prescribed in 3.3.

The applicant shall use the default dataset listed in Table 6.4.1 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.4 Use."

The activity data for a time period of the last one year, or any period of time equivalent to the last one year, shall be used.

Table 6.4.1. ***Use -Use of IT equipment (capitals indicate those processes expected to be run by the company)***

Name of the process	***Unit of measurement (output)***	***Default amount per FU***			***Default dataset to be used***	***Dataset source***	***UUID***	***Default DQR***				***Most relevant process [Y/N]***
		Power consumption of products	operating time	Life-time				*P*	*TiR*	*GR*	*TeR*	
USE OF IT EQUIPMENT	kWh	mandatory company-specific information.	8760 hrs/year (24 hrs x 365 days)	1 year (default total year is 5 years)	Electricity grid mix 1kV-60kV AC, technology mix consumption mix, at consumer 1kV - 60kV	http://lcdn.thinkstep.com/Node/	34960d4d-af62-43a0-aa76-adc5fcf57246	2	1	1	1	Y

See the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.4 Use" for the list of all processes to be included in this stage.

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

For the use stage the consumption grid mix shall be used. The electricity mix shall reflect the ratios of sales between EU countries/regions. To determine the ratio number of pieces sold shall be used. Where such data

are not available, the average EU consumption mix (EU-28 +3), or region representative consumption mix, shall be used.

The waste of products during the use stage shall be included in the modelling. The waste of products in this stage is the consumables; that is HDDs 2.5 inch and HDDs 3.5 inch in this PEFCR. The manufacturing of consumables shall be modelled following points (2) and (3) below, and its environmental impact shall be added to those of use stage. The recycling of consumables shall be modelled according to section 6.5 and its environmental impact shall be added to those of EoL stage.

(2) Consumables used during the product use stage

The applicant should collect the mass of consumables (HDDs 2.5 inch and HDDs 3.5 inch) which will be used during the use stage of the equipment through actual measurement for the processes listed in table 6.4.2 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.4 Use." (These HDDs are used for replacement of failure HDDs during the product use stage therefore these are different form the HDDs in raw material acquisition and pre-processing phase.)

This data should be collected as the combined mass of HDDs needed to be replaced throughout in the entire duration of use of the products.

The applicant may use the default dataset for the processes listed in Table 6.4.2 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.4 Use."

The activity data for a time period of the last one year, or any period of time equivalent to the last one year, shall be used.

Where actual measurement of the mass of consumables is not feasible, it shall be calculated by using the following formula:

$$Mass\ of\ consumables = W_{HDD} \times D_{use} \times k$$

W_{HDD}: Mass of all HDDs used (kg), when data is collected as "piece" it shall be converted to "kg" based on 0.63kg/piece
D_{use}: Duration of use of product (year)
k: Failure rate of HDDs per year (= 0.01, based on an estimated annual failure rate of 1%)

Table 6.4.2. ***Use- Consumables used during the product use stage(capitals indicate those processes expected to be run by the company)***

Process name	*Unit of measurement (output)*	*Default*				*UUID*	*Default DQR*				*Most relevant process [Y/N]*
		R_1	*Amount per FU*	*Dataset*	*Dataset source*		*P*	*TiR*	*GR*	*TeR*	
CONSUMABLES (HDDS 2.5 INCH AND HDDS 3.5 INCH)	kg In a calculation, "kg" is converted to "pcs" based on 1.59 pcs/kg	0	The following formula may be used: Mass of consumable = W_{HDD} X D_{use} x k	Hard disk drive, for desktop computer technology mix production mix, at plant 1 piece of HDD	http://lcdn.thinkstep.com/Node/	baae86df-8225-4dbd-8df2-0efaf696dc71	2	2	2	3	N

(3) Transport of consumables

The applicant shall collect the mass of components of, accessories for, and packaging for IT equipment through actual measurement for the processes listed in Table 6.4.3.

- The applicant should collect the following activity data through actual measurement for the processes listed in Table 6.4.3:

- -Transport mode
- -Distance per transport mode
- -Utilization ratios for truck transport

The mass of components shall be collected as the combined mass of HDDs needed to be replaced in the entire duration of use of products.

The applicant shall use the default dataset for the processes listed in Table 6.4.3 and the excel file named "PEFCR for IT equipment-6.4 Use(transport)."

The activity data for a time period of the last one year, or any period of time equivalent to the last one year, shall be used.

Where actual measurement of the mass of consumables is not feasible, the formula used for calculating the mass of consumables in point (2) of this chapter shall be used.

Where transport mode, distance per transport mode, and utilization ratios are not collected through actual measurement, the default data in Table 6.4.3 may be used.

Table 6.4.3. ***Use -transport – example (capitals indicate those processes expected to be run by the company)***

Process name	*Unit of measurement (output)*	*Transport mode*	*Default (per FU)*			*Default dataset*	*Dataset source*	*UUID*	*Default DQR*				*Most relevant [Y/N]*
			Distance	*Utilisation ratio*	*Empty return*				*P*	*TiR*	*GR*	*TeR*	
TRANSPORT OF IT EQUIPMENT PRODUCTS FROM PRODUCTION SITES TO CONSUMERS	tkm	Truck	1200km	64%	included	Articulated lorry transport, Euro 4, Total weight >32 t (without fuel)	http://lcdn.thinkstep.com/Node/	938d5ba6-17e4-4f0d-bef0-481608681f57	2	1	1	1	N

6.5 End of life

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

During the EoL stage, end-of-life products and used packaging are transported to recycling plants, where some of them are recycled while others are refurbished. For the purpose of the PEF calculation, the combined life cycle inventory associated with the recycling ($E_{EoL\_recycling}$) and the refurbishment ($E_{EoL\_refurbish}$) respectively, shall be considered, as shown below:

$$E_{EoL} = E_{EoL\,recycling} + E_{EoL\,refurbish}$$

On the assumption that recycling is undertaken within Europe, collecting data from within Europe will be adequately justified.

6.5.1.Recycling of end-of-life IT equipment products and used packaging

The life cycle inventory for this process ($E_{EoL\_recycling}$) is obtained by the calculated values per end-of-life product, multiplied by the ratio of those end-of-life products recycled to the total number of units of such products per year ($1-N_{refurbish}/N$). The combined life cycle inventory for the end-of-life product is calculated

by aggregating the calculated data, by type of materials classified under Categories “Metals,” “Plastics,” “Other materials,” and “Packaging parts” and names of materials that constitute “Electronic parts,” results for all types of materials. The EoL processes assumed for these materials are shown in Annex 5. Thus, $E_{EoL\_recycling}$ should be calculated by applying formula (a), or alternatively, if those materials that constitute electronic parts are difficult to identify, formula (b):

(a) Materials other than electronic parts, and materials that constitute electronic parts

The life cycle inventory is calculated in following equation:

$$E_{EoL\ recycling} = \left(1 - \frac{N_{refurbish}}{N}\right) \times Circular\ Footprint\ Formula(CFF)$$

The applicant should collect the following activity data through actual measurement and use the default dataset for the processes listed in Table 6.5.1. and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx”, sheet named ”6.5 EoL.":

- Number of units of end-of-life products during the last one year (N)
- Number of units of end-of-life products during the last one year that were refurbished ($N_{refurbish}$)

The applicant shall collect the following activity data through actual measurement and use the default dataset for the processes listed in Table 6.5.1. and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx”, sheet named ”6.5 EoL.":

- Mass of those materials(W) that constitute components and accessories as input into the process of IT equipment assembly and are classified under Categories “Metals,” “Plastics,” “Other materials,” and “Packaging parts”
- Mass of those materials(W) included in “Electronic parts” that constitute components and accessories as input into the process of IT equipment assembly

The activity data for a time period of the last one year, or any period of time equivalent to the last one year, shall be used.

Where actual measurement of the number of units of end-of-life products (N) is not feasible, the volume of products shipped per year may be used instead.

Whenever the recycling of products of the target equipment is undertaken in several recycling facilities, the data on N, $N_{refurbish}$, shall be collected for all the relevant recycling facilities.

Where values $N_{refurbish}$ are difficult to collect, the relationship of $N_{refurbish} = 0$ may be established on the assumption that all of end-of-life products are to be recycled.

Table 6.5.1. ***End of Life. – example (capitals indicate those processes expected to be run by the company)***

Name of the process			*Unit of measurement (output)*	*Default amount per FU*	*Default dataset to be used*	*Dataset source*	*UUID*	*Default DQR*				*Most relevant process [Y/N]*
								P	*Ti_R*	*G_R*	*Te_R*	
RECYCLING OF END-OF-LIFE IT EQUIPMENT PRODUCTS AND USED PACKAGING	STEEL	(1-A)R2*E Eolrecycling	kg	EoL parameters × mass of material	Recycling of steel into steel scrap collection, transport, pretreatment, remelting production mix, at plant steel waste, efficiency 95%	http://lcdn.thinkstep.com/Node/	7bd54804-bcc4-4093-94e4-38e4facd4900	2	2	2	2	N

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

The end of life shall be modelled using the formula and guidance provided in chapter 'End of life modelling' of this PEFCR together with the default parameters listed in the table below.

Before selecting the appropriate R_2 value, an evaluation for recyclability of the material shall be done and the PEF study shall include a statement on the recyclability of the materials/products. The statement on the recyclability shall be provided together with an evaluation for recyclability that includes evidence for the following three criteria (as described by ISO 14021:1999, section 7.7.4 'Evaluation methodology'):

1. The collection, sorting and delivery systems to transfer the materials from the source to the recycling facility are conveniently available to a reasonable proportion of the purchasers, potential purchasers and users of the product;
2. The recycling facilities are available to accommodate the collected materials;
3. Evidence is available that the product for which recyclability is claimed is being collected and recycled.

Point 1 and 3 can be proven by recycling statistics (country specific) derived from industry associations or national bodies. Approximation to evidence at point 3 can be provided by applying for example the design for recyclability evaluation outlined in EN 13430 Material recycling (Annexes A and B) or other sector-specific recyclability guidelines if available[19].

Following the evaluation for recyclability, the appropriate R_2 values (supply-chain specific or default) shall be used. If one criteria is not fulfilled or the sector-specific recyclability guidelines indicate a limited recyclability an R_2 value of 0% shall be applied.

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

Company-specific R_2 values (measured at the output of the recycling plant) shall be used when available. If no company-specific values are available and the criteria for evaluation of recyclability are fulfilled (see below), application-specific R_2 values shall be used as listed in the table below,

- If an R_2 value is not available for a specific country, then the European average shall be used.
- If an R_2 value is not available for a specific application, the R_2 values of the material shall be used (e.g. materials average).
- In case no R_2 values are available, R_2 shall be set equal to 0 or new statistics may be generated in order to assign an R_2 value in the specific situation.

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

Company-specific values for R1, R2 and R3 should be used when available, following the rules of the DNM. With regard to R3, if the company-specific values of target products recycled are not available, values for equivalent products e.g. previous-generation products, or products in the same category may be substituted. Where the values of R1, R2 and R3 are not available as company-specific data, the values of following table shall be used.

The values to be used for A, B, Qsin/Qp, and Qsout/Qp shall always be derived from the Table below."Table 6.5.2. ***Circular footprint formula, default values***

Default Final PEFCR LCI Name	R1	R2	R3	A	B	Qs_{in}/Qp	Qs_{out}/Qp
Steel	0	0.85	0.0675	0.2	0	1	1
Stainless Steel	0	0.85	0.0675	0.2	0	1	1
Aluminum	0	0.9	0.045	0.2	0	1	1
Copper	0.3	0.95	0.0225	0.2	0	1	1
ABS	0	0.29	0.3195	0.5	0	0.9	0.9
PET	0	0	0.45	0.5	0	0.9	0.9
HDPE	0	0	0.45	0.5	0	0.9	0.9
PP	0	0	0.45	0.5	0	0.9	0.9
PC	0	0.29	0.3195	0.5	0	0.9	0.9
Nylon 6	0	0.29	0.3195	0.5	0	0.9	0.9
PVC	0	0.321	0.30555	0.5	0	0.9	0.9
PMMA	0	0.29	0.3195	0.5	0	0.9	0.9
Other Plastics	0	0.29	0.3195	0.5	0	0.9	0.9
Glass	0	0	0.45	0.2	0	1	1
Corrugated cardboard	0.88	0.75	0.1125	0.2	0	0.85	0.85
Wood	0	0.3	0.315	0.8	0	1	1
Paper	0.21	0.62	0.171	0.5	0	0.85	0.85
LDPE	0	0	0.45	0.5	0	0.75	0.75
Expanded PP	0	0.29	0.3195	0.5	0	0.9	0.9
Hard Disc Drive	-	-	-	-	-	-	1

Printed Circuit Board	-	-	-	-	-	-	1
Power Supply Unit	-	-	-	-	-	-	1

The values for hard disc drive, printed circuit board and power supply unit are set as thinkstep. The values of Qsin/Qp and Qsout/Qp of wood are defined by TS. The other values are referenced from Annex C of PEFCR guidance. The values of Qsin/Qp and Qsout/Qp of PP are used for those of all plastics.

(b) Electronic parts

Where it is difficult to identify materials that constitute electronic parts, the life cycle inventory for electronic parts is calculated by the following equation:

$$E_{EoL\ recycling} = \left(1 - \frac{N_{refurbish}}{N}\right) \times Circular\ Footprint\ Formula(CFF)$$

The applicant should collect the following activity data through actual measurement and use the default dataset for the processes listed in Table 6.5.1 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.5 EoL.":

- Number of units of end-of-life products during the last one year (N)
- Number of units of end-of-life products during the last one year that were refurbished ($N_{refurbish}$)

The applicant shall collect the mass of electronic parts(W) through actual measurement and use the default dataset for the processes listed in Table 6.5.1 and the excel file named "PEFCR for IT equipment version 1.1 - Life cycle inventory.xlsx", sheet named "6.5 EoL.".

The activity data for a time period of the last one year, or any period of time equivalent to the last one year, shall be used.

Where actual measurement of the number of units of end-of-life products (N) is not feasible, the volume of products shipped per year may be used instead.

Whenever the recycling of products of the target equipment is undertaken in several recycling facilities, the data on N, $N_{refurbish}$, shall be collected for all the relevant recycling facilities.

Where values $N_{refurbish}$ are difficult to collect, the relationship of $N_{refurbish} = 0$ may be established on the assumption that all of end-of-life products are to be recycled.

The end of life shall be modelled using the formula and guidance provided in chapter 'End of life modelling' of this PEFCR together with the default parameters as described in section 6.5.1.

6.5.2. Refurbishment of end-of-life IT equipment products

The life cycle inventory for this process ($E_{EoL\_refurbish}$) is obtained by the calculated values per end-of-life product, multiplied by the ratio of those end-of-life products refurbished to the total number of units. By aggregating the calculated results for two different types of materials that constitute end-of-life products, namely (a) materials reused as products and (b) materials as new input, and materials recycled from end-of-life products, $E_{EoL\_refurbish}$ based on the combined amount of $E_{EoL\_refurbish(a)}$ and $E_{EoL\_refurbish(b)}$ can be obtained.

$$E_{EoL\ refurbish} = \frac{N_{refurbish}}{N} \times \left(E_{EoL\ refurbish(a)} + E_{EoL\ refurbish(b)}\right)$$

(a) Materials reused as products

This process shall be based on the assumption that materials reused as products do not undergo energy recovery, and that the procedure of refurbishment is included in (b) below. Thus, $E_{EoL\_refurbish(a)}$ can be calculated by assigning values of $E_{recycling\ EoL}$= 0, R3 = 0 to the circular footprint formula (CFF).

The applicant shall collect the activity data and use datasets as listed for the recycling. In this case, however, "materials that constitute components and accessories as input into the process of IT equipment assembly" refer to materials reused as products.

(b) Materials as new input, and materials recycled from end-of-life products

The calculation formula is the same as for recycling. The applicant shall collect the activity data and use datasets as listed for the recycling. In this case, however, "materials that constitute components and accessories as input into the process of IT equipment assembly" refer to materials as new input and materials recycled from end-of-life products for the purpose of refurbishment.

6.5.3. Disposal of consumables

This process involves HDDs 2.5 inch and HDDs 3.5 inch as waste. The calculation formula and data items to be collected are the same as for recycling, and are therefore not listed here.

7 PEF results

7.1 Benchmark values

The impact assessment for representative product was performed. The results are provided per functional unit (per TB・year) as shown in Tables 7.1, 7.2, and 7.3. These values shall be used as benchmarks.

Table 7.1 *- Characterised benchmark values for storage (absolute values)*

Impact category	Unit	Life cycle excl. use stage	Use stage
Climate change	kg $CO_{2\ eq}$	5.43E+00	5.01E+01
Ozone depletion	kg CFC-11_{eq}	2.76E-10	1.88E-08
Particulate matter	disease incidence	3.94E-07	1.54E-06
Ionising radiation, human health	kBq U^{235}	3.04E-01	2.10E+01
Photochemical ozone formation, human health	kg $NMVOC_{eq}$	1.66E-02	8.07E-02
Acidification	mol $H+_{\ eq}$	3.46E-02	1.51E-01
Eutrophication, terrestrial	mol $N_{\ eq}$	6.27E-02	3.02E-01
Eutrophication, freshwater	kg P	4.61E-05	1.05E-04
Eutrophication, marine	kg N	5.95E-03	2.96E-02
Land use	Dimensionless (pt)	2.46E+01	3.65E+02
Water use	$m^3\ world_{eq}$	3.37E+00	7.13E+00
Resource use, minerals and metals	kg Sb_{eq}	3.74E-04	3.46E-05
Resource use, fossils	MJ	6.48E+01	8.60E+02

Table 7.2*- Normalised benchmark values for storage (absolute values)*

Impact category	Life cycle excl. use stage	Use stage
Climate change	7.00E-04	6.46E-03
Ozone depletion	1.18E-08	8.03E-07
Particulate matter	6.18E-04	2.42E-03
Ionising radiation, human health	7.20E-05	4.96E-03
Photochemical ozone formation, human health	4.09E-04	1.99E-03
Acidification	6.23E-04	2.73E-03
Eutrophication, terrestrial	3.54E-04	1.70E-03
Eutrophication, freshwater	1.81E-05	4.10E-05
Eutrophication, marine	2.10E-04	1.05E-03
Land use	1.85E-05	2.75E-04
Water use	2.93E-04	6.20E-04
Resource use, minerals and metals	6.45E-03	5.98E-04
Resource use, fossils	9.93E-04	1.32E-02

Table 7.3 *- Weighted benchmark values for storage (absolute values)*

Impact category	Life cycle excl. use stage	Use stage
Climate change	1.55E-04	1.43E-03
Ozone depletion	7.96E-10	5.42E-08
Particulate matter	5.89E-05	2.31E-04
Ionising radiation, human health	3.87E-06	2.67E-04
Photochemical ozone formation, human health	2.09E-05	1.01E-04
Acidification	4.14E-05	1.81E-04

Impact category	Life cycle excl. use stage	Use stage
Eutrophication, terrestrial	1.39E-05	6.66E-05
Eutrophication, freshwater	5.33E-07	1.21E-06
Eutrophication, marine	6.56E-06	3.26E-05
Land use	1.55E-06	2.31E-05
Water use	2.64E-05	5.60E-05
Resource use, minerals and metals	5.21E-04	4.83E-05
Resource use, fossils	8.85E-05	1.18E-03

7.2 PEF profile

The applicant shall calculate the PEF profile of its product in compliance with all requirements included in this PEFCR. The following information shall be included in the PEF report:

- full life cycle inventory;
- characterised results in absolute values, for all impact categories (including toxicity; as a table);
- normalised and weighted result results in absolute values, for all impact categories (including toxicity; as a table);
- the aggregated single score in absolute values.

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

7.3 Additional technical information

Not applicable for this PEFCR.

7.4 Additional environmental information

Biodiversity is not considered relevant for this PEFCR.

8 Verification

The verification of an EF study/report carried out in compliance with this PEFCR shall be done according to all the general requirements included in Section 8 of PEFCR Guidance 6.3 and the requirements listed below. The verifier(s) shall verify that the EF study is conducted in compliance with this PEFCR.
These requirements will remain valid until an EF verification scheme is adopted at European level or alternative verification approaches applicable to EF studies/report are included in existing or new policies.

8.1 Specific requirements for the verification

The verifier(s) shall validate the accuracy and reliability of the quantitative information used in the calculation of the study. As this can be highly resource intensive, the following requirements shall be followed:

- the verifier shall check if the correct version of all impact assessment methods was used. For each of the most relevant impact categories, at least 50% of the characterisation factors (for each of the most relevant EF impact categories) shall be verified, while all normalisation and weighting factors of all ICs shall be verified. In particular, the verifier shall check that the characterisation factors correspond to those included in the EF impact assessment method the study declares compliance with[20];
- all the newly created datasets shall be checked on their EF compliancy (for the meaning of EF compliant datasets refer to Annex H of the Guidance). All their underlying data (elementary flows, activity data and sub processes) shall be validated;
- the aggregated EF-compliant dataset of the product in scope (meaning, the EF study) is available on the EF node (http://eplca.jrc.ec.europa.eu/EF-node).
- for at least 70% of the most relevant processes in situation 2 option 2 of the DNM, 70% of the underlying data shall be validated. The 70% data shall including all energy and transport sub processes for those in situation 2 option 2;
- for at least 60% of the most relevant processes in situation 3 of the DNM, 60% of the underlying data shall be validated;
- for at least 50% of the other processes in situation 1, 2 and 3 of the DNM, 50% of the underlying data shall be validated.

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

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

These data checks shall include, but should not be limited to, the activity data used, the selection of secondary sub-processes, the selection of the direct elementary flows and the CFF parameters. For example, if there are 5 processes and each one of them includes 5 activity data, 5 secondary datasets and 10 CFF parameters, then the verifier(s) has to check at least 4 out of 5 processes (70%) and, for each process, (s)he shall check at least 4 activity data (70% of the total amount of activity data), 4 secondary datasets (70% of the total amount of secondary datasets), and 7 CFF parameters (70% of the total amount of CFF parameters), i.e. the 70% of each of data that could be possible subject of check.

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

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

9 References

Existing PCRs, methodology guides, and other documents listed below are referred to while developing this PEFCR:

Existing PCRs and sector guidelines

2013/179/EU - COMMISSION RECOMMENDATION of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:124:FULL:EN:PDF

Product Environmental Footprint Category Rules Guidance, Version 6.3 – December 2017

The CFP-PCR of "IT equipment" (PA-CI-04), Carbon Footprint of Products Communication Program (Japan) http://pcr-library.edf.org.tw/data/japan/JEMAI201310_Electronics_IT%20Equipment.pdf

Product Category Rules "UN CPC 45264 - Laser printers used with data processing machines", PCR 2010:04, Version 1.1, International EPD® System, http://environdec.com/en/PCR/Detail/?Pcr=5930

PCR Basic Module "UN CPC Division 47 - Radio, television, and communication equipment and apparatus", Draft version 0.5, dated 2009-08-11, International EPD® System, http://environdec.com/en/PCR/Detail/?Pcr=5900

Product Category Rules "UN CPC 47223 - Home and SOHO Gateway", PCR 2013:10, Version 1.0, date 2013-07-17, International EPD® System, http://environdec.com/en/PCR/Detail/?Pcr=9135

The PCR Basic Module of "UN CPC Division 45 - Office, accounting and computing machinery", Version 2.0, International EPD® System (Sweden) http://environdec.com/en/PCR/Detail/?Pcr=7068

The PCR of "Personal computer" of Carbon Footprint Label (Korea)

ETSI TS 203 199 - V1.3.1 - Environmental Engineering (EE); Life Cycle Assessment (LCA) of ICT equipment, networks and services; General methodology and common requirements http://www.etsi.org/deliver/etsi_es/203100_203199/203199/01.03.01_60/es_203199v010301p.pdf

ITU-T/L.1410 - Methodology for the assessment of the environmental impact of information and communication technology goods, networks and services http://www.itu.int/rec/T-REC-L.1410-201203-I/en

IEC/TR 62725 - Analysis of quantification methodologies of greenhouse gas emissions for electrical and electronic products and systems http://www.iec.ch/dyn/www/f?p=103:22:0::::FSP_ORG_ID,FSP_LANG_ID:1314,25 http://webstore.iec.ch/webstore/webstore.nsf/artnum/047668!opendocument

GHG Protocol Product Life Cycle Accounting and Reporting Standard ICT Sector Guidance - Chapter 6: Guide for assessing GHG emissions of Hardware (draft)
http://www.ghgprotocol.org/files/ghgp/GHGP-ICT-Hardware-v3-2-26JAN2013.pdf

Product Category Rules of the PEP ecopassport PROGRAM – Product Environmental Profile for Electrical, Electronic and HVAC-R equipments
http://www.pep-ecopassport.org/documents/PEP-PCR-ed%202.1-EN-2012%2012%2011.pdf

SNIA

SNIA Emerald™ Power Efficiency Measurement Specification, Version 2.0.2
http://snia.org/sites/default/files/EmeraldMeasurementV2_0_2.pdf

The 2014 SNIA Dictionary - A glossary of storage networking, data, and information management terminology
http://www.snia.org/sites/default/files/SNIADictionary2014-1-ENG.pdf

Other related documents

ENERGY STAR® Data Center Storage Specification Version 1.0
http://www.energystar.gov/products/specs/data_center_storage_specification_version_1_0_pd

DG ENTR Lot 9 preparatory study on Enterprise servers – Documents
http://www.ecodesign-servers.eu/documents

IEC/TR 62635 Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment
http://webstore.iec.ch/webstore/webstore.nsf/artnum/047037!opendocument

IEC/DTR 62921 - Electrotechnical Products – Quantification methodologies for greenhouse gas emissions for computers and monitors

Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE)
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:197:0038:0071:en:PDF

ANNEX 1 - List of EF normalisation and weighting factors

Global normalisation factors are applied within the EF. The normalisation factors as the global impact per person are used in the EF calculations.

Table A1.1. Normalisation factors

Impact category	Unit	Normalisation factor	Normalisation factor per person	Impact assessment robustness	Inventory coverage completeness	Inventory robustness	Comment
Climate change	kg $CO_{2\ eq}$	5.35E+13	7.76E+03	I	II	I	
Ozone depletion	kg CFC-11 $_{eq}$	1.61E+08	2.34E-02	I	III	II	
Human toxicity, cancer	CTUh	2.66E+05	3.85E-05	II/III	III	III	
Human toxicity, non-cancer	CTUh	3.27E+06	4.75E-04	II/III	III	III	
Particulate matter	disease incidence	4.39E+06	6.37E-04	I	I/II	I /II	NF calculation takes into account the emission height both in the emission inventory and in the impact assessment.
Ionising radiation, human health	kBq U^{235} $_{eq}$	2.91E+13	4.22E+03	II	II	III	
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	2.80E+11	4.06E+01	II	III	I/II	
Acidification	mol H+ $_{eq}$	3.83E+11	5.55E+01	II	II	I/II	
Eutrophication, terrestrial	mol N $_{eq}$	1.22E+12	1.77E+02	II	II	I/II	

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

Weighting factors for Environmental Footprint

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

ANNEX 2 - check-list for supporting study and PEF study

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

ITEM	***Included in the study (Y/N)***	***Section***	***Page***
Summary			
General information about the product			
General information about the company			
Diagram with system boundary and indication of the situation according to DNM			
List and description of processes included in the system boundaries			
List of co-products, by-products and waste			
List of activity data used			
List of secondary datasets used			
Data gaps			
Assumptions			
Scope of the study			
(sub)category to which the product belongs			
DQR calculation of each dataset used for the most relevant processes and the new ones created			

ITEM	*Included in the study (Y/N)*	*Section*	*Page*
DQR (of each criteria and total) of the study			

ANNEX 3 - Critical review report

The 1st review panel was held on 18 October 2016, 31 October 2016, and 9 November 2016. The review was conducted by comparing with the requirements of PEF guide and PEFCR guidance version 5.2 one by one. There were comments and they were reflected to PEFCR as follows.

Comment 1:

There are overlaps in the prescriptions concerning specific data, secondary data, etc. The structure of document should be reviewed.

Justification for comment 1:

This comment was accepted and the repeated prescriptions were integrated. The main changes are as follows.

-The tables for minimum list of specific data in "5.3.4 Minimum list of processes covered by specific data (this subsection was deleted in draft PEFCR ver. 3.0)" were integrated into the tables for foreground data in "Annex VIII – Foreground data."

-The tables for background data in "Annex IX background data (this Annex was replaced with Annex for EoL formula in draft PEFCR ver.3.0)" were eliminated because they are the same as the tables in "5.4 requirements regarding background generic data and data gaps."

Comment 2:

The calculation results of screening study are found in the body of PEFCR. These data should be moved to the Annex and just the instructions to perform PEF study should be included in the body of PEFCR.

Justification for comment 2:

This comment is accepted. The main changes are as follows.

-Tables for hot spots in "5.1 Screening step" were moved to "Annex XV Hot spots" (this Annex was newly created in draft PEFCR ver. 3.0) and referred to from the body of PEFCR.

-The calculation results of screening study in "6 Benchmark and classes of environmental performance" were moved to "Annex XI Background information on methodological choices taken during the development of the PEFCR" (the number of this Annex was changed to Annex X in draft PEFCR ver.3.0).

Comment 3:

Section 5.1 “Screening step” shows just the results of the screening step. This section should address how the data collection rules were decided based on the results of screening study.

Justification for comment 3:

This comment was accepted. Section 5.1 “Screening step” was changed to prescribe that the most relevant impact categories and processes were decided based on the results of screening study as follows.

″The electricity consumption in use phase and printed circuit board in raw material acquisition and pre-processing phase were identified as the 2 most significant life cycles processes in the screening step. For these processes, the requirements for the most relevant processes in Table 5 shall be applied.”

Comment 4:

The reviewer proposed to prescribe the following in Chapter 7 “Interpretation.”

-The uncertainty of the most relevant impact categories should be evaluated, and considered when the PEF study is used for comparison with similar products

-In order to ensure the evaluation of uncertainty, collected data for the most relevant processes should be verified.

Justification for comment 4:

This comment was accepted. The indications by reviewers were reflected and the context of Chapter 7 was revised in terms of following viewpoints.

-Original: prescribing what should be considered to develop PEFCR for comparative assertion

-Revised: prescribing what should be conducted in PEF study for comparative assertion

Comment 5:

The equal weighting factor (1-1-1-…) may cause misunderstanding on the relevance of impact categories. The weighting factor should be improved.

Justification for comment 5:

This comment was accepted but the weighting factor has still been discussed on TAB. Therefore, it will be replaced with the one which the European Commission will decide.

Comment 6:

If there exists environmental information which is not included in PEFCR although users of IT equipment or consumers are interested in it, that environmental information should be noted in the section "4.6 Additional environmental information."

Justification for comment 6:

There is no environmental information which should be included in PEFCR except for the default 15 environmental impact categories. Therefore, the additional environmental information is not included in the PEFCR for IT equipment.

The 2nd review panel was held on 19 and 26 December 2017. After the 1st review, the PEFCR was changed reflecting the change of the PEFCR guidance from version 5.2 to 6.2. The changes of PEFCR were reviewed in the 2nd review panel. There were comments, which were reflected to PEFCR as follows.

Comment 1:

ISO 14025 essentially defines that the comparison between products is only allowed when the products have identical functions. The comparison between products with different functions is not allowed.

If Technical Secretariat (TS) thinks that the comparability has not yet well-ensured with the rules developed so far, the specific reasons and items to be considered may better be stated.

For example, the product with different functions essentially cannot be compared in accordance with ISO14025; however, the identical function can only be available with the same product. Different products certainly have different functions, even in the same product category. Eventually, products are incomparable.

Comment 2:

Within EF framework, applicants of the PEFCR should not disclose results which claim competitive advantages over other products produced by other actors, but may better make comparative assertions against the benchmark, the agreed reference calculated based on the common tool which agreed and recognized by concerned parties including stakeholders, so the users of the results can make decisions according to the purpose of the framework.

Justification for comment 1 & 2:

TS has adopted the description below specified in the PEFCR templates:

PEF studies carried out in compliance with this PEFCR would reasonably lead to reproducible results and the information included therein may be used to make comparisons and comparative assertions under the prescribed conditions (see chapter on limitations).

Comment 3:

Describing functional unit by a year may be a matter of communication for the result of calculation, but if it is described as functional unit, the duration should be set as 5 years.

TS needs to confirm to European Commission how functional unit should be described at functional unit and reference flow on page 20, whether it should be specified with the rules for calculation and communication or product's service life time.

Justification for comment 3:

The explanation of "How well" and "How long" is to be illustrated out of the table.

Comment 4:

The results of impact assessment which led to most relevant impact category and life cycle stages based on remodeling and reference for weighting factors applied to the assessment should better be stated as much as possible (e.g. add web-links).

In terms of weighting, the current weighting factor is applicable during the transition phase, so TS should report to European Commission the need of updating weighting factor and request to continue updating it.

Justification for comment 4:

Reference for weighting factor and others are to be specified as much as possible (e.g. add web-links).

Comment 5:

There is no need for the same tables or figures to be put twice.

PEFCR should be simplified as much as it can, which is easier for users to use. Overlapped descriptions should be removed.

Therefore, some items on table 5.2 which are not described on table 5.1 remains and the rest (overlapped parts) should be removed.

Justification for comment 5:

Table 5.2 is prescribed format, which is unable to be changed. TS needs to confirm to EC whether it can be changed.

Comment 6:

Regarding allocation rules described in chapter 5.8, cost of production of products shall not be included in physical allocation.

Allocation rules apply only to the case which various types of products are manufactured at one place. Overlapped description at chapter 5.9 should be removed.

Justification for comment 6:

Overlapped parts of allocation rules are to be reviewed.

Comment 7:

Is the model of CFF fully understood and written in a way which is easy for users to understand by reading PEFCR? Even if current rules stipulate that the CFF should be used it is necessary to make efforts to be able to provide simple explanation in general.

It is fundamental to apply CFF on data and verify it by calculating. Verify it with inventory data used in the assessment of remodelling.

Justification for comment 7:

A set of relevant data is to be obtained from thinkstep, the consulting firm which is in charge of remodeling.

Comment 8:

Since the environmental impacts have to be taken into account in the complete value chain today, EF framework should offer country/region-specific dataset so that a company can select a country and region where their raw materials and parts come from.

Justification for comment 8:

With the current data availability, it is not possible to comply with this comment. We expect that the needed datasets would become available as more PEF studies are performed.

Comment 9:

The developed PEFCR includes large amounts of contents and covers extensive fields. When considering future operation and implementation of PEFCR, TS should pay heed that PEFCR needs to be developed in a way that business can carry out calculation reasonably.

Justification for comment 9:

The PEFCR was developed in accordance with PEF Guidance. The feasibility was taken into account and default data are provided as much as possible. TS regards the further improvement of feasibility as a future challenge.

ANNEX 4 – Representative product

The virtual product which has the average configuration in EU was used as representative product. The average configurations in EU were defined as follows.

(1) Average storage capacity

Average storage capacity was estimated through the following procedure:

- IDC (International Data Corporation Japan) provides statistical data of storage capacity sold in Western Europe divided into 3 and 10 price ranges (“Worldwide Quarterly Disk Storage Systems Tracker -2013Q1”). In this screening study, the data of 10 price ranges were referred to in order to estimate average storage capacity.

- The IDC data mentioned above don't include entry level products whose prices range between $1,000 and $15,000. In order to complement these products, IDC's “Personal & Entry Level Storage Tracker” was referred to.

Through the estimation, average storage capacity was set as 102TB.

(2) Configurations of products

Based on the average storage capacity, configurations of products were considered according to the following conditions:

- HDDs of both 3.5 inch (7200rpm, 4TB) and 2.5 inch (10,000rpm, 0.9TB) shall be mounted onto products.
- HDDs of 3.5 inch and 2.5 inch shall compose nearly identical storage capacity.
- RAID level may be set on the basis of product policies by each company.
- Controllers and disk enclosure shall be included in the system boundary.
- Rack shall be excluded from the system boundary.

In accordance with these configurations, data were collected with regard to 4 products provided by TS members. Then the collected data were averaged and used as the data of virtual product. The bill of materials (BOM) of the virtual product estimated in this manner is shown in Table A4.1.

Table A4.1 BOM of the representative product

Category	Name	Unit	Quantity
Steel	Steel	kg	74.7
	Stainless steel	kg	13.0
Non-ferrous metals	Aluminum sheet	kg	1.02
	Copper	kg	5.80
Plastics	ABS	kg	3.05
	PET	kg	0.544
	HDPE	kg	0.585
	PP	kg	0.111
	PC	kg	1.73
	Nylon 6	kg	0.0324
	PVC	kg	1.06
	PMMA	kg	0.0255
	Other plastics	kg	0.200
Electronics	HDD - 3.5 inch	kg	12.5
		P	15.3
	HDD - 2.5 inch	kg	22.5
		p	74.5

Category	Name	Unit	Quantity
	Printed circuit board	kg	10.1
	Power supply unit	kg	14.1
	Battery	kg	1.09
Others	Glass	kg	0.0941
Packaging materials	Corrugated cardboard	kg	5.54
	LDPE	kg	0.607
	Expanded PP	kg	0.533
	Wood	kg	0.277
		m3	0.000407
	Paper	kg	0.150
Total	(including packaging materials)	kg	169
	(excluding packaging materials)	kg	162

The data were collected in accordance with the system boundary shown in Figure A4.2.

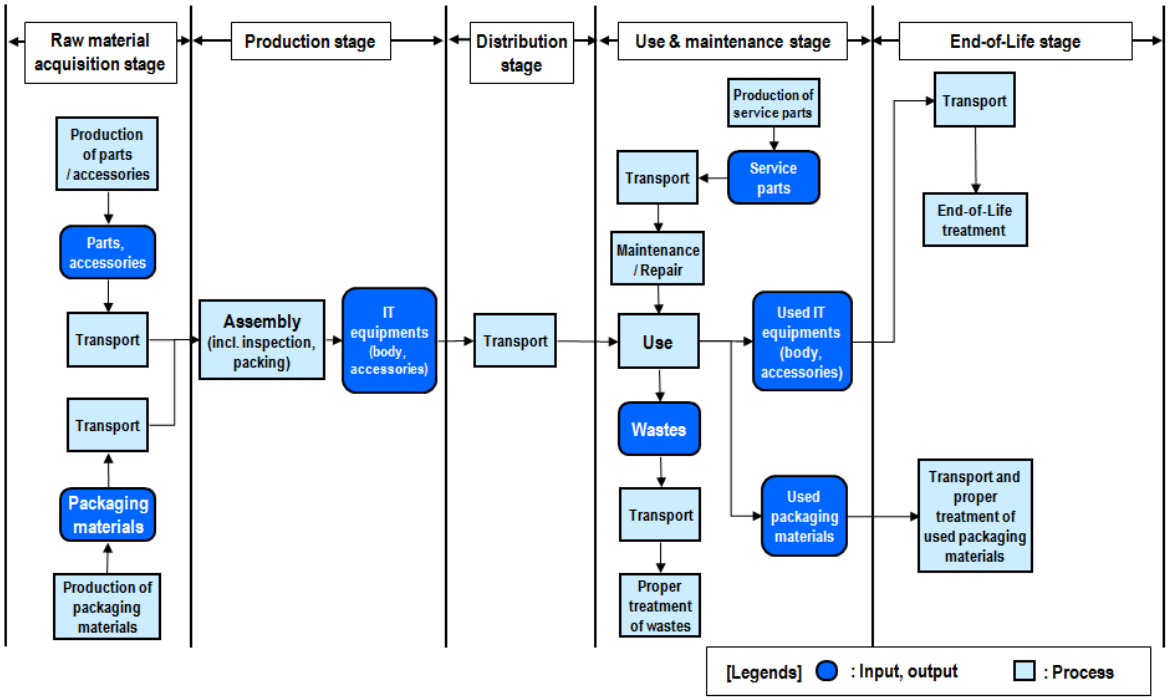

Figure A4.2 System diagram used for screening study

For transportation, the scenarios in PCR of the “PEP ecopassport” were referred to under following assumptions. The parts, accessories, and packaging materials are transported from suppliers in foreign countries to assembly site of product in the EU by worldwide transport and intracontinental transport. Then the products are assembled in the EU and transported to customers in the EU by intracontinental transport. The used products and packages are transported from customers to the plants for End-of-life treatment in the EU by local transport.

For use stage, the power consumption of products from 4 TS member companies was measured in the following manner described in “Act on the Rational Use of Energy” (a law in Japan):

- The ambient temperature shall be in a range from 16 degrees C to 32 degrees C.

- The power supply voltage shall be within 10 percent above or below the rated input voltage.

- The power supply frequency shall be the rated frequency.

- For bare drives, measurements shall be made within the scope of a built-in control device, a cache memory for buffer use, and the disk drive.

- For subsystems, measurements shall be made within the scope of controllers; cache memories for buffer use; power supply units needed to operate magnetic disk devices; and the maximum number of disk drives and the maximum number of input/output signal transmission lines that are connectable to the control device.

- Measurements shall be made in a state ready to promptly write and read data while disks are enabled to rotate after the power has been input.

In order to estimate the power consumption through whole lifetime, the measured power consumptions were averaged and multiplied by operating hours described in Table A4.3. Table A4.3 was defined under the assumption that a storage device runs continuously through its lifetime.

Table A4.3 Operating time of the product

Article	Unit	Quantity
Daily operating hours	hours/day	24
Yearly operating days	days/year	365
Service life	years	5
Total operating hours	hours	43,800

For EoL stage, baseline EoL scenario (defined by JRC) was applied.

ANNEX 5 - Assumption of EoL process

The end-of-life (EoL) process for end-of-life products and used packaging involves the disassembly, fragmentation/sorting-out, material recycling, energy recovery, incineration without energy recovery, and landfill. These steps are supposed to be undertaken in sequence as shown in Figure A5.1. For the purpose of the EoL process, the assembly is intended for products and packaging as a unit, followed by the subsequent procedures intended for materials, by type, that constitute products and packaging. The process flow for end-of-life products and used packaging, as well as their materials, is indicated below:

1. End-of-life products

(1) Some of end-of-life products are to be recycled, while the other products are to be refurbished.
(2) All those products that are recycled are disassembled into individual materials (electronic parts, metals, plastics, and other materials).
(3) All of such disassembled materials are fragmented and sorted out, and then undergo, by type, the following procedures:

- For metals, (R2)% of them by mass are recycled, while the others are landfilled;
- For plastics, (R2)% of them by mass are recycled, and (R3)% of them by mass are used for energy recovery, while the others are incinerated without energy recovery or landfilled;
- For other materials, (R2)% of them by mass are recycled, while the others are landfilled; and
- Electronic parts are further sorted out into metals, plastics, and other materials, to which the same procedures as above are applied.

2. Packaging

(1) All of used packaging is disassembled into individual materials.
(2) Such disassembled materials undergo the following procedures:

- For plastics, the same procedures as for those plastics that constitute products are applied; and
- For packaging parts, (R2) % of them by mass are recycled, and (R3) % of them by mass are used for energy recovery, while the others are incinerated without energy recovery or landfilled.

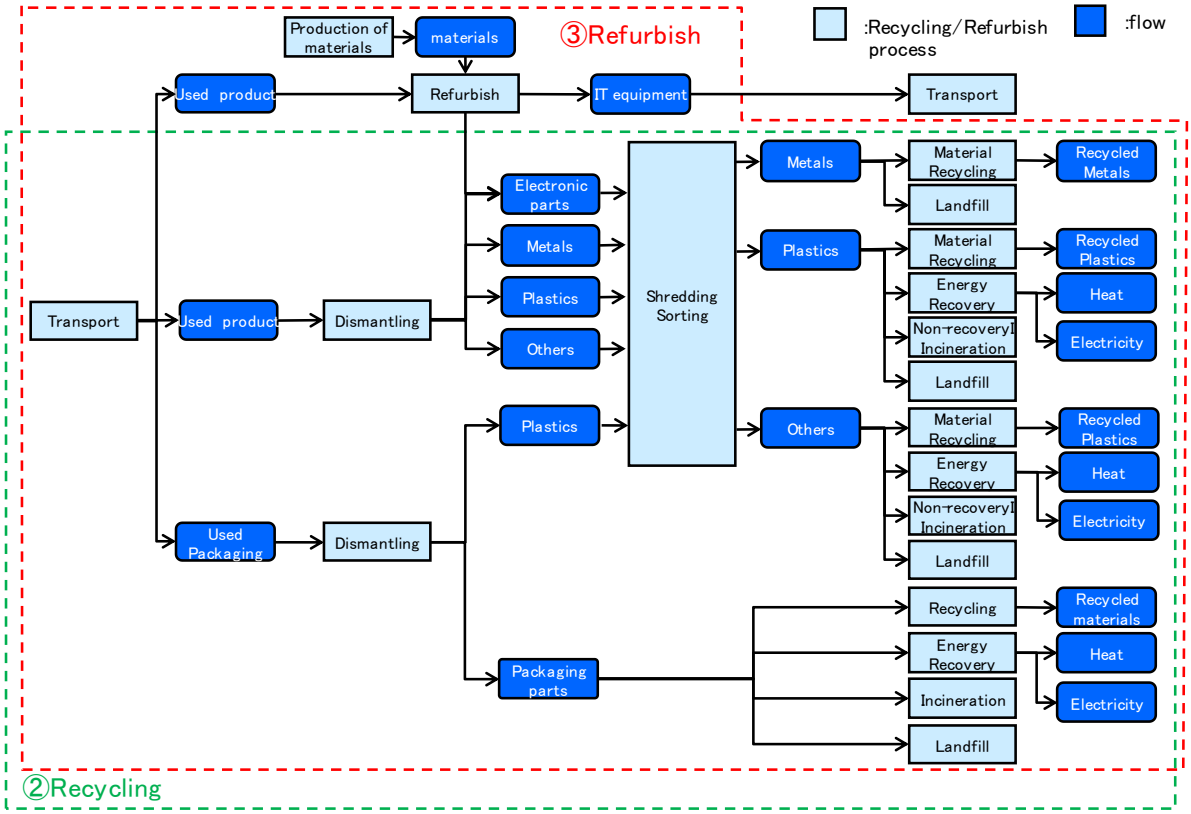

Figure A5.1 EoL process for end-of-life products and used packaging