Product Environmental Footprint Category Rules (PEFCR)

T-shirts

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Acronyms

AC	Acidification
AD	Activity Data
ADEME	Agence de l'Environnement et de la Maitrise de l'Energie
AF	Allocation Factor
AFNOR	Agence Française de Normalisation
AISE	International Association for Soaps, Detergents and Maintenance Products
AR	Allocation Ratio
B2B	Business to Business
B2C	Business to Consumer
BIOIS	Bio Intelligence Service
BoC	Bill of Components
BoM	Bill of Materials
BP	Bonne Practique
BREF	Best Available Techniques Reference Document
CC	Climate change
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
CTUe	Comparative Toxic Unit for ecosystems
CTUh	Comparative Toxic Unit for humans
DC	Distribution Centre
DMI	Dry Matter Intake
DNM	Data Needs Matrix
DQR	Data Quality Rating
EA	Economic Allocation
EC	European Commission
EDIP	Environment-Dependent Interatomic Potential
EF	Environmental Footprint
EFTA	European Free Trade Association
EI	Environmental Impact
ELCD	European Reference Life Cycle Database
EMAS	Environmental Management and Audit Scheme
EoL	End-of-Life
EPD	Environmental Product Declaration
EU	European Union
FE	Freshwater eutrophication
FEco	Freshwater ecotoxicity
FRT	Sustainable Consumption and Production Food Round Table

FU	Functional Unit
GE	Gross Energy intake
GHG	Greenhouse Gas
GLO	Global
GR	Geographical Representativeness
GRI	Global Reporting Initiative
GWP	Global Warming Potential
HD	Helpdesk
HTc	Human toxicity, cancer effects
HTn-c	Human toxicity, non-cancer effects
ILCD	International Reference Life Cycle Data System
IPCC	Intergovernmental Panel on Climate Change
IR	Ionizing radiation HH
ISO	International Organisation for Standardisation
JRC	Joint Research Centre
LCA	Life Cycle Assessment
LCDN	Life Cycle Data Network
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LCS	Life Cycle Stage
LT	Lifetime
LU	Land use change
ME	Marine eutrophication
MS	Member State
NACE	Nomenclature Générale des Activités Economiques dans les Communautés Européennes
NASS	National Agricultural Statistics Service of the United States Department of Agriculture
NDA	Non Disclosure Agreement
NE	Not evaluated / unknown
NGO	Non-Governmental Organisation
NMVOC	Non-methane volatile compounds
OD	Ozone depletion
OEF	Organisation Environmental Footprint
OEFSR	Organisation Environmental Footprint Sectorial Rule
P	Precision
PAS	Publicly Available Specification
PCF	Product Carbon Footprint
PCR	Product Category Rules
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PET	Polyethylene Terephthalate
PM	Particulate matter
POF	Photochemical ozone formation

QR	Quick Response Code
RD	Mineral, fossil & ren resource depletion
RF	Reference Flow
RM	Raw Material
RP	Representative Product
SAC	Sustainable Apparel Coalition
SB	System Boundary
SC	Steering Committee
SME	Small and Medium Enterprise
SMRS	Sustainability Measurement & Reporting System
SS	Supporting study
TAB	Technical Advisory Board
TE	Terrestrial eutrophication
TeR	Technological Representativeness
TiR	Time Representativeness
TS	Technical Secretariat
UNEP	United Nations Environment Programme
UUID	Universally Unique Identifier
WD	Water resource depletion
WMO	World Meteorological Organization
WRI	World Resource Institute

Definitions

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

Aggregated dataset - This term is defined as a life cycle inventory of multiple unit processes (e.g. material or energy production) or life cycle stages (cradle-to-gate), but for which the inputs and outputs are provided only at the aggregated level. Aggregated datasets are also called "LCI results", “cumulative inventory” or “system processes” datasets. The aggregated dataset can have been aggregated horizontally and/or

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

vertically. Depending on the specific situation and modelling choices a "unit process" dataset can also be aggregated. See Figure 1[2].

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.

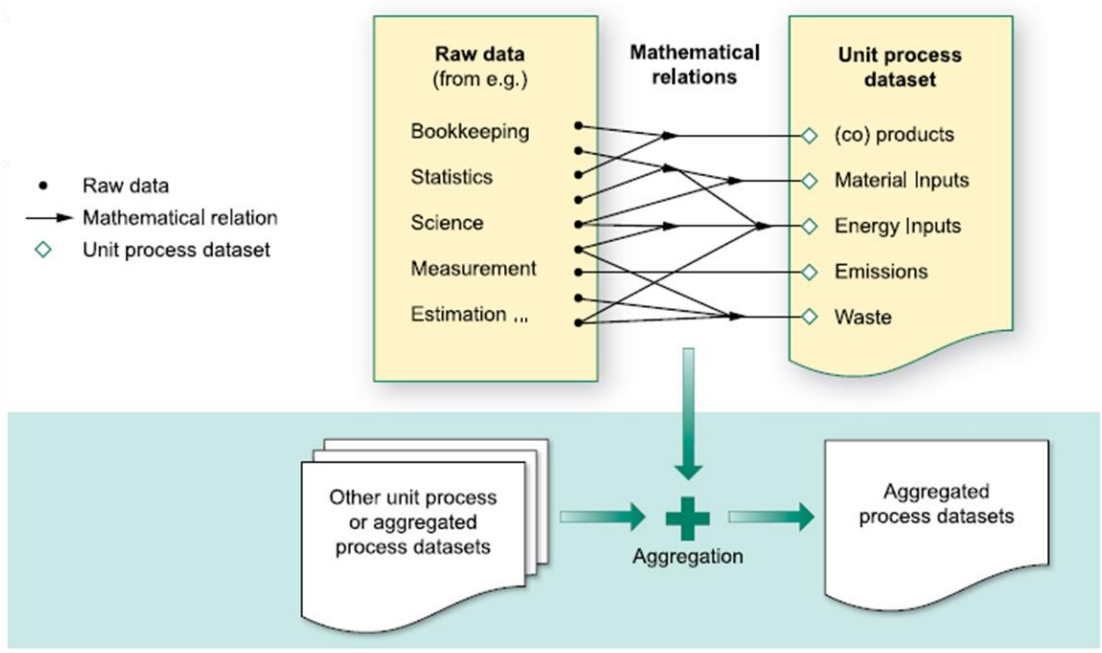

Figure 1: Definition of a unit process dataset and an aggregated process dataset

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".

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

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

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

Comparative assertion – An 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 (also named elementary flows) – All output emissions and input resource use that arise directly in the context of a process. Examples are emissions from a chemical process, or fugitive emissions from a boiler directly onsite. See Figure 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, labels, environmental product declarations, green claims, websites, 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.

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 a LCI dataset.

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

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 a LCI that contains elementary flows and activity data, and that only in combination with its complementing underlying datasets yield a complete aggregated LCI data

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

set. We refer to a partially disaggregated dataset at level 1 in case the LCI contains elementary flows and activity data, while all complementing underlying dataset are in their aggregated form (see an example in Figure 2).

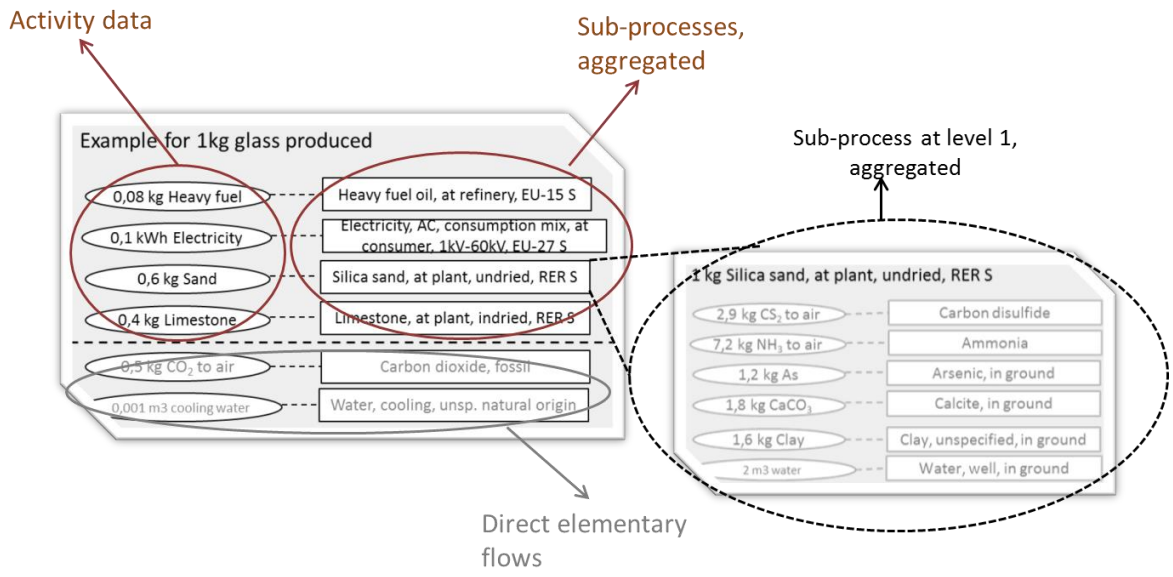

Figure 2: An example of a partially disaggregated dataset, at level 1. The activity data and direct elementary flows are to the left, and the complementing sub-processes in their aggregated form are to the right. The grey text indicates elementary flows

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 PEF Guide, PEFCR 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 the same product) or supply-chain-specific. Primary data may be obtained through meter readings, purchase records, utility bills, engineering models, direct monitoring, material/product balances, stoichiometry, or other methods for obtaining data from specific processes in the value chain of the 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 (or 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 – It is the process of restoring components to a functional and/or satisfactory state to the original specification (providing the same function), using methods such as resurfacing, repainting, etc. Refurbished products may have been tested and verified to function properly.

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

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

Secondary data[5] - It 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.

Site-specific data – It refers to directly measured or collected data from one facility (production site). It is synonymous to "primary 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 a 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 2).

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

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

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

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

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

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

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

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

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

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

1 Introduction

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

For all requirements not specified in this PEFCR the applicant shall refer to the 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

The list of the organizations in the TS at the time of final vote is provided in the Table 1.

Table 1. List of the organizations in the TS

Name of the organization	Type of organization	Participation since
ADEME	Public authorities	December 2013
Cycleco	LCA consultant TS coordinator	November 2013
Decathlon	Retailers	November 2013
Devernois	Retailers	November 2013
French Ministry for the Ecological	Public authorities	November 2013

and Inclusive Transition (MTES)		
La Redoute	Retailers	October 2014
Les Tissages de Charlieu – LTC	Producers	November 2013
Okaïdi	Retailers	February 2016
Pimkie	Retailers	November 2013
Promod	Retailers	November 2013
Swiss Federal Office of the Environment - FOEN	Public authorities	November 2013
Teintures et Apprêts Danjoux - TAD	Producers	November 2013

2.2 Consultations and stakeholders

1st stakeholders' consultation:

From 17th of February to 28th of March; Stakeholders Meeting in Brussels on 14th of March 2014

This first consultation related to the definition of the PEF product category, the scope of the PEFCR and the definition of the representative product.

Eleven written documents were received from: CIRFS, CRDC, Ministry for the Environment, Land and Sea; Republic of Italy - CO2Print LLC, The International EPD® System / Swedish Environmental Management council, Hugo Boss for Ticino SA, Lenzing AG, Belgian Directorate-General for Environment - Department of Product Policy and Chemical Substances, LTC, FPS, Euratex, Technical Helpdesk.

107 comments received.

1st Stakeholders Meeting participants:
A.I.S.E. (Valerie Sejourne)
Belgian Federal Public Service for Health & Environment (Hannelore Schorpion)
Bureau Veritas CODDE (Jessica Petit)
Business Environmental Performance Initiative (BEPI) (Stuart Harker)
CIRFS (Bernard Defraye)
Cotton Research & Development Corporation (Allan Williams)
Euratex (Adil Elmassi)
European Commission / Env. (Jiannis Kougoulis)

European Commission / Env. (Michele Galatola)
Hugo Boss (Heinz Zeller)
Hugo Boss (Michela Gioacchini)
ICAC (Jose Sette)
Inditex (Natalia Capelán Teijido)
Lenzing AG (Christian Schuster)
Ministry for the Environment, Land and Sea of the Republic of Italy (Vladimir Stefanovic)
Nike, Inc (Annette Herboth)
thinkstep (formerly known as PE International) (Diana Eggers)
thinkstep (formerly known as PE International) (Michael Spielmann)
SAC Europe (Dai Forterre)

Including members of the Technical Secretariat:
ADEME (Emilie Machefaux)
Cycleco (Gemma Fortea)
Cycleco (Jérôme Payet)
Cycleco (Sandrine Pesnel)
Decathlon (Raffaele Duby)
DETEC/FOEN (Marie-Amélie Dupraz-Ardiot)
DETEC/FOEN (Ruth Freiermuth Knuchel)
Devernois (Eric Bougard)
Les Tissages de Charlieu (Eric Boël)
MEDDE (French Environment Ministry) (Sylvain Chevassus)
Ministry of Sustainable Development (French Environment Ministry) (Jean-Paul Ventère)
Promod (Céline Rotthier)
Promod (Florence Vacheron)

2nd stakeholders' consultation:
From 10th of September to 7th of October 2015

This second consultation related to the first draft of the T-shirts PEFCR and the PEF screening report.

Eight written documents were received from: European Man-made Fibres Association (CIRFS), Cotton Research & Development Corporation (CRDC), Hugo Boss for Ticinomoda, International Wool Textile Organisation (IWTO), Lenzing AG, The Nordic Environmental Footprint group (NEF) – a Nordic Council of Ministers working party, Sustainable Apparel Coalition (SAC), thinkstep AG.

101 comments received on the PEFCR, 41 comments received on the PEF screening.

3rd stakeholders' consultation:
From 29th of July to 12th of September 2016

This third consultation related to the draft final T-shirts PEFCR.

Twelve written documents were received from: 2.-0 LCA consultants, Cotton Research & Development Corporation (CRDC), European Environmental Bureau (EEB), Hugo Boss, DG ENV – European Commission, ENEA + Italian Ministry of Environment, International Wool Textile Organisation (IWTO), maki Consulting GmbH, WL Gore & associates, Sustainable Apparel Coalition, UIT (French Textile Industry Federation), Belgium - Federal Public Service - Health, Food chain safety and Environment (SPF-BE).

184 comments received.

Review of the PEF screening:
The review of the PEF screening (model and report) was done by Ms Kirana Wolf.

Verification of the supporting study:
The supporting study made for the T-shirt n°1 (cf. Annex II) has been verified by Ernst & Young.

Web page relating to the PEFCR development:

https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/Stakeholder+workspace%3A+PEFCR+pilot+T-shirts

2.3 Review panel and review requirements of the PEFCR

The composition of the review panel is described in the Table 2.

Table 2. Members of the review panel

Name of the member	Affiliation	Role
Ugo Pretato	Studio Fieschi & soci Srl	Chair of the review panel LCA expert
Vanessa Pasquet	[avniR] Platform Quantis	LCA applied to textile specialist
Jacques Poulenard	Thaïs Quality Consulting	Industry 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, and
- 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(s) correctly describe the average product(s) sold in Europe for the product group in scope of this PEFCR.

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

The critical review report is available in Annex 3.

2.5 Geographic validity

This PEFCR is valid for products in scope sold 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.

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 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

This PEFCR relates to the T-shirts product category.

The T-shirts product category can be described as follows:
Apparel products that are fit to dress the upper body, mainly consisting of a knitted fabric (i.e. at least 51% of the product's weight), without a full-length opening (from top to bottom) at the front. Knitted fabric is produced by circular or tubular knitting with a gauge higher than 16 needles per inch and a surface density which is less than 270 g/m².

Some fashion T-shirts are composed of a woven part and a knitted part. These products are included in the product category. The 51% threshold value on the weight of knitted fabric compared to the product's weight is used to restrict the scope of the PEFCR to products mainly composed of knitted fabric. With this threshold, T-shirts are differentiated from other items composed of woven fabrics like blouses and tunics. Information on the exclusion of these products from the scope of the PEFCR is provided below.

The definition takes into account the technology used (type of knitting and gauge) and the surface density of the products so as to differentiate T-shirts from pullovers. T-shirts are produced on circular or tubular knitting, compared to pullovers which are mainly produced with flat knitting. This criterion does not exclude any T-shirts from the scope of the PEFCR. The threshold on the gauge and the surface density are also used to define a limit between T-shirts (items with low surface density, produced with a small gauge) and pullovers (items with a larger surface density, produced with a larger gauge). The value of 270 g/m² was defined according to data originating from the retailers of the Technical Secretariat and the Cotton Research & Development Corporation (CRDC) / Cotton Incorporated input.

The product category covers the following products:

- T-shirts used for sport activities,
- Singlets and other vests,
- T-shirts with long and short sleeves,
- Sleeveless T-shirts,
- Polo shirts,
- Un-printed and printed T-shirts,
- T-shirts with or without accessories (buttons, zip, strass…),
- T-shirts with or without specific treatment (moisture transfer…).

This product group excludes:

- Shirts because they have a full-length opening (from top to bottom) at the front,
- Singlets and other vests not knitted or crocheted (e.g. blouses, tunics), due to their process of production (not knitted fabric),

- Pullovers, due to their higher gauge and surface density,
- T-shirts without washing (the care label does not recommend any type of washing).

Shirts, singlets and other vests not knitted or crocheted (items composed of woven fabrics like blouses and tunics), and pullovers are excluded from the scope because they correspond to markets that are different (they are covered by other CPA codes).

Five sub-categories are considered in this product category, that is, one for each size category:

- Men T-shirts
- Women T-shirts
- Children (2 to 7 years old) T-shirts
- Children (8 to 14 years old) T-shirts
- Babies T-shirts

3.1 Product classification

The CPA code for the products included in this PEFCR is C14.14.3 “T-shirts, singlets and other vests, knitted or crocheted”.

3.2 Representative product(s)

Five representative products (one for each sub-category: Men T-shirts / Women T-shirts / Children (2 to 7 years old) T-shirts / Children (8 to 14 years old) T-shirts / Babies T-shirts) are developed to take into account the differences in weight and composition from one category to another. This point is also connected with the method used for the size management (see chapter 3.3 Functional unit and reference flow, “Weight of the T-shirt: Size management”).

These representative products characterize what is potentially sold and used on the European market. The representative products are all virtual (“average”) products. They have been defined using available market data and data relating to products specifically sold by the retailers of the Technical Secretariat.

The bill of materials of the representative products can be found in Table 3. It takes into account the textile-made part of the product (composed of cotton, polyester, viscose…) and the accessories that remain on the T-shirt (i.e. buttons, zips, strass, care label…).

Table 3. Bill of materials of the representative products [1]

Materials *	**Men T-shirts**	**Women T-shirts**	**Children (2 to 7 years old) T-shirts**	**Children (8 to 14 years old) T-shirts**	**Babies T-shirts**
	g / 1 T-shirt				
Cotton	122,25	114,55	76,05	99,15	71,59
Polyester	25,30	23,71	15,74	20,52	0

Viscose	3,01	2,82	1,87	2,44	0
Polyamide	2,76	2,59	1,72	2,24	0
Polypropylene	2,02	1,89	1,25	1,64	0
Acrylic	1,54	1,45	0,96	1,25	0
Wool	0,87	0,82	0,54	0,71	0
Elastane	0,40	0,37	0,25	0,32	0
Chlorofibre	0,34	0,32	0,21	0,28	0
Flax	0,12	0,11	0,08	0,10	0
Hemp	0,07	0,07	0,04	0,06	0
Silk	0,08	0,08	0,05	0,07	0
Brand tag	0,25	0,25	0,25	0,25	0,25
Care label	0,60	0,60	0,60	0,60	0,60
Buttons	0,14	0,14	0,14	0,14	2,57
Zips	0,25	0,25	0,25	0,25	-
Strass	0,001	0,001	0,001	0,001	-
Total weight	**160 g**	**150 g**	**100 g**	**130 g**	**75 g**

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 “To wear a clean T-shirt until it becomes dirty 52 times”. Table 4 defines the key aspects used to define the FU.

Table 4. Key aspects of the FU

What?	T-shirt The T-shirt description is available in the part “3 PEFCR scope”.
How much?	1 T-shirt
How well?	Wearing a clean T-shirt until it becomes dirty
How long?	52 times

The criterion "how long" has an influence on the environmental impact of the use stage. The impact of the use stage is proportional to the number of use of an article, that is, the more the article is worn, the more the use stage is impacting.

This functional unit enables to compare the different T-shirts based on the function brought by the product. It covers the entire category of the products investigated.

The reference flow is the amount of product needed to fulfil the defined function and shall be 1 single T-shirt. All quantitative input and output data collected in the study shall be calculated in relation to this reference flow.

Weight of the T-shirt: Size management

Different T-shirt sizes can be found on the market. To ease their calculation, environmental impacts are provided to customers for one and only reference size (identified according to the article). T-shirts weight is considered as primary data (specific data for each article). As an example, the environmental impacts of a woman T-shirt are provided for a 92-95 cm chest size only, instead of providing different environmental impacts for the chest 80-83, 84-87, 88-91, 92-95 and 96-99.
The weight of the T-shirt is equal to the weight of the finished product. It includes the textile-made part of the product and all non-removable accessories such as buttons, zips, strass, care label… It does not include accessories which are removed before wearing the T-shirt such as price tag, cardboard brand tag...

Table 5. Reference sizes

Type of article	EU Standard
Men	Chest size: 97-104 cm [a]
Women	Chest size: 92-95 cm [a]
Children (2 to 7 years old)	Height: 98-104 cm [b]
Children (8 to 14 years old)	Height: 135-140 cm [b]
Babies	Height: 71-76 cm
Information originating from: [a] French measurement campaign, IFTH, 2006 [b] ADEME-AFNOR, "Clothing" PCR, 2013	

A T-shirts size chart is provided below [11]:

Men

Chest (cm)	73-80	81-88	89-96	**97-104**	105-112	113-120	121-128	129-136

Women

Chest (cm)	76-79	80-83	84-87	88-91	**92-95**	96-99	100-103	continued below…

Chest (cm)	…	104-107	108-113	114-119	120-125	126-131	132-137

Children (from 2 to 7 years old)

Height (cm)	83-89	90-97	**98-104**	105-110	111-116	117-122

Children (from 8 to 14 years old)

Height (cm)	123-128	129-134	**135-140**	141-146	147-152	153-164

Babies

Height (cm)	47-50	51-55	56-63	64-70	**71-76**	77-82

Retailers usually only know the weight of the prototype. The size of a prototype can be different from one company to another, and can therefore be different from the reference size. Should this be the case, the weight of the prototype is rectified using a ±5% default value correction factor when moving from one size interval to another (see Figure 3). The default value can be replaced by primary data.

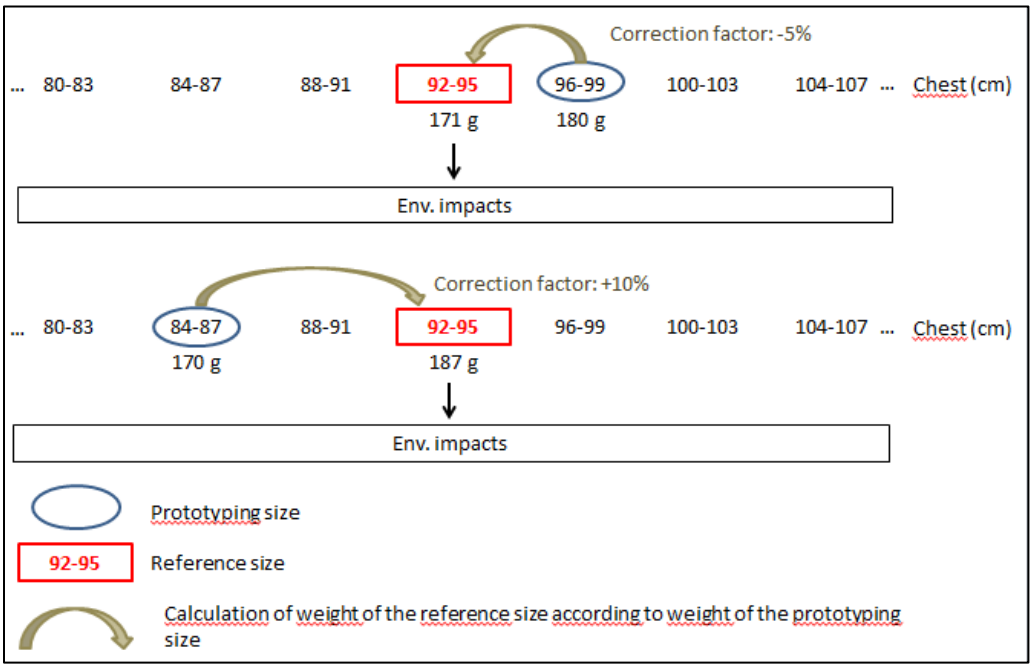

Figure 3. Examples to explain the use of the reference size and the correction factor

Example 1: A women's T-shirt has a weight of 190 g for a 92-95 cm prototype chest size. The prototype size is also the reference size. In this case, the t-shirt's environmental impacts shall be calculated based on 190 g.

Example 2: A women's T-shirt has a weight of 180 g for a 96-99 cm prototype chest size. In this case, the t-shirt's environmental impacts shall be calculated based on 171 g (180 - 180 x 5/100) (cf. Figure 3 - Example n°1).

Example 3: A women's T-shirt has a weight of 170 g for a 84-87 cm prototype chest size. In this case, the t-shirt's environmental impacts shall be calculated based on 187 g (170 + 170 x 10/100) (cf. Figure 3 - Example n°2).

The 5% correction factor is an average value based on measurements performed by the members of the Technical Secretariat (cf. Annex 4). It is also used in the BP X30-323-23: General principles for an environmental communication on mass market products Part 23: Methodology for the environmental impacts assessment of clothing [8].

Note: Why is it not appropriate to consider a single standard T-shirt?

- The calculation of impacts for a single 'standard' T-shirt can be confusing for the consumer. A babies T-shirt would present impacts close to a men T-shirt. This can cause a misunderstanding.
- As the weight of the reference size is not always known by the retailers, a method is proposed to correct the weight of T-shirts. The adjustment by weight is based on classification of the T-shirts according to the sizes (source: European Standard, Size designation of clothes — Part 3: Measurements and intervals, 1803 prEN 13402-3:2011), and the size is expressed for the chest or the height depending on the product category. According to the European Standard, at least 3 sizes are necessary (men, women and children/babies).

3.4 System boundary

Figure 4 shows the system boundary diagram with the cradle-to-grave system boundary (simplified), the processes for which some primary activity data is required (mandatory company-specific data) and company access to primary data. In practice, access to primary data may be very different from one company to another. This difference is particularly significant as far as the T-shirt production stage is concerned.

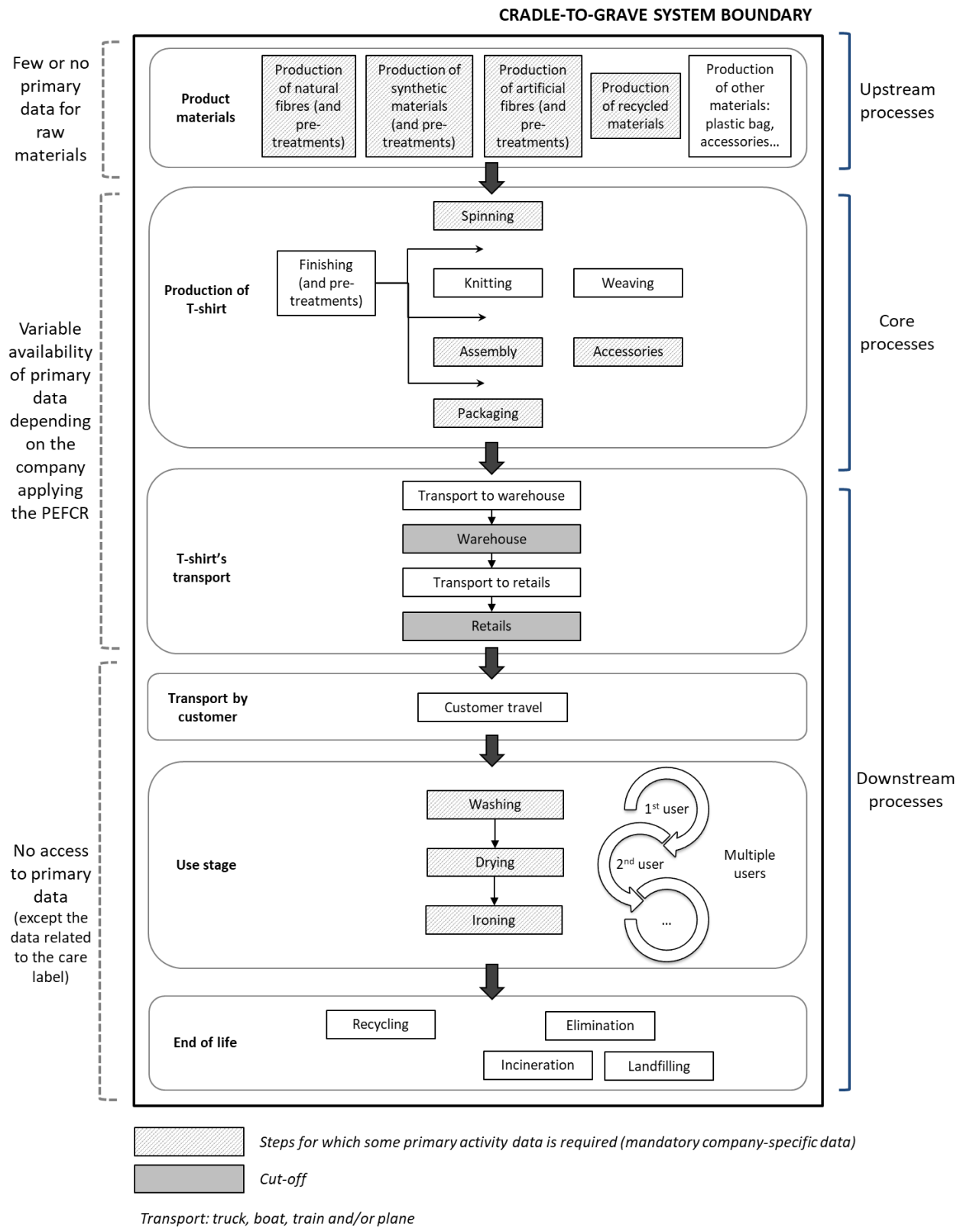

Figure 4. Product system with system boundary

The Product Environmental Footprint of a T-shirt shall be based on a "cradle-to-grave" analysis. The cradle-to-grave system shall start when resources are extracted from nature and end when the product is treated during the end-of-life after its use phase.

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

Table 6. Life cycle stages

Life cycle stage	**Short description of the processes included**
Production of materials	This LCS covers the production of textile raw materials, and the production of other materials (packaging and accessories). The production of textile raw materials consists of the production or extraction of raw materials (breeding, husbandry, crop cultivation, fossil resources, wood…). This step also includes the preparation of fibres (e.g. wool scouring). Bleaching of natural fibres is taken into account at this stage. The following raw materials are covered by the PEFCR: cotton, polyester, viscose, polyamide, polypropylene, acrylic, wool, elastane, chlorofibre, flax... The exhaustive list of textile raw materials is available in the Table 31. It is a closed list. This list of raw materials used to produce T-shirts has been identified during the definition of the representative product. Other materials could be added during revision of the PEFCR. The blends and single-material textiles are covered by the PEFCR.
Production of T-shirts	The production of T-shirts comprises the following processes: - Production of yarn through spinning (production of yarn with staple fibres) or production of filament yarns, Please note that texturizing, thermofixation and scouring of the synthetic fibres are taken into account during the spinning process. - Knitting (production of knitted fabric), - Weaving (production of woven fabric), - Finishing (treatment of a textile product: dyeing, printing…) which occurs at different production stages: e.g. dyeing may be performed on yarn or on fabric. The following processes are included in this stage: desizing, softening, singeing (in case of printing process) and heat-setting, - Assembly which includes cutting, sewing (composition and care labels, brand tag and accessories such as buttons, zip, strass or snaps sewn on the T-shirt), ironing, trimming, folding and all production steps occurring prior to packaging,

	- Packaging of the final product (primary, secondary and/or tertiary packaging), - Transportation between production stages: transportation occurs after raw material production and in-between production processes. Wastewater treatment, textile production waste management and end-of-life of secondary/tertiary packaging are taken into account. All processes, such as sizing for example, required/used to produce the final product shall be modelled in the study.
Distribution / T-shirts' transport	The T-shirt's transport consists of the transport between the assembly factory and the stores or the delivery points via warehouses. Warehouses and retails (stores or delivery points) fall under the cut-off so they are not modelled.
Distribution / Transport by customer	The customer travel is customers' round trip from his/her home to the stores or the delivery points. The transportation modes taken into account are: car, scooter, bicycle, public transports (such as tram and bus), walking and home/pick-up point delivery.
Use stage	The use stage comprises three processes: washing, drying and ironing.
End-of-life stage	The end-of-life stage includes the i. recycling and disposal (incineration or landfilling) of the T-shirts, ii primary packagings' end-of-life (transportation from consumer house to textile recycling center, transportation from textile recycling center to incineration and landfill sites including polypropylene garbage bags).

According to the PEF guidance 6.3, the T-shirt's transport and the transport by customer are part of the "Distribution" LCS. The TS decided to separate these two steps as they concern two different actors. The remodelling of the benchmark was also performed by distinguishing the two life cycle stages.

According to this PEFCR, the following processes shall be excluded based on the cut-off rule*:* the warehouse (distribution center), the retail place, employee-related activities such as travels, meals, business trips, water (tap water, toilets) and the transport between different users during the use phase.

The production and the end-of-life of the washing machine, the tumble drier and the ironing machine are excluded based on the paragraph 7.17 "Use stage modelling" in the PEFCR Guidance [33]. These processes are product dependent but not most relevant. According to the Table 27 of the PEFCR Guidance, their modelling is optional. They are not taken into account in this PEFCR.

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

Impact category	Indicator	Unit	Recommended default LCIA method
Climate change [6]	Radiative forcing as Global Warming Potential (GWP100)	kg $CO_{2\ eq}$	Baseline model of 100 years of the IPCC (based on IPCC 2013)
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 $_{eq}$	Steady-state ODPs 1999 as in WMO assessment
Human toxicity, cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al, 2008)
Human toxicity, non-cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al, 2008)
Particulate matter	Impact on human health	disease incidence	UNEP recommended model (Fantke et al 2016)
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq U^{235} $_{eq}$	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC $_{eq}$	LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe
Acidification	Accumulated Exceedance (AE)	mol H^+ $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P $_{eq}$	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N $_{eq}$	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Ecotoxicity, freshwater*	Comparative Toxic Unit for ecosystems (CTU_e)	CTUe	USEtox model, (Rosenbaum et al, 2008)

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

Impact category	Indicator	Unit	Recommended default LCIA method
Land use	• Soil quality index[7] • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Dimensionless (pt) • kg biotic production[8] • kg soil • m^3 water • m3 groundwater	• Soil quality index based on LANCA (EC-JRC)[9] • 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.xhtml

3.6 Limitations

The lack of the assessment of biodiversity impacts is a limitation of the PEFCR (cf. 7.4 Additional environmental information). Biodiversity is relevant, and should in principle be considered as additional environmental information. However, the suggested approaches in PEFCR guidance v6.3 are difficult to implement in the textile sector.

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

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

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

Life span

The life span of the studied T-shirt corresponds to the number of washes tolerated by the T-shirt. Life span is an important parameter when the environmental impacts of products are studied with Life Cycle Assessment [2, 3]. Some studies were done to evaluate the life span of products thanks to the measurement of technical properties (e.g. abrasion resistance, colour durability…) [4, 5, 6]. This subject was also discussed for the calculation of the environmental footprint for textile products, and no method has been defined yet to quantify the life span of textile items and T-shirts in particular [7, 8, 9]. As this parameter has an important influence on the environmental impacts of products, it is necessary to control it in term of certification / validation aspects (to avoid allegations). In the absence of a method allowing to quantify it [1, 10], it is not possible to introduce a variable life span in the PEFCR. Therefore the PEFCR relies on a standard (typical) life span and assumes that T-shirts have a standard life span of 52 washes [1]. During the revision of the PEFCR (after the expiry date), it will be necessary to check whether a method allowing to quantify the lifetime exists. Should this be the case, a variable lifetime might be used in the PEFCR.

The use of a standard life span is a limitation of the study as some T-shirts may have a shorter or a longer lifespan than 52 washes, for example with different raw materials or different production processes. An increase in the lifetime results in a reduction in the environmental impacts resulting from the production (steps before the use stage) and the end-of-life. For example for a T-shirt with a lifetime three times longer, the impact of the production and the end-of-life will be divided by three (all other things being equal). The impact of the use phase remains the same. The most affected life cycle stages are the raw materials production and the T-shirt production. All environmental indicators are concerned. However, the influence is limited for the indicator "Ionizing radiations" which is mainly dominated by the use stage.

Guidance on comparison and comparative assertion

For any T-shirt, comparison or comparative assertion can be made against the benchmark (corresponding representative product), or between T-shirts belonging to the same representative product. However, there is a restriction: the PEFCR assumes an identical life span for all items.

4 Most relevant impact categories, life cycle stages and processes

The most relevant impact categories for the sub-category Men T-shirts in scope of this PEFCR are the following:

- Acidification terrestrial and freshwater
- Climate Change [6]
- Resource use, energy carriers
- Respiratory inorganics
- Water scarcity

- Freshwater eutrophication
- Marine eutrophication

The most relevant impact categories for the sub-category Women T-shirts in scope of this PEFCR are the following:

- Acidification terrestrial and freshwater
- Climate Change [6]
- Resource use, energy carriers
- Respiratory inorganics
- Water scarcity
- Freshwater eutrophication
- Marine eutrophication

The most relevant impact categories for the sub-category Children (2 to 7 years old) T-shirts in scope of this PEFCR are the following:

- Acidification terrestrial and freshwater
- Climate Change [6]
- Resource use, energy carriers
- Respiratory inorganics
- Water scarcity
- Freshwater eutrophication
- Marine eutrophication

The most relevant impact categories for the sub-category Children (8 to 14 years old) T-shirts in scope of this PEFCR are the following:

- Acidification terrestrial and freshwater
- Climate Change [6]
- Resource use, energy carriers
- Respiratory inorganics
- Water scarcity
- Freshwater eutrophication
- Marine eutrophication

The most relevant impact categories for the sub-category Babies T-shirts in scope of this PEFCR are the following:

- Acidification terrestrial and freshwater
- Climate Change [6]
- Resource use, energy carriers
- Resource use, mineral and metals

- Respiratory inorganics
- Water scarcity
- Freshwater eutrophication
- Marine eutrophication

The most relevant life cycle stages for the sub-category Men T-shirts in scope of this PEFCR are the following:

- LCS1-Production of material
- LCS2-Production of T-shirt
- LCS5-Use stage

The most relevant life cycle stages for the sub-category Women T-shirts in scope of this PEFCR are the following:

- LCS1-Production of material
- LCS2-Production of T-shirt
- LCS5-Use stage

The most relevant life cycle stages for the sub-category Children (2 to 7 years old) T-shirts in scope of this PEFCR are the following:

- LCS1-Production of material
- LCS2-Production of T-shirt
- LCS4-Transportation by customer
- LCS5-Use stage

The most relevant life cycle stages for the sub-category Children (8 to 14 years old) T-shirts in scope of this PEFCR are the following:

- LCS1-Production of material
- LCS2-Production of T-shirt
- LCS4-Transportation by customer
- LCS5-Use stage

The most relevant life cycle stages for the sub-category Babies T-shirts in scope of this PEFCR are the following:

- LCS1-Production of material
- LCS2-Production of T-shirt
- LCS4-Transportation by customer
- LCS5-Use stage

The most relevant processes for the sub-category Men T-shirts are the following:

Table 8. List of the most relevant processes for the sub-category Men T-shirts

Impact category	Processes	% Contribution
Acidification terrestrial and freshwater	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	24,6
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	6,8
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	4,7
	GLO: Circular knitting (from LCS2-Production of T-shirt)	5,1
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	11,3
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	3,9
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	14,2
	GLO: Passenger car, average (from LCS4-Transportation by customer)	7,2
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	4,0
Climate Change	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	23,7
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	5,0
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	3,3
	GLO: Circular knitting (from LCS2-Production of T-shirt)	3,6
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	10,7
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	3,9
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	9,1
	GLO: Passenger car, average (from LCS4-Transportation by customer)	13,6
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	7,9
Resource use, energy carriers	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	21,7
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,2
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	2,9
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	12,8
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	4,6

	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	10,3
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Drying)	2,4
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	8,4
	GLO: Passenger car, average (from LCS4-Transportation by customer)	13,6
Respiratory inorganics	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	23,5
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	14,0
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	8,6
	GLO: Spinning, production of polyester filament (from LCS2-Production of T-shirt)	4,5
	GLO: Circular knitting (from LCS2-Production of T-shirt)	7,2
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	11,0
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	14,2
Water scarcity	EU-28+3: Tap water (from LCS5-Use stage)	30,0
	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	58,3
Freshwater eutrophication	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	5,0
	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	75,7
Marine eutrophication	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	25,8
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,5
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	3,4
	GLO: Circular knitting (from LCS2-Production of T-shirt)	4,0
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	8,1
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	2,9
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	9,4
	GLO: Passenger car, average (from LCS4-Transportation by customer)	11,0
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	3,5
	EU-28+EFTA: Treatment of residential wastewater, small plant (from LCS5-Use stage)	7,6

The most relevant processes for the sub-category Women T-shirts are the following:

Table 9. List of the most relevant processes for the sub-category Women T-shirts

Impact category	Processes	% Contribution
Acidification terrestrial and freshwater	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	24,3
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	6,7
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	4,7
	GLO: Circular knitting (from LCS2-Production of T-shirt)	5,0
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	11,2
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	3,9
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	14,1
	GLO: Passenger car, average (from LCS4-Transportation by customer)	7,6
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	4,2
Climate Change	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	23,2
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,9
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	3,2
	GLO: Circular knitting (from LCS2-Production of T-shirt)	3,5
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	10,5
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	3,8
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	8,9
	GLO: Passenger car, average (from LCS4-Transportation by customer)	14,2
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	8,3
Resource use, energy carriers	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	21,3
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,1
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	2,9
	GLO: Circular knitting (from LCS2-Production of T-shirt)	3,2
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	12,6
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	4,5
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	8,2

	GLO: Passenger car, average (from LCS4-Transportation by customer)	14,2
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	10,8
Respiratory inorganics	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	23,4
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	13,9
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	14,2
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	11,0
	GLO: Circular knitting (from LCS2-Production of T-shirt)	7,1
	GLO: Spinning, production of polyester filament (from LCS2-Production of T-shirt)	4,4
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	8,5
Water scarcity	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	56,8
	EU-28+3: Tap water (from LCS5-Use stage)	31,2
Freshwater eutrophication	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	75,5
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	4,9
Marine eutrophication	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	25,3
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,4
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	3,4
	GLO: Circular knitting (from LCS2-Production of T-shirt)	3,9
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	7,9
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	2,8
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	9,2
	GLO: Passenger car, average (from LCS4-Transportation by customer)	11,5
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	3,6
	EU-28+EFTA: Treatment of residential wastewater, small plant (from LCS5-Use stage)	8,0

The most relevant processes for the sub-category Children (2 to 7 years old) T-shirts are the following:

Table 10. List of the most relevant processes for the sub-category Children (2 to 7 years old) T-shirts

Impact category	Processes	% Contribution
Acidification terrestrial and freshwater	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	22,9
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	6,3
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	4,4
	GLO: Circular knitting (from LCS2-Production of T-shirt)	4,7
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	10,5
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	3,6
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	13,3
	GLO: Passenger car, average (from LCS4-Transportation by customer)	10,7
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	3,7
Climate Change	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	21,3
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,5
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	3,0
	GLO: Circular knitting (from LCS2-Production of T-shirt)	3,3
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	3,5
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	8,2
	GLO: Passenger car, average (from LCS4-Transportation by customer)	19,6
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	7,1
	EU-28+EFTA: Treatment of residential wastewater, small plant (from LCS5-Use stage)	2,5
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	9,6
Resource use, energy carriers	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	19,5
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	3,8
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	2,6
	GLO: Circular knitting (from LCS2-Production of T-shirt)	2,9
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	11,5

	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	4,1
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	7,5
	GLO: Passenger car, average (from LCS4-Transportation by customer)	19,6
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	9,3
Respiratory inorganics	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	22,9
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	13,6
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	8,3
	GLO: Spinning, production of polyester filament (from LCS2-Production of T-shirt)	4,3
	GLO: Circular knitting (from LCS2-Production of T-shirt)	7,0
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	10,8
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	13,9
Water scarcity	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	57,8
	EU-28+3: Tap water (from LCS5-Use stage)	29,8
Freshwater eutrophication	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	75,6
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	4,9
Marine eutrophication	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	23,2
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,0
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	3,1
	GLO: Circular knitting (from LCS2-Production of T-shirt)	3,6
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	7,3
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	8,5
	GLO: Cargo plane (from LCS3 - T-shirt's transport)	3,4
	GLO: Transoceanic ship, containers (from LCS3 - T-shirt's transport)	2,6
	GLO: Passenger car, average (from LCS4-Transportation by customer)	15,9
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	3,1
	EU-28+EFTA: Treatment of residential wastewater, small plant (from LCS5-Use stage)	6,9

The most relevant processes for the sub-category Children (8 to 14 years old) T-shirts are the following:

Table 11. List of the most relevant processes for the sub-category Children (8 to 14 years old) T-shirts

Impact category	Processes	% Contribution
Acidification terrestrial and freshwater	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	25,1
	GLO: Wool fibres (from LCS1-Production of material)	2,1
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	6,9
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	4,8
	GLO: Spinning, production of polyester filament (from LCS2-Production of T-shirt)	1,8
	GLO: Circular knitting (from LCS2-Production of T-shirt)	5,2
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	11,5
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	4,0
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	4,7
	GLO: Transoceanic ship, containers (from LCS3 - T-shirt's transport / Transport to warehouse)	1,8
	GLO: Passenger car, average (from LCS4-Transportation by customer)	9,0
	EU-28: Electricity grid mix ts (from LCS5-Use stage / Washing)	4,6
Climate Change	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	22,7
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,8
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	3,2
	GLO: Circular knitting (from LCS2-Production of T-shirt)	3,5
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	10,2
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	3,7
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	8,7
	GLO: Passenger car, average (from LCS4-Transportation by customer)	16,1
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	7,6
Resource use, energy carriers	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	20,8
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,0

	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	2,8
	GLO: Circular knitting (from LCS2-Production of T-shirt)	3,1
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	12,3
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	4,4
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	8,0
	GLO: Passenger car, average (from LCS4-Transportation by customer)	16,0
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	10,0
Respiratory inorganics	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	25,9
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	15,4
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	9,4
	GLO: Spinning, production of polyester filament (from LCS2-Production of T-shirt)	4,9
	GLO: Circular knitting (from LCS2-Production of T-shirt)	7,8
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	12,2
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	4,3
	GLO: Passenger car, average (from LCS4-Transportation by customer)	3,4
Water scarcity	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	57,9
	EU-28+3: Tap water (from LCS5-Use stage)	30,0
Freshwater eutrophication	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	75,7
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	5,0
Marine eutrophication	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	24,7
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,3
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	3,3
	GLO: Circular knitting (from LCS2-Production of T-shirt)	3,8
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	7,7
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	2,7
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	9,0
	GLO: Cargo plane (from LCS3 - T-shirt's transport)	2,8
	GLO: Passenger car, average (from LCS4-Transportation by customer)	13,0

	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	3,4
	EU-28+EFTA: Treatment of residential wastewater, small plant (from LCS5-Use stage)	7,4

The most relevant processes for the sub-category Babies T-shirts are the following:

Table 12. List of the most relevant processes for the sub-category Babies T-shirts

Impact category	Processes	% Contribution
Acidification terrestrial and freshwater	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	26,6
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	7,3
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	5,1
	GLO: Circular knitting (from LCS2-Production of T-shirt)	4,2
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	9,4
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	11,9
	GLO: Passenger car, average (from LCS4-Transportation by customer)	13,3
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	3,5
Climate Change	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	24,2
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	5,1
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	3,4
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	8,4
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	3,0
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	7,2
	GLO: Passenger car, average (from LCS4-Transportation by customer)	23,8
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	6,5
Resource use, energy carriers	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	22,6
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,4
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	10,3
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	3,6
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	6,7

	GLO: Passenger car, average (from LCS4-Transportation by customer)	24,0
	EU-28+3: Electricity grid mix 1kV-60kV (from LCS5-Use stage / Washing)	8,6
Resource use, mineral and metals	GLO: Metal snaps (from LCS1-Production of material)	29,7
	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	28,0
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	18,1
	GLO: Yarn dyeing (from LCS2-Production of T-shirt)	6,3
Respiratory inorganics	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	28,2
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	16,7
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	10,3
	GLO: Circular knitting (from LCS2-Production of T-shirt)	6,6
	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	10,2
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	13,2
Water scarcity	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	63,2
	EU-28+3: Tap water (from LCS5-Use stage)	26,0
Freshwater eutrophication	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	77,0
	GLO: Metal snaps (from LCS1-Production of material)	5,5
Marine eutrophication	GLO: Fabric dyeing (from LCS2-Production of T-shirt)	6,4
	GLO: Cotton fibres (conventional) (from LCS1-Production of material)	26,5
	GLO: Spinning, production of cotton yarn (combed) (from LCS2-Production of T-shirt)	4,6
	GLO: Spinning, production of cotton yarn (carded) (from LCS2-Production of T-shirt)	3,5
	GLO: T-shirt assembly (from LCS2-Production of T-shirt)	7,4
	GLO: Cargo plane (from LCS3 - T-shirt's transport)	4,1
	GLO: Transoceanic ship, containers (from LCS3 - T-shirt's transport)	3,2
	GLO: Passenger car, average (from LCS4-Transportation by customer)	19,3
	EU-28+EFTA: Treatment of residential wastewater, small plant (from LCS5-Use stage)	6,3

When a textile raw material, a spinning process or a dyeing process is identified as relevant, all the processes of the category need to be considered as relevant. The three categories are described in the Table 13. For example, when the process "GLO: Cotton fibres (conventional)" is identified as relevant for a representative

product, all the textile raw materials are considered as relevant for the PEF studies. Thus, if a 100% polyester T-shirt is studied, the production of polyester is a most relevant process. Another example, when the process "GLO: Fabric dyeing" is identified as relevant for a representative product, the processes "yarn dyeing" and "apparel dyeing" are also considered as relevant for the PEF studies.

Table 13. Description of the categories

Textile raw material
Production of conventional cotton fibres (GLO)
Production of organic cotton fibres (GLO)
Production of polyester granulates (GLO)
Production of polyester fibres (GLO)
Production of viscose fibres (GLO)
Production of polyamide 6.6 fibres (GLO)
Production of polypropylene fibres (GLO)
Production of acrylic fibres (GLO)
Production of sheep wool fibres (GLO)
Production of elastane (GLO)
Production of chlorofibre fibres (GLO)
Production of flax fibres (GLO)
Production of silk (cocoon) (GLO)
Production of hemp fibres (GLO)

Spinning process
Spinning, production of cotton yarn, carded process
Spinning, production of cotton yarn, combed yarn
Spinning, production of polyester filament
Spinning, production of yarn (produced with staple fibres) for synthetic fibres (polyester, polyamide, polypropylene, chlorofibre, acrylic)
Spinning, production of viscose yarn
Spinning, production of wool yarn, carded process
Spinning, production of wool yarn, combed yarn
Spinning, production of elastane filament
Spinning, production of flax yarn
Spinning, production of silk yarn
Spinning, production of hemp yarn

Dyeing process
Yarn dyeing
Fabric dyeing
Apparel dyeing

5 Life cycle inventory

All newly created processes shall be EF-compliant, as defined in the PEFCR guidance this document is conform with.

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.

Sampling procedure

According to the PEFCR guidance (paragraph 7.5 "Sampling procedure"), the following procedure shall be applied in order to select a representative sample as a stratified sample (some examples are provided in the guidance) [33]:

- Step 1: define the population
- Step 2: define homogenous sub-populations (stratification)
- Step 3: define the sub-samples at sub-population level
- Step 4: define the sample for the population starting from the definition of sub-samples at sub-population level.

For the step 2, the aspects that shall be taken into consideration when identifying the sub-populations are:

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

For the step 3, the approach based on the total production of the sub-population (first approach) shall be used to define the size of sub-samples at sub-population level in case the applicant needs a sampling procedure. The percentage of production to be covered by each sub-population is 50%, expressed in the relevant unit. The unit of measure for the production is described in the Table 14.

Table 14. Units of measure

Process	Unit of measure
Spinning	Mass
Sizing	Mass
Knitting	Mass
Dyeing	Mass
Printing	Area
Finishing	Mass
Assembly	Mass

For the step 4, the representative sample of the population corresponds to the sum of the sub-samples at sub-population level [33].

The following information shall be described in the EF report: description of the population and of the selected sample used for the EF study (% of the total production).

Supply chain (producing countries and transport)

The identification of the countries of production shall be carried taking into account at least 70% of the production (main production and restocking), based on the overall order that is placed.

5.1 List of mandatory company-specific data

The Table 15 identifies the processes for which company-specific information is mandatory and, for each process, the list of the activity data to be used in the calculations.

Table 15. List of mandatory processes and activity data to be used in the calculations

Mandatory processes	Activity data to be used in the calculations
-	- Weight of T-shirt (primary data or calculated data based on primary data) - Textile material input and output for each process (calculated data based on the weight of the T-shirt's textile portion (for the reference size) and residual textile losses for each process[10])
Textile raw materials production	- % of each raw material in the final product - % of recycled material (R1) - raw material type (select the appropriate raw material)
Spinning	- Technology (depending on raw materials AND spinning technology: carded, combed, open-end, filament, staple fibres) - Production location (choice of the continent)
Printing	- Printed surface
Finishing	- Type of finishing (if relevant)
Accessories	- Quantity of material - Type of material (composition label, brand tag, button, zip, strass, snaps)
Packaging	- Quantity of material - Type of packaging (primary, secondary or tertiary, choose accordingly) - Type of material (composition in case of material mixing)
Assembly	- Assembly time - Use of ironing: yes or no

[10] Explanations on the calculations are available in the chapter 6.2 Manufacturing / paragraph "Calculation of quantities according to waste"

	- Country of production (choice of electricity LCI dataset)
Washing	- Type of washing (machine washing or handwashing) - Washing machine cycle (gentle or normal) - Washing temperature
Drying	- Use of tumble drier is allowed: yes or not
Ironing	- Ironing is allowed: yes or not - Ironing temperature (iron setting)

Note: for the assembly process, there are two options to identify the countries of production:

- Option 1: the entire production of the article is taken into account
- Option 2: the company implementing the PEFCR can choose to go into more detail when identifying production countries (for example: distinguishing restocking of the first supply, or consider only the products sold in Europe).

Note: for the spinning process, the technology and the production location are required to have a better knowledge of this step. Based on these data, it will be possible to make a precise estimation of the electricity consumption for spinning with the most accurate selection of the corresponding dataset for the process. Spinning is a process which occurs at the early beginning of the production for which it is difficult to have primary data on electricity consumption and countries of production. The difference in spinning technology is the main driver of the differences in electricity consumption. The variability of electricity consumption within a technology is small. That's why the data collection is about the technology and the production location. On the short term, the production location will be identified by continent. In a mid-term perspective (next revision of the PEFCR), the aim is to identify the production location at the country level.

See excel file named "[T-shirts PEFCR_version 1] - Life cycle inventory" for the list of all company-specific data to be collected, downloadable at: http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm.

5.2 List of processes expected to be run by the company

The following processes are expected to be run by the company applying the PEFCR:

- Spinning, production of cotton yarn, carded process
- Spinning, production of cotton yarn, combed yarn
- Spinning, production of polyester filament
- Spinning, production of yarn (produced with staple fibres) for synthetic fibres (polyester, polyamide, polypropylene, chlorofibre, acrylic)
- Spinning, production of viscose yarn
- Spinning, production of wool yarn, carded process
- Spinning, production of wool yarn, combed yarn
- Spinning, production of elastane filament
- Spinning, production of flax yarn

- Spinning, production of silk yarn
- Spinning, production of hemp yarn
- Sizing for natural yarn
- Sizing for synthetic yarn
- Knitting
- Weaving
- Non-woven fabric
- Yarn dyeing
- Fabric dyeing
- Apparel dyeing
- Fix-washed printing
- Pigment printing
- Anti-bacterial finishing
- Stain resistant finishing
- Assembly

Depending of the company achieving the PEF study, one or several production processes are expected to be run by the company (examples are presented in Annex 5).

The information to be collected in situation 1 is detailed in the associated excel file (e.g. activity data, datasets to be used). In the excel file are also the DQRs of the EF-compliant datasets embedded.

For all activity data, the frequency of measurement is 1 year average.

See excel file named "[T-shirts PEFCR_version 1] - Life cycle inventory" for the list of all processes to be expected in situation 1, downloadable at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm.http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm

The data collection requirements for knitting and dyeing processes are provided as examples in the Table 16, Table 17 and Table 18.

Table 16. Data collection requirements for knitting process

Requirements for data collection purposes		**Requirements for modelling purposes**								**Remarks**
Activity data to be collected	*Unit of measure*	*Default dataset to be used*	*Dataset source (i.e. node)*	*UUID*	*TiR*	*GR*	*TeR*	*P*	*DQR*	
Inputs:										
Electricity consumption (medium voltage)	MJ/kg	See part "Electricity" (residual grid mix) in the excel file								

Outputs:			
Textile waste	%	See Table 34 "End of life of production waste (capitals indicate those processes expected to be run by the company)" in the PEFCR	

Table 17. Data collection requirements for dyeing process

Requirements for data collection purposes		**Requirements for modelling purposes**								**Remarks**
Activity data to be collected	*Unit of measure*	*Default dataset to be used*	*Dataset source (i.e. node)*	*UUID*	*TiR*	*GR*	*TeR*	*P*	*DQR*	
Inputs:										
Technology: natural or synthetic fibre desizing	*Choice between natural or synthetic fibre desizing*	Desizing for natural fibres	Data gap (cf. 5.3 Data gaps section)							
		Desizing for synthetic fibres	Data gap (cf. 5.3 Data gaps section)							
Electricity consumption (medium voltage)	MJ/kg	See part "Electricity" (residual grid mix) in the excel file								
Heat consumption (heat from coal)	MJ/kg	Please use the most appropriate regional EF-compliant dataset								
Heat consumption (heat from biomass)	MJ/kg	Please use the most appropriate regional EF-compliant dataset								
Heat consumption (heat from heavy fuel oil)	MJ/kg	Please use the most appropriate regional EF-compliant dataset								
Heat consumption (heat from natural gas)	MJ/kg	Please use the most appropriate regional EF-compliant dataset								
Water consumption	L/kg	EU-28+3: Tap water	https://lcdn.quantis-software.com/PEF/	212b8494-a769-4c2e-8d82-9a6ef61baad7	2,42	2,025	2,038	2,02	2,126	
Dyeing technology type (chemical consumption)	*Choice between yarn, fabric and apparel dyeing*	Chemical production for yarn dyeing	Data gap (cf. 5.3 Data gaps section)							
		Chemical production for fabric dyeing	Data gap (cf. 5.3 Data gaps section)							

		Chemical production for apparel dyeing	Data gap (cf. 5.3 Data gaps section)							
Outputs:										
Wastewater quantity	L/kg	Waste water treatment (3 levels of efficiency)	Data gap (cf. 5.3 Data gaps section)							
Textile waste	%	See Table 34 "End of life of production waste (capitals indicate those processes expected to be run by the company)" in the PEFCR								

Table 18. Direct elementary flow collection requirements for dyeing process

Emissions/resources	Elementary flow	Frequency of measurement	Default measurement method
VOC emissions	VOC, volatile organic compound (emissions to air, unspecified)	6 or 12 months	Not available

Additional information for spinning

Data collection requirements for spinning process are available in the excel file named "[T-shirts PEFCR_version 1] - Life cycle inventory".

Table 19 describes the scope of the spinning process data collection (per raw material). A synthetic fibres scouring process needs to be included for man-made materials (polyester, polyamide, polypropylene, acrylic, chlorofibres, viscose and elastane).

Table 19. Scope of the spinning process data collection

Raw material	Step included and associated activity data (AD)
Cotton yarn	Spinning AD: electricity, lubricating oil
Wool yarn	
Hemp yarn	Spinning AD: electricity, lubricating oil, water
Silk	Reeling AD: water, heat, diesel, electricity, natural gas, hard coal
Flax long fibres yarn	Wet spinning AD: electricity, water, lubricating oil, wastewater treatment
Polyester yarn	Spinning AD: electricity, lubricating oil
PA yarn	

PP yarn	
Acrylic yarn	
Chlorofibres yarn	
Viscose yarn	Spinning AD: electricity
Polyester filament	Melt-spinning FOY/POY AD: water, lubricating oil, electricity, VOC emissions, waste treatment, wastewater treatment Texturizing AD: electricity, water, wastewater treatment Thermofixation AD: electricity
Elastane	Wet spinning AD: dimethylacetamide, electricity Texturizing AD: electricity, water, wastewater treatment Thermofixation AD: electricity

Additional information for dyeing

Data collection requirements for dyeing process are available in the excel file named "[T-shirts PEFCR_version 1] - Life cycle inventory".

Data collection includes desizing process. Nevertheless in order to avoid any double counting when consumption of energy, heat, water, etc cover both dyeing and desizing, only the chemical used for desizing need to be added.

The difference of colour tones is not taken into account.[11]

[11] The default datasets are available for the different types of support: yarn dyeing, fabric dyeing and apparel dyeing. Each of these datasets is developed based on: a mix of technology (ex: five technologies are covered for fabric dyeing: beck, pad, beam, jigger and jet/overflow), and a mix of raw materials (the dyeing of cellulosic (57%), polyamidic (10%) and synthetic (33%) fibres is taken into account). The colour tone is not mentioned in the datasets. The datasets "chemical consumption" identified in the PEFCR should be developed in accordance with the default datasets (to be consistent with the benchmark), that is to say without distinction of colour tone.

Additional information for printing

Data collection requirements for printing process are available in the excel file named "[T-shirts PEFCR_version 1] - Life cycle inventory".

Data collection includes desizing, softening and singeing processes. If the primary data (consumption of energy, heat, water, etc.) cover both printing, desizing and softening, only the chemical used for desizing and softening need to be added. If the primary data cover also the singeing, the default dataset “Singeing” does not need to be added.

Additional information for assembly

Data collection requirements for assembly process are available in the excel file named "[T-shirts PEFCR_version 1] - Life cycle inventory".

Assembly includes cutting, sewing, trimming, folding and all pre-packaging production steps.

The electricity consumption of assembly shall be calculated with the following formula based on the primary information: the assembly time and the ironing or not of the article at this stage, and the default values provided in the Table 20.

$$Electricity\ consumption = assembly\ time\ \times power_{assembly} + ironing\ time\ \times power_{ironing}$$

With:

- Electricity consumption (in kWh)
- Assembly time (in hours)
- Ironing time (in hours)
- Power for the assembly (in kW)
- Power for the ironing (in kW)

Table 20. Data for the calculation of electricity consumption of the assembly process

	Data for modelling
Assembly time	Primary data to be filled in by companies
Power for the assembly	0,54 kW
Ironing time	1 minute if ironing is used, 0 minute if ironing is not used
Power for the ironing	0,3 kW

Additional information for accessories

Data collection requirements for accessories are available in the excel file named "[T-shirts PEFCR_version 1] - Life cycle inventory".

Two categories of accessories are considered:

- Non-removable accessories like buttons, zips, strass, care label… which are part of the bill of materials,
- Temporary labels removed before product's use such as price tags, cardboard brand tags…

Additional information for packaging

Data collection requirements for packaging are available in the excel file named "[T-shirts PEFCR_version 1] - Life cycle inventory".

Note: should a packaging contain several T-shirts (e.g. one corrugated cardboard containing 30 t-shirts), the packaging total weight should be divided by the number of t-shirts enclosed.

5.3 Data gaps

The data gaps in default datasets listed in the PEFCR are listed in the Table 21.

Table 21. Data gaps

Life cycle stage	Data gaps
Production of T-shirt	Spinning at technology, continent and material levels Synthetic fibres scouring Chemical production for sizing (natural fibres) Chemical production for sizing (synthetic fibres) Desizing for natural fibres Desizing for synthetic fibres Chemical production for yarn dyeing Chemical production for fabric dyeing Chemical production for apparel dyeing Softening Singeing Chemical production for fix-washed printing Chemical production for pigment printing Chemical production for anti-bacterial finishing Chemical production for stain resistant finishing Waste water treatment (3 levels of efficiency) Transport by train
Distribution (T-shirt's transport and transport by customer)	Transport by train Transport, regular bus Transport, passenger, bicycle Transport, passenger, motor scooter Transport, tram
Use stage	Powder laundry detergent Liquid laundry detergent

End of life	Production of paper rags (E*V) Recycling of the cardboard (ErecyclingEOL)

The proxy datasets (ILCD entry level compliant datasets) are listed in the Table 22, Table 23 and Table 24. These datasets are used as proxy within the calculations of the representative product. However, the applicant of the PEFCR shall apply an EF-compliant dataset if available (following the rules layout in chapter 5.6 on which datasets to use). If this is not available, the applicant shall use these proxies.

Table 22. Proxy data for raw material acquisition and processing (ILCD entry level compliant datasets)

Process name*	***Unit of measurement (output)***	***Proxy***		***UUID***	***Default DQR***				***Most relevant process [Y/N]***
		Dataset	***Dataset source***		*P*	*TiR*	*GR*	*TeR*	
Production of conventional cotton fibres (GLO)	*Kg*	*Cotton fibres (conventional)*	*https://node.cycleco.eu/node/*	*26a36a21-3479-4c9f-96cd-651c6b491f62*	*2*	*2*	*1*	*1*	*See chapter 4 (page 30)*
Production of organic cotton fibres (GLO)	*Kg*	*Cotton fibres (organic)*	*https://node.cycleco.eu/node/*	*8e643499-1b7f-4d8e-831e-9f3af6b7599e*	*2*	*2*	*1*	*1*	*See chapter 4 (page 30)*
Production of polyester granulates (GLO)	*Kg*	*Polyester granulate*	*https://node.cycleco.eu/node/*	*44646307-d03b-480d-baab-128a50bc7e57*	*2*	*1*	*1*	*3*	*See chapter 4 (page 30)*
Production of polyester fibres (GLO)	*Kg*	*Polyester fibres*	*https://node.cycleco.eu/node/*	*cebced0a-b162-41fc-8a90-ae6a36d12ceb*	*2*	*1.5*	*1*	*1*	*See chapter 4 (page 30)*
Production of viscose fibres (GLO)	*Kg*	*Viscose fibres*	*https://node.cycleco.eu/node/*	*5e2607b9-5f08-4637-9120-9e483578fb0c*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
Production of polyamide 6.6 fibres (GLO)	*Kg*	*Polyamide fibres*	*https://node.cycleco.eu/node/*	*e0d0da1d-0b1c-4fdb-a239-9d8f3dae908b*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
Production of polypropylene fibres (GLO)	*Kg*	*Polypropylene fibres*	*https://node.cycleco.eu/node/*	*770435cb-71ab-422d-ad9c-8873e6527a63*	*2*	*1.33*	*1*	*1*	*See chapter 4 (page 30)*
Production of acrylic fibres (GLO)	*Kg*	*Acrylic fibres*	*https://node.cycleco.eu/node/*	*f76b7ef9-41db-40fc-9194-b3a1f69d4d5b*	*2*	*3*	*1*	*1*	*See chapter 4 (page 30)*

Production of sheep wool fibres (GLO)	*Kg*	*Wool fibres*	*https://node.cycleco.eu/node/*	*07535ec2-654b-4415-9ad0-a70963b26fc8*	*2*	*1.27*	*1*	*1.70*	*See chapter 4 (page 30)*
Production of elastane (GLO)	*Kg*	*Elastane fibres*	*https://node.cycleco.eu/node/*	*5a5c512d-9242-457c-89ae-f6be4c4692d5*	*2*	*1.5*	*1*	*2*	*See chapter 4 (page 30)*
Production of chlorofibre fibres (GLO)	*Kg*	*Chlorofibre fibres*	*https://node.cycleco.eu/node/*	*8eb69397-4128-4e82-ad4b-fbc84f8ffbee*	*2*	*1*	*1.50*	*1*	*See chapter 4 (page 30)*
Production of flax fibres (GLO)	*Kg*	*Flax fibres*	*https://node.cycleco.eu/node/*	*8e1eb44a-262d-4090-b2f0-0ebee561d3cc*	*2*	*1.21*	*1*	*1*	*See chapter 4 (page 30)*
Production of silk (cocoon) (GLO)	*Kg*	*Silk (cocoon)*	*https://node.cycleco.eu/node/*	*11665a6c-46f8-4aa8-9da5-519d883d9cae*	*2*	*3*	*1*	*2*	*See chapter 4 (page 30)*
Production of hemp fibres (GLO)	*Kg*	*Hemp fibres*	*https://node.cycleco.eu/node/*	*630824b2-ed2d-4944-9b85-5d5b969e0c03*	*2*	*3*	*1*	*1.75*	*See chapter 4 (page 30)*
Woven label (woven fabric in PES)	*Kg*	*Woven label*	*https://node.cycleco.eu/node/*	*31f8cd88-7187-4b66-8ba1-69a1e7873e57*	*2*	*1.5*	*1*	*2*	*See chapter 4 (page 30)*
Double hangtag	*Kg*	*Hangtag*	*https://node.cycleco.eu/node/*	*a8dbaea0-6c1b-49ab-bd06-adbccd09b60f*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*
Adhesive sticker	*Kg*	*Hangtag*	*https://node.cycleco.eu/node/*	*a8dbaea0-6c1b-49ab-bd06-adbccd09b60f*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*
Cardboard label	*Kg*	*Hangtag*	*https://node.cycleco.eu/node/*	*a8dbaea0-6c1b-49ab-bd06-adbccd09b60f*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*
Metal buttons (zinc or other metal)	*Kg*	*Metal buttons*	*https://node.cycleco.eu/node/*	*86374dd4-0e5b-406b-9ca6-9515215cf766*	*2*	*1.5*	*1*	*3*	*See chapter 4 (page 30)*
Plastic buttons (polyethylene terephthalate)	*Kg*	*Plastic buttons*	*https://node.cycleco.eu/node/*	*f2d86ef9-c632-4133-9141-0d7ef2882524*	*2*	*1*	*1.48*	*3*	*See chapter 4 (page 30)*
Wood buttons	*Kg*	*Wood buttons*	*https://node.cycleco.eu/node/*	*a32135df-bfc1-4568-94a5-2fe6a374ff6e*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*

Zips	*Kg*	*Zips*	*https://node.cycleco.eu/node/*	*050e7ee1-0250-42cf-96ce-aa0c945c08d6*	*2*	*1.44*	*1.12*	*2.12*	*See chapter 4 (page 30)*
Strass	*Kg*	*Strass*	*https://node.cycleco.eu/node/*	*7d308d7b-4472-4ef6-9562-e54f60743b16*	*2*	*1*	*1*	*3*	*See chapter 4 (page 30)*
Metal snaps	*Kg*	*Metal snaps*	*https://node.cycleco.eu/node/*	*b0ae4228-adbf-42eb-9a63-1071b215ce3a*	*2*	*1*	*2*	*3*	*See chapter 4 (page 30)*
Plastic snaps	*Kg*	*Plastic snaps*	*https://node.cycleco.eu/node/*	*e0ef86e1-96eb-4188-8eab-95f6435689c5*	*2*	*1*	*1.54*	*3*	*See chapter 4 (page 30)*

Table 23. Proxy data for manufacturing (capitals indicate those processes expected to be run by the company) (ILCD entry level compliant datasets)

Name of the process*	***Unit of measurement (output)***	***Proxy dataset to be used***	***Dataset source***	***UUID***	***Default DQR***				***Most relevant process [Y/N]***
					P	*Ti_R*	*G_R*	*Te_R*	
SPINNING, PRODUCTION OF COTTON YARN, CARDED PROCESS	*Kg*	*Spinning, production of cotton (carded) yarn*	*https://node.cycleco.eu/node/*	*296fd720-4375-49bc-9ddd-482bdaf0dc2d*	*2*	*2.08*	*1*	*1.28*	*See chapter 4 (page 30)*
SPINNING, PRODUCTION OF COTTON YARN, COMBED YARN	*Kg*	*Spinning, production of cotton (combed) yarn*	*https://node.cycleco.eu/node/*	*b52c1a74-db01-40b0-8d17-4dba1c7c10e2*	*2*	*2.08*	*1*	*1.28*	*See chapter 4 (page 30)*
SPINNING, PRODUCTION OF POLYESTER FILAMENT	*Kg*	*Spinning, production of polyester filaments*	*https://node.cycleco.eu/node/*	*d8737eb1-aa43-47b8-90c9-49ebb91dadbd*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
SPINNING, PRODUCTION OF YARN (PRODUCED WITH STAPLE FIBRES) FOR SYNTHETIC FIBRES (POLYESTER, POLYAMIDE,	*Kg*	*Spinning, production of yarn for synthetic fibres*	*https://node.cycleco.eu/node/*	*3eaa3c5d-cb75-4d25-b61c-6230b203b5ca*	*2*	*1*	*1*	*2.18*	*See chapter 4 (page 30)*

POLYPROPYLENE, CHLOROFIBRE, ACRYLIC)									
SPINNING, PRODUCTION OF VISCOSE YARN	*Kg*	*Spinning, production of viscose yarn*	*https://node.cycleco.eu/node/*	*a7731364-696c-4d52-a7eb-bae70aca4e85*	*2*	*2.92*	*1*	*2.68*	*See chapter 4 (page 30)*
SPINNING, PRODUCTION OF WOOL YARN, CARDED PROCESS	*Kg*	*Spinning, production of wool (carded) yarn*	*https://node.cycleco.eu/node/*	*30937fb6-4c4e-492b-aae0-dc26a7572e68*	*2*	*1.41*	*1*	*1.19*	*See chapter 4 (page 30)*
SPINNING, PRODUCTION OF WOOL YARN, COMBED YARN	*Kg*	*Spinning, production of wool (combed) yarn*	*https://node.cycleco.eu/node/*	*936538fa-300e-4593-9606-1929d3e3611e*	*2*	*1.5*	*1*	*1*	*See chapter 4 (page 30)*
SPINNING, PRODUCTION OF ELASTANE FILAMENT	*Kg*	*Spinning, production of elastane filaments*	*https://node.cycleco.eu/node/*	*e9978dd0-7a27-418c-89d8-b1839b72e156*	*2*	*2.78*	*1*	*2.13*	*See chapter 4 (page 30)*
SPINNING, PRODUCTION OF FLAX YARN	*Kg*	*Spinning, production of flax yarn*	*https://node.cycleco.eu/node/*	*f8c22714-9cf8-4f60-aae8-ffa193a1014c*	*2*	*3*	*1*	*1*	*See chapter 4 (page 30)*
SPINNING, PRODUCTION OF SILK YARN	*Kg*	*Cocoon reeling*	*https://node.cycleco.eu/node/*	*194e0b21-5ff6-4fe4-b29f-80d3ad87c5ff*	*2*	*1*	*3*	*1*	*See chapter 4 (page 30)*
SPINNING, PRODUCTION OF HEMP YARN	*Kg*	*Spinning, production of hemp yarn*	*https://node.cycleco.eu/node/*	*7a2fa0a0-61e1-4f78-ad90-3e51bc705f29*	*2*	*3*	*1*	*1*	*See chapter 4 (page 30)*
SIZING FOR NATURAL YARN	*Kg*	*Sizing for natural yarn*	*https://node.cycleco.eu/node/*	*bcbf77fe-7406-4b3d-aab3-e839daa7edad*	*2*	*1*	*1*	*3*	*See chapter 4 (page 30)*
SIZING FOR SYNTHETIC YARN	*Kg*	*Sizing for synthetic yarn*	*https://node.cycleco.eu/node/*	*046e092a-50b1-4250-98c4-2921e80469e2*	*2*	*2.60*	*1*	*2*	*See chapter 4 (page 30)*
KNITTING	*Kg*	*Knitting*	*https://node.cycleco.eu/node/*	*f035e97e-c0ae-4514-9cd8-e6fc4b76c1f7*	*2*	*1*	*1*	*1.38*	*See chapter 4 (page 30)*

WEAVING	*kg*	Yarn weaving	*https://node.cycleco.eu/node/*	*ed236b49-e86a-41a2-95b9-cd96810cfc1e*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
NON-WOVEN FABRIC	*Kg*	*Non-woven fabric*	*https://node.cycleco.eu/node/*	*2863e7d9-2da0-47a6-bcc9-cc089e6d9112*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
YARN DYEING	*Kg*	*Yarn dyeing*	*https://node.cycleco.eu/node/*	*9c24534c-b5c8-4139-b265-7b39ff7205f9*	*2*	*3*	*2*	*2*	*See chapter 4 (page 30)*
FABRIC DYEING	*Kg*	*Fabric dyeing*	*https://node.cycleco.eu/node/*	*2e491781-b5c4-44f0-a765-628e56ea2b1e*	*2*	*3*	*1.71*	*1.71*	*See chapter 4 (page 30)*
APPAREL DYEING	*Kg*	*Apparel dyeing*	*https://node.cycleco.eu/node/*	*65140f6b-d3e3-40dd-af43-7d782cfe3d67*	*2*	*1.5*	*2*	*2*	*See chapter 4 (page 30)*
FIX-WASHED PRINTING	*m²*	*Fix-washed printing*	*https://node.cycleco.eu/node/*	*51397020-ed37-4e62-a6f5-f6483407a652*	*2*	*2.84*	*1.38*	*1.38*	*See chapter 4 (page 30)*
PIGMENT PRINTING	*m²*	*Pigment printing*	*https://node.cycleco.eu/node/*	*627b61ad-7e6c-4963-8914-2e1475c878b2*	*2*	*2.80*	*1.20*	*1.33*	*See chapter 4 (page 30)*
ANTI-BACTERIAL FINISHING	*Kg*	*Anti-bacterial finishing*	*https://node.cycleco.eu/node/*	*905aba47-a8b0-458f-b796-1743e1595a26*	*2*	*1*	*3*	*2*	*See chapter 4 (page 30)*
STAIN RESISTANT FINISHING	*Kg*	*Stain resistant finishing*	*https://node.cycleco.eu/node/*	*59816266-8295-4d1d-90bb-6cb154536017*	*2*	*1.20*	*2*	*1.90*	*See chapter 4 (page 30)*

Table 24. Proxy data for end-of-life (ILCD entry level compliant datasets)

Dataset	**Proxy dataset**		
	Proxy dataset to be used	Dataset source	UUID
Production of glass wool (E*V)	EU-28: Glass wool	http://lcdn.thinkstep.com/Node/	{898618B8-3306-11DD-BD11-0800200C9A66}
Recycling in polypropylene granulates (ErecyclingEOL)	EU-28+EFTA: Plastic granulate secondary (simplified, non specific) [p-agg]	http://lcdn.thinkstep.com/Node/	3B801715-5E3F-426F-8B24-A84DBD4F3165

Table 25. Proxy data for end-of-life (proxy concerning the perimeter of the dataset) (EF compliant datasets)

Dataset	Proxy dataset	
	Proxy dataset to be used	UUID
Recycling in insulation material (ErecyclingEOL)	EU-28+EFTA: Recycling of textiles into fibers	4de00366-d538-4a7b-bdab-38a50ac1d077
Recycling in rags (ErecyclingEOL)	EU-28+EFTA: Recycling of textiles into fibers	4de00366-d538-4a7b-bdab-38a50ac1d077
Incineration (without energy recovery) (ED) (for T-shirt end-of-life)	EU-28+EFTA: Waste incineration of textile, animal and plant based	99347a16-a176-4471-b6ef-35f37d2e9d09
Incineration without energy recovery of polypropylene (ED)	EU-28+EFTA: Waste incineration of PP	7b75dda4-b006-4d8c-8949-e16c2e0dd5c0
Incineration without energy recovery of packaging cardboard (ED)	EU-28+EFTA: Waste incineration of paper and board	b6ce954d-deb4-4c16-907a-c67b71e1e862

5.4 Data quality requirements

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

$$DQR = \frac{\overline{TeR} + \overline{GR} + \overline{TiR} + \bar{P}}{4} \qquad \text{[Equation 1]}$$

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 26.

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 Table 26. It shall be evaluated for example, the timing of the flow measured, for which technology the flow was measured and in which geographical area.

2.b) Each most relevant process is a combination of activity data and the secondary dataset used. For each most relevant process, the DQR is calculated by the applicant of the PEFCR as a combination of the 4 DQR criteria for activity data and the secondary dataset: (i) 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 the total DQR of the newly developed dataset using the 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).

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

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

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

Table 26. 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
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 27). 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 27. Data Needs Matric (DNM)[12]. *Disaggregated datasets shall be used.

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

Examples on how to use the DNM are available in the Annex 5.

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

5.5.1 Processes in situation 1

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

- The process is in the list of most relevant processes as specified in the PEFCR or is not in the list of most relevant process, but still the company wants to provide company specific data (option 1);
- The process is not in the list of most relevant processes and the company prefers to use a secondary dataset (option 2).

Situation 1/Option 1

For all processes run by the company and where the company applying the PEFCR uses company specific data. The DQR of the newly developed dataset shall be evaluated as described in section 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[13] (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.

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

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.

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. The criteria G_R shall be lowered by 30%[14] and the criteria P shall keep the original value.

Situation 2/Option 3

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

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

Table 28. 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.

[14] 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.

	TiR	TeR	G_R
5	The EF report publication date happens later than 6 years after the time validity of the dataset	The technologies used in the EF study are different from those included in the scope of the dataset	The process modelled in the EF study takes place in a different country than the one the dataset is valid for

5.5.3 Processes in situation 3

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

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

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. In such case this information shall be included in the "data gap" section of the PEF report.
    - Textile datasets are available on this node: https://node.cycleco.eu/node/

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

The following allocation rules shall be used by PEF studies:

Table 29. Allocation rules

Process	Allocation rule	Modelling instructions
Transport	Mass	As far as transportation is concerned, the allocation of impacts is based on the distance and the mass of the good being transported.
Spinning	Mass	When data (entire manufacturing consumption) from the industry (consumption of energy, water, etc...) are collected, an allocation based on physical relationship (mass or area) is needed to obtain the consumption per T-shirt.
Sizing	Mass	
Knitting	Mass	
Dyeing	Mass	
Printing	Area	
Finishing	Mass	
Assembly	Mass	

For raw materials, multi-functionality is related to the following processes: cotton fibres, flax fibres (long fibres), viscose fibres, hemp fibres, silk and wool. The allocations used in the default datasets of the benchmark are described in the documentation of each dataset (cf. Table 22).

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 30. Allocation rules for electricity

Process	Physical relationship	Modelling instructions
The same allocation rules shall be applied for electricity as mentioned in section 5.8 and Table 29.	The same allocation rules shall be applied for electricity as mentioned in section 5.8 and Table 29.	The same allocation rules shall be applied for electricity as mentioned in section 5.8 and Table 29.

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[15].
- 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.
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[16] 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: No. All biogenic carbon emissions and removals shall be modelled separately. However, note that the corresponding characterisation factors for biogenic CO_2 uptakes and emissions within the EF impact assessment method are set to zero.

   The product life cycle or part of the life cycle does not have a carbon storage beyond 100 years and therefore credits from biogenic carbon storage must not be modelled.

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[17] 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

[15] For some countries, this option is a best case rather than a worst case.
[16] 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.
[17] Following the instantaneous oxidation approach in IPCC 2013 (Chapter 2).

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

The GHG emissions and removals arising from direct land use change shall be assessed for any input to the life cycle of a product originating from that land and shall be included in the assessment of GHG emissions. The emissions arising from the product shall be assessed on the basis of the default land use change values provided in PAS 2050:2011 Annex C, unless better data is available. For countries and land use changes not included in this annex, the emissions arising from the product shall be assessed using the included GHG emissions and removals occurring as a result of direct land use change in accordance with the relevant sections of the IPCC (2006). The assessment of the impact of land use change shall include all direct land use change occurring not more than 20 years, or a single harvest period, prior to undertaking the assessment (whichever is the longer). The total GHG emissions and removals arising from direct land use change over the period shall be included in the quantification of GHG emissions of products arising from this land on the basis of equal allocation to each year of the period[18].

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

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

change in land use from the previous land use to the current land use in that country (additional guidelines on the calculations can be found in PAS 2050-1:2012);

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

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

Soil carbon storage shall be modelled, calculated and reported as additional environmental information: No

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

The sub-category 'Climate change-biogenic' shall be reported separately: No.

The sub-category 'Climate change-land use and land transformation' shall be reported separately: No.

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

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

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

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

With the following parameters:

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

B: allocation factor of energy recovery processes: it applies both to burdens and credits. It shqll be set to zero for all PEF studies.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

6 Life cycle stages

6.1 Raw material acquisition and pre-processing

For textile raw materials (such as the production of cotton fibres, the production of polyester granulates, the production of viscose fibres and the production of polyamide 6.6 fibres), proxy datasets are available in the chapter 5.3 Data gaps (cf. Table 22). The amount per FU is a calculated data (see paragraph "Calculation of quantities according to waste" in the part 6.3 Manufacturing).

Proxy datasets are also available in the chapter 5.3 Data gaps (cf. Table 22) for the accessories (such as buttons, zips, strass and snaps).

The datasets for packaging are listed in the Table 31. The plastic bag is considered as primary packaging. Its end-of-life is described in the chapter 6.5 End of life. The corrugated cardboard is a secondary packaging. The end of life of corrugated cardboard is described in the chapter 6.2 Manufacturing.

Table 31. Raw material acquisition and processing (capitals indicate those processes expected to be run by the company)

Process name*	***Unit of measurement (output)***	***Default***		***UUID***	***Default DQR***				***Most relevant process [Y/N]***
		Dataset	***Dataset source***		*P*	*TiR*	*GR*	*TeR*	
Plastic bag (PP)	*m²*	*EU-28+EFTA: Plastic bag, PP*	*http://lcdn.thinkstep.com/Node/*	*9127181c-e424-4cc3-9083-3dff8e1b090e*	*2*	*2*	*2*	*2*	*See chapter 4 (page 30)*
Corrugated cardboard	*Kg*	*EU-28+EFTA: Corrugated board, uncoated*	*http://lcdn.thinkstep.com/Node/*	*574bdb1e-2ed3-46f1-bd14-bb76f739bb71*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*

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

Modelling the recycled content

The following formula is used to model the recycled content:

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

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

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

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

Default parameters for A, R1 and Q_{sin}/Q_p are listed in the Table 32.

Table 32. Default parameters for A, R1 and Qsin/Qp

	PEF nomenclature	T-shirt		Packaging	
		Textile part	Accessories	Plastic bag	Cardboard
Factor of burdens between supplier and user of recycled material	A [32]	0,8	Function of the material Cf. Annex C of the PEFCR Guidance [32]	0,5	0,2
Recycled (or reused) content of material	R1 [32]	Variable (primary data)	0	0	88%
Dimensionless ratio taken as an approximation for any differences in quality between ingoing secondary material and primary material	Qs_{in}/Qp [32]	0,05 *(see explanation below)*	Function of the material Cf. Annex C of the PEFCR Guidance [32]	0,9	1

The quality factor (Qs_{in}/Qp) is estimated based on the prices of T-shirts and textile rags. The following prices are considered:

- 1723 €/tonne for the textile rags (WRAP, Evaluation of the end markets for textile rag and fibre within the UK, Final Report, May 2014)
- 31587 €/tonne for T-shirts (Eurostats, 2014) (the price per tonne is calculated considering an average weight of 160g/T-shirt)

Thus, the quality factor is 5%. This value is also used as an approximation for the recycling in thermal insulation material.

For the cardboard, Ev = E*v is considered. Qs_{in}/Qp ratio of 1 is used [13, 32]. A recycling efficiency rate of 92% is considered [14].

6.2 Manufacturing

For textile processes (such as spinning, sizing, knitting, dyeing, printing and assembly), proxy datasets are available in the chapter 5.3 Data gaps (cf. Table 23).

The Table 33 provides the information relative to the transport during the manufacturing. The default values for distance were calculated with the formula provided in the paragraph "Transportation processes default value and secondary data" (available at the end of the chapter 6.2 Manufacturing) considering the main countries of production for each process.

Note: for the transport at production stage (transport of raw materials to transport before assembly), the quantity transported for each transport step is equal to the output quantity of the process which precedes transport. The transport of the production waste is not included.

Table 33. Transport (capitals indicate those processes expected to be run by the company)

Process name*	***Unit of measurement (output)***	***Default (per FU)***			***Default dataset***	***Dataset source***	***UUID***	***Default DQR***				***Most relevant [Y/N]***
		Distance	***Utilisation ratio****	***Empty return***				*P*	*TiR*	*GR*	*TeR*	
Transport of raw materials												
Conventional cotton	*Kg.km*	2686 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	7699 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Organic cotton	*Kg.km*	2847 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*

	Kg.km	7248 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Polyester – filament	*Kg.km*	2315 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	2586 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Polyester – yarn	*Kg.km*	2518 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	4783 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Viscose	*Kg.km*	2613 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	7381 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Polyamide 6.6	*Kg.km*	2980 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	10036 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Polypropylene	*Kg.km*	2911 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	12274 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-*	*2*	*1*	*2*	*2*	*See chapter*

							abfa-4accc66a8a63					*4 (page 30)*
Acrylic	*Kg.km*	2339 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	7110 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Wool	*Kg.km*	2058 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	8960 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Elastane	*Kg.km*	2302 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	3427 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Chlorofibre	*Kg.km*	2584 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	8512 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Flax	*Kg.km*	3214 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	14238 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*

Silk	*Kg.km*	2531 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	3806 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Hemp	*Kg.km*	2413 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	9199 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Transport of yarn												
Yarn	*Kg.km*	2326 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	6848 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Filament	*Kg.km*	2285 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	6736 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Transport of knitted fabric	*Kg.km*	500 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
Transport of dyed fabric	*Kg.km*	500 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*

Transport of printed fabric	*Kg.km*	500 km	*64% (this utilisation ratio includes empty return trips)*	*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
Transport before assembly	*Kg.km*	1730 km	*64% (this utilisation ratio includes empty return trips)*	*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	Kg.km	5958 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
	Kg.km	391 km	-	-	*GLO: Cargo plane*	http://lcdn.thinkstep.com/Node/	*1cc5d465-a12a-43da-aa86-a9c6383c78ac*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*

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

The following dataset shall be used to model the production of diesel (for lorry and van): EU-28+3: Diesel at refinery (UUID: 66a4e262-23ce-4140-9112-0a654a00b86d).

The waste of products used during the manufacturing shall be included in the modelling. The section below explains how to calculate the quantities of textile for each step of the production according to the waste of each process. The production waste shall be included in all modelling steps up to the output of the manufacturing (from cradle to manufacturing gate). The end of life of the production waste is described in the section "Modelling of production waste and cardboard end-of-life" below.

Calculation of quantities according to waste

Textile material input and output are calculated based on the weight of the T-shirt's textile portion (for the reference size) and residual textile losses for each process. The weight of the textile-made part is equal to the difference between the T-shirt's weight and the weight of non-removable accessories such as buttons, zips, strass and care labels. For a process n, the amount of input material is calculated as follows:

If textile waste is expressed in percent, the following formula should be used:

$$Amount\ of\ input\ material_n = \frac{Amount\ of\ output\ material_n}{1 - Textile\ waste_n}$$

With:

- Amount of input textile-made part for the process n (in kg)
- Amount of output textile-made part for the process n (in kg)
- Textile waste for the process n (in %)

If textile waste is a quantity (kg of textile waste/kg produced), the following formula should be used:

$$Amount\ of\ input\ material_n = Amount\ of\ ouput\ material_n \times (1 + Textile\ waste_n)$$

With:

- Amount of input textile-made part for the process n (in kg)
- Amount of output textile-made part for the process n (in kg)
- Textile waste for the process n (in kg/kg)

Should the printing process be expressed in m², the following formula should be used to calculate the amount of input material for this process.

$$Amount\ of\ input\ material_{Printing} = Amount\ of\ output\ material_{Printing} + (Printed\ surface \times Textile\ waste_{Printing})$$

With:

- Amount of input material for the process n (in kg)
- Amount of output material for the process n (in kg)
- Printed surface (in m²)
- Printing process-related textile waste (in kg/m²)

In all cases, the following hypothesis is considered: the amount of input material for process n is equal to the amount of output material for process n-1.

Example: the weight of the textile-made part of a men's t-shirt is 150 g for the reference size. The T-shirt's life cycle includes the following processes: production of the raw materials, spinning, knitting and assembly. Assembly generates 10% textile waste. Thus, the amount of input material for assembly is 166,7 g (= 150 / (1 – 10%)). It also corresponds to the amount of output material of the process prior to assembly, that is, knitting. Based on this quantity and the knitting process-related percentage of waste, it is possible de calculate the amount of input material for the knitting process.

Note: textile waste includes production waste and defective products.

Note: secondary data for textile waste are available in the default secondary datasets. Proxy datasets are available in the chapter 5.3 Data gaps (cf. Table 23).

Modelling of production waste and cardboard end-of-life

The following distribution is considered for the end of life of the production waste for all textile raw materials and accessories: recycling (11%)[3], incineration (with energy recovery) (36%)[25], incineration (without energy recovery) (1,4%)[3] and landfill (51,6%)[25]. The production waste are recycled into insulation materials (production of a non-woven). The recycling avoids the production of glass wool.

The datasets are listed in Table 34 and Table 35.

Table 34. End of life of production waste (capitals indicate those processes expected to be run by the company)

Name of the process*	***Unit of measurement (output)***	***Default dataset to be used***	***Dataset source***	***UUID***	***Default DQR***				***Most relevant process [Y/N]***
					P	*Ti_R*	*G_R*	*Te_R*	
Recycling in insulation material (ErecyclingEOL)	*Kg*	*EU-28+EFTA: Recycling of textiles into fibers*	*http://lcdn.thinkstep.com/Node/*	*4de00366-d538-4a7b-bdab-38a50ac1d077*	*2*	*2*	*2*	*2*	*See chapter 4 (page 30)*
Production of glass wool (E*V)	*Kg*	*EU-28: Glass wool*	*http://lcdn.thinkstep.com/Node/*	*{898618B8-3306-11DD-BD11-0800200C9A66}*					*See chapter 4 (page 30)*
Incineration (with energy recovery) (EER)	*Kg*	*EU-28+EFTA: Waste incineration of textile, animal and plant based*	*http://lcdn.thinkstep.com/Node/*	*99347a16-a176-4471-b6ef-35f37d2e9d09*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*
Landfilling of T-shirts (ED)	*Kg*	*EU-28+EFTA: Landfill of textile*	*http://lcdn.thinkstep.com/Node/*	*7e851603-761f-4f7c-b5c9-145d0a703a44*	*2*	*2*	*2*	*2*	*See chapter 4 (page 30)*
Incineration (without energy recovery) (ED)	*Kg*	*EU-28+EFTA: Waste incineration of textile, animal and plant based*	*http://lcdn.thinkstep.com/Node/*	*99347a16-a176-4471-b6ef-35f37d2e9d09*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*

Table 35. End of life of cardboard (capitals indicate those processes expected to be run by the company)

Name of the process*	***Unit of measurement (output)***	***Default dataset to be used***	***Dataset source***	***UUID***	***Default DQR***				***Most relevant process [Y/N]***
					P	*Ti_R*	*G_R*	*Te_R*	
Recycling of the cardboard (ErecyclingEOL)	*Kg*	*Data gap*							

*Production of core board (E*V)*	*Kg*	*EU-28+EFTA: Kraft paper, uncoated*	*http://lcdn.thinkstep.com/Node/*	*03dea8f0-44e0-4bf3-a862-bb572c9d5f5e*	*2*	*3*	*3*	*2*	*See chapter 4 (page 30)*
Incineration with energy recovery of packaging cardboard (EER)	*Kg*	*EU-28+EFTA: Waste incineration of paper and board*	*http://lcdn.thinkstep.com/Node/*	*b6ce954d-deb4-4c16-907a-c67b71e1e862*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*
Landfilling of packaging cardboard (ED)	*Kg*	*EU-28+EFTA: Landfill of paper and paperboard waste*	*http://lcdn.thinkstep.com/Node/*	*ca6d1bd3-059f-4208-8dfc-d155e0fc7d33*	*2*	*2*	*2*	*2*	*See chapter 4 (page 30)*
Incineration without energy recovery of packaging cardboard (ED)	*Kg*	*EU-28+EFTA: Waste incineration of paper and board*	*http://lcdn.thinkstep.com/Node/*	*b6ce954d-deb4-4c16-907a-c67b71e1e862*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*

End-of-life modelling parameters for production waste and cardboard are described in the Table 36.

Table 36. End-of-life modelling parameters for production waste and cardboard

	PEF nomenclature	Production waste	Cardboard
Factor of burdens between supplier and user of recycled material	A [32]	0,8	0,2
Factor of energy recovery processes	B [33]	0	0
Recycling (or reuse) fraction of material	R2 [32]	0,11	0,75
Proportion of material in the product that is used for energy recovery	R3	Country specific	Country specific
Dimensionless ratio taken as an approximation for any differences in quality between outgoing secondary material and primary material	Qs_{out}/Qp	-	1 [32]

For production waste, the quality ratio associated to the recycled content (Qsin/Qp) is considered due to Ev ≠ E*v. For the cardboard, Ev = E*v is considered. Qsout/Qp ratio of 1 is used [13, 32]. A recycling efficiency rate of 92% is considered [14].

Industry primary data (i.e. energy consumption, water consumption, etc...)

Data from the industry could be collected specifically for T-shirts studied or according to the manufacture's consumption.

Transportation processes default value and secondary data

The Table 33 shows the default value and the secondary data for the transportation processes. These distances are calculated by considering the countries of production identified for the representative products (cf. Annex I). The countries of production of raw materials are available in the datasets.
Calculating the average transport distance was made considering each starting country and each country of destination. These countries are weighted by their percentage of the production.
In the first instance, the distance to each country of destination is calculated.

$$Transport_{DCx} = (Dist_{SC1-DCx} \times Prod_{SC1}) + (Dist_{SC2-DCx} \times Prod_{SC2}) + \cdots$$

Where:

- Transport $_{DCx}$: distance traveled to each country of destination x
- Dist $_{SC1-DCx}$: distance between the starting country 1 and the country of destination x
- Prod $_{SC1}$: percentage of production of the starting country 1

Then the average transport distance is calculated based on the percentage of production of each country of destination.

$$Average\ transport = (Transport_{DC1} \times Prod_{DC1}) + (Transport_{DC2} \times Prod_{DC2}) + \cdots$$

Where:

- Average transport: average transport distance between two processes of production
- Transport $_{DC1}$: distance traveled to the country of destination 1
- Prod $_{DC1}$: percentage of production of the country of destination 1

The transport step includes the following steps [18, 19]:

1) Inland transport (with trucks) from the center of the starting country to its main seaport,
2) Maritime transport (with a freight ship) from the main seaport of the starting country to the main seaport of the country of destination,
3) Inland transport (with trucks) from the main seaport of the country of destination to its center.

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 a private individual.

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

Distribution stage is divided into two different life cycle stages: the T-shirt's transport and the customer travel.

T-shirt's transport

Note: for the T-shirt transport (transport between assembly and warehouse and transport between warehouse and store), the weight transported is: the sum of the T-shirt's weight plus all removable accessories such as price tags, cardboard brand tags … plus the packaging.

Table 37. T-shirt's transport (capitals indicate those processes expected to be run by the company)

*Process name**	*Unit of measurement (output)*	*Default (per FU)*			*Default dataset*	*Dataset source*	*UUID*	*Default DQR*				*Most relevant [Y/N]*
		Distance	*Utilisation ratio*	*Empty return*				*P*	*Ti_R*	*G_R*	*Te_R*	
Transport between assembly and warehouse	*kg.km*	1540 km	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	kg.km	5527 km	-	-	*GLO: Transoceanic ship, containers*	http://lcdn.thinkstep.com/Node/	*6ca61112-1d5b-473c-abfa-4accc66a8a63*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
	kg.km	800 km	-	-	*GLO: Cargo plane*	http://lcdn.thinkstep.com/Node/	*1cc5d465-a12a-43da-aa86-a9c6383c78ac*	*2*	*1*	*2*	*2*	*See chapter 4 (page 30)*
Transport between warehouse and store	*kg.km*	*1173 km*	*64% (this utilisation ratio includes empty return trips)*		*EU-28+3: Articulated lorry transport, Euro 4, Total weight >32 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*938d5ba6-17e4-4f0d-bef0-481608681f57*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
	kg.km	*0,26 km*	*20%*	-	*EU-28+3: Articulated lorry transport, Euro 3, Total weight <7.5 t (without fuel) <u-so>*	http://lcdn.thinkstep.com/Node/	*aea613ae-573b-443a-aba2-6a69900ca2ff*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*

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

The Table 38 describes the assumptions used for the transport between warehouse and store.

Table 38. Transport between warehouse and store

In-store sales	
Transportation mode	travel by truck
Distance	for 100% of in-store sales: 1200 km
Online sales	
Transportation mode	travel by van and truck
Distance (round trip)	for 100% of online sales: 688 km by truck and 3,19 km by van (16,8 km for 3.63 products in 69% of cases)
Percentage of product returns	17,5% of product returns
Distance taking into account the % of product returns	for 100% of online sales: 808 km by truck and 3,75 km by van
Calculation of default values	
Percentage of online vs in-store sales	93% of in-store sales, 7% of online and mail-order sales
Distance for in-store sales	1116 km by truck *(1200 km x 93%)*
Distances for online sales	57 km by truck *(808 km x 7%)* 0,26 km by van *(3,75 km x 7%)*
Total	1173 km by truck 0,26 km by van

Customer travel

Table 39. Customer travel (capitals indicate those processes expected to be run by the company)

Process name*	***Unit of measurement (output)***	***Default (per FU)***			***Default dataset***	***Dataset source***	***UUID***	***Default DQR***				***Most relevant [Y/N]***
		Distance	***Utilisation ratio***	***Empty return***				*P*	*Ti_R*	*G_R*	*Te_R*	
Transport, passenger car	*km*	*4,59 km*	*-*	*-*	*GLO: Passenger car, average*	*http://lcdn.thinkstep.com/Node/*	*1ead35dd-fc71-4b0c-9410-7e39da95c7dc*	3	1	3	3	*See chapter 4 (page 30)*
Transport, regular bus	*Person.km*	*0,14 person. km*	*-*	*-*	*Data gap*							

Transport, passenger, bicycle	*Person.km*	*0,06 person. km*	-	-	*Data gap*							
Transport, passenger, motor scooter	*Person.km*	*0,05 person. km*	-	-	*Data gap*							
Transport, tram	*Person.km*	*0,11 person. km*	-	-	*Data gap*							

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

The waste of products during the distribution and retail shall be included in the modelling. For T-shirts category, the loss rate during the distribution is 0%.

The Table 40 describes the assumptions used for the customer travel.

Table 40. Customer travel

Percentage of online vs in-store sales *(cf. information asked for transport between warehouse and store)*	*93% of in-store sales, 7% of online and mail-order sales* [20]
In-store sales	
Transportation mode (public transports, bicycle, car, motorcycle…)	See paragraph "Customer travel – In-store sales"
Distance	
Online sales	
Distance (transport by car)	*for 100% of online sales: 2,9 km (4,17 km by car in 69% of cases)* [34]
% of product returns	*17,5% of product returns* [34]
Distance taking into account the % of product returns	*for 100% of online sales: 3,4 km*

Note: customer travel should include round trip.

Customer travel – In-store sales

For in-store sales, customer travel impact is calculated as follows:

$$Impact_{customer\ travel} = \frac{\sum(Km_i \times T_i \times I_i) \times \left(Tud + \frac{Tsd}{Nsv}\right)}{\frac{Np}{Nv}}$$

With:

- Impact $_{customer\ travel}$: customer travel environmental impact per product
- Km_i: average distance (round-trip) per transportation mode (in km)
- T_i: average % of main transportation (fraction)
- Tud: % customers visiting one shop (transportation with one sole destination) (fraction)
- Tsd: % customers visiting several shops (transportation with several destinations) (fraction)
- Nsv: average number of shops visited
- Nv: number of visitors for one year (including buyers and non-buyers)
- Np: number of products sold in one year
- I_i: environmental impact per km by transportation mode

Data to be used are listed below and in Table 41 [35, 36]:

- % customers visiting one shop (Tud): 37%
- % customers visiting several shops (Tsd): 63%
- Average number of shops visited (Nsv): 3,5
- Number of visitors for one year (including buyers and non-buyers) (Nv): 93 074 310
- Number of products sold in one year (Np): 249 209 524

Table 41 - Customer travel secondary data

Transport by	T_i: average % of main transport	Km_i: average distance round-trip (in km)	Number of customers per vehicle
Bus	5,10%	14,6	1
Bicycle	1,70%	18,7	1
Car	85,40%	28	1,05
Carpooling	0,20%	30	2
Motorcycles	1,40%	20,4	1
Foot	1,90%	4	1
Subway/tram	4,50%	12,3	1

These data come from a customer survey conducted by Decathlon (900 French customers surveyed with 600 responses)[35] and statistics of Decathlon stores for the number of visitors for one year and the number of products sold in one year (data collected in 2013)[36].

Calculation of distance according to the percentage of product returns

The percentage of product returns has an influence on the distance traveled. The following formula should be used to calculate the distance according to the percentage of product returns:

$$Distance_{total} = distance \times (1 + \%_{return})$$

Where:

- Distance $_{total}$: distance taking into account the % of product returns (km)
- distance: round trip distance (km)
- $\%_{return}$: % of product returns (fraction)

6.4 Use stage

As indicated in the chapter 3.3 Functional unit and reference flow, a standard life span of 52 washes is considered for all T-shirts. The use stage is modelled according to the Main Function approach (all activities linked to the main function of the product are taken into account) [33].

Use phase' modelling with primary data is performed according to the washing instructions featuring on the care label. The activity data to be used in the calculations are listed in the Table 15.

Washing

The T-shirts PEFCR assumes that T-shirts have a standard lifetime of 52 washings [1].

Table 42. Data for washing (for 1 kg of T-shirt)

	Washing cycle scenario		
	Machine washing (laundry weight: 4,5 kg [21])		**Handwashing**
Washing temperature	30°C	40°C [21]	-
Energy consumption for normal washing cycle	1,404 MJ/wash [8] i.e. 0,312 MJ/wash/kg	2,297 MJ/wash [21] i.e. 0,510 MJ/wash/kg	-
Energy consumption for gentle washing cycle	0,702 MJ/wash [8] i.e. 0,156 MJ/wash/kg	1,148 MJ/wash [8] i.e. 0,255 MJ/wash/kg	-
Water consumption	11,11 L / kg [21]		23 L / kg [9]
Quantity of wastewater	11,11 L / kg [21]		23 L / kg [9]
Detergent quantity and type	Datagap *(liquid laundry detergent and powder laundry detergent datasets are not available, cf. Table 21)*		

Note: the washing of representative products is modelled based on washing at 40°C (0% of handwashing [9]).

Note: detergent production is a data gap. The process of "washing with detergent" dataset (developed by the « Household liquid laundry detergents » pilot) was tested during the pilot phase. This dataset covers the

life cycle of the detergent i.e. its production, its use during the washing and its end-of-life. Thus, this dataset requires to have identical washing step for all T-shirts. However, as it is modelled currently in the T-shirts PEFCR, T-shirts can be washed in different ways: machine washing with different washing temperature, handwashing, gentle washing cycle or not. In terms of impacts, the contribution of detergent production is less important than the influence of washing temperature or type of washing. Based on these considerations and in order to keep the higher possibility to present differences between T-shirts depending on their life cycle, it was decided to have detergent production as a data gap. It will be possible to modify it for the next revision of the PEFCR if a dataset coherent with the perimeter defined by the T-shirts PEFCR is made available at that time.

Drying

Drying depends on the textile composition. If drying in tumble drier is allowed (depending on care label instructions), we consider 90% of air drying and 10% of tumble drier (the use rate is defined in Annex 4).
The energy consumption is 2.01 kWh/cycle (full load of 6 kg) [22].
Thus, the energy consumption is 0,1206 MJ/kg of T-shirt for one drying cycle (this value takes into account the use rate).

Time of drying is not adapted depending on fibres[19].

Ironing

An ironing time of 3 min is indicated in the IMPROTEX study [3]. However, the time was considered too long in view of the product (product with simple ironing compared to shirts, T-shirts are not always ironed depending on consumers' habits). An ironing time of 1 min is therefore assumed. Considering that only 50% of T-shirts are ironed [20], the ironing time is downscaled to 30 sec.

Should ironing be allowed, the electricity consumption is function of the setting (depending on care label instructions) (Table 43). The average power for 110 and 150°C are calculated proportionally to the temperature on the basis of the power consumed for a temperature of 200°C.

Table 43. Electricity consumption of ironing

Maximum ironing temperature [23]	Iron setting	Average power	Electricity consumption (for 1 ironing)
110°C	1 point	165 W	4,95E-03 MJ/ironing
150°C	2 points	225 W	6,75E-03 MJ/ironing
200°C	3 points	300 W [24]	9,00E-03 MJ/ironing

Datasets

The processes taking place in this life cycle stage are listed in the Table 44.

[19] According to the screening, the drying in tumble dryer has low influence on the impacts for all the life cycle compared with air drying only (as the tumble dryer use rate is 10%).

Table 44. Use stage (capitals indicate those processes expected to be run by the company)

*Name of the process**	*Unit of measurement (output)*	*Default dataset to be used*	*Dataset source*	*UUID*	*Default DQR*				*Most relevant process [Y/N]*
					P	*TiR*	*GR*	*TeR*	
Tap water	*L*	*EU-28+3: Tap water*	*https://lcdn.quantis-software.com/PEF/*	*212b8494-a769-4c2e-8d82-9a6ef61baad7*	*2,0*	*2,4*	*2,0*	*2,0*	*See chapter 4 (page 30)*
Powder laundry detergent	*kg*	*Data gap*							
Liquid laundry detergent	*mL*	*Data gap*							
Wastewater	*L*	*EU-28+EFTA: Treatment of residential wastewater, small plant*	*http://lcdn.thinkstep.com/Node/*	*8126980a-29e9-416c-991d-2aa5fdad9062*	*2*	*2*	*2*	*2*	*See chapter 4 (page 30)*
Electricity grid mix, low voltage	*MJ*	*Please use the most appropriate regional EF-compliant dataset*	*http://lcdn.thinkstep.com/Node/*	*-*	*-*	*-*	*-*	*-*	*See chapter 4 (page 30)*

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 a physical unit shall be used (e.g. number of pieces or kg of product). Where such data are not available, the average EU consumption mix (EU-28 +EFTA), or region representative consumption mix, shall be used.

The waste of products during the use stage shall be included in the modelling. For T-shirts category, the loss rate at consumer is 0%.

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.

T-shirts end-of-life corresponds to the following breakdown between recycling and waste elimination (landfilling and incineration):

- Recycling (11%) [3],
- Incineration (with energy recovery) (36%) [25],
- Incineration (without energy recovery) (1,4%) [3],
- Landfilling (51,6%) [25].

Recycling technologies (11 out of 100 T-shirts are recycled at end-of-life) are detailed as follows:

- 87% of the T-shirts are recycled into wiping cloths
- 13% of the T-shirts are recycled into insulation materials [26]

Recycling into cloths avoids the production of wiping paper [27]. The production of insulation materials avoids the production of glass wool [26].

Re-use-related information: reuse is taken into account in the lifetime of the T-shirts which corresponds to a whole lifetime: after the use-phase, T-shirts are worn out and cannot be reused. The use phase could correspond to the number of users wearing the T-shirt.

The datasets are listed in Table 45 and Table 46.

Table 45. End of life of T-shirts (capitals indicate those processes expected to be run by the company)

Name of the process*	***Unit of measurement (output)***	***Default dataset to be used***	***Dataset source***	***UUID***	***Default DQR***				***Most relevant process [Y/N]***
					P	*Ti R*	*G R*	*Te R*	
Recycling in insulation material (ErecyclingEOL)	*Kg*	*EU-28+EFTA: Recycling of textiles into fibers*	*http://lcdn.thinkstep.com/Node/*	*4de00366-d538-4a7b-bdab-38a50ac1d077*	*2*	*2*	*2*	*2*	*See chapter 4 (page 30)*
Recycling in rags (ErecyclingEOL)	*Kg*	*EU-28+EFTA: Recycling of textiles into fibers*	*http://lcdn.thinkstep.com/Node/*	*4de00366-d538-4a7b-bdab-38a50ac1d077*	*2*	*2*	*2*	*2*	*See chapter 4 (page 30)*
Production of glass wool (E*V)	*Kg*	*EU-28: Glass wool*	*http://lcdn.thinkstep.com/Node/*	*{898618B8-3306-11DD-BD11-0800200C9A66}*					*See chapter 4 (page 30)*
Production of paper rags (E*V)	*Kg*	*Data gap*							

Incineration (with energy recovery) (EER)	*Kg*	*EU-28+EFTA: Waste incineration of textile, animal and plant based*	*http://lcdn.thinkstep.com/Node/*	*99347a16-a176-4471-b6ef-35f37d2e9d09*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*
Landfilling of T-shirts (ED)	*Kg*	*EU-28+EFTA: Landfill of textile*	*http://lcdn.thinkstep.com/Node/*	*7e851603-761f-4f7c-b5c9-145d0a703a44*	*2*	*2*	*2*	*2*	*See chapter 4 (page 30)*
Incineration (without energy recovery) (ED)	*Kg*	*EU-28+EFTA: Waste incineration of textile, animal and plant based*	*http://lcdn.thinkstep.com/Node/*	*99347a16-a176-4471-b6ef-35f37d2e9d09*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*

Table 46. End of life of plastic bag (capitals indicate those processes expected to be run by the company)

Name of the process*	***Unit of measurement (output)***	***Default dataset to be used***	***Dataset source***	***UUID***	***Default DQR***				***Most relevant process [Y/N]***
					P	*Ti_R*	*G_R*	*Te_R*	
Recycling in polypropylene granulates (ErecyclingEOL)	*Kg*	*EU-28+EFTA: Plastic granulate secondary (simplified, non specific) [p-agg]*	*http://lcdn.thinkstep.com/Node/*	*3B801715-5E3F-426F-8B24-A84DBD4F3165*					*See chapter 4 (page 30)*
*Production of polypropylene granulates (E*V)*	*Kg*	*EU-28+EFTA: PP granulates*	*http://lcdn.thinkstep.com/Node/*	*eb6c15a5-abcd-4d1a-ab7f-fb1cc364a130*	*2*	*1*	*1*	*1*	*See chapter 4 (page 30)*
Incineration with energy recovery of polypropylene (EER)	*Kg*	*EU-28+EFTA: Waste incineration of PP*	*http://lcdn.thinkstep.com/Node/*	*7b75dda4-b006-4d8c-8949-e16c2e0dd5c0*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*
Landfilling of	*Kg*	*EU-28+EFTA: Landfill of plastic waste*	*http://lcdn.thinkstep.com/Node/*	*f2bea0f5-e4b7-4a2c-*	*2*	*2*	*2*	*2*	*See chapter 4 (page 30)*

polypropylene (ED)				*9f34-4eb32495cbc6*					
Incineration without energy recovery of polypropylene (ED)	*Kg*	*EU-28+EFTA: Waste incineration of PP*	*http://lcdn.thinkstep.com/Node/*	*7b75dda4-b006-4d8c-8949-e16c2e0dd5c0*	*2*	*1*	*1*	*2*	*See chapter 4 (page 30)*

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[20].

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

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

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

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

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

End-of-life modelling parameters for T-shirts and plastic bag are described in the Table 47.

Table 47. End-of-life modelling parameters for T-shirts and plastic bag

	PEF nomenclature	T-shirt	Plastic bag
Factor of burdens between supplier and user of recycled material	A [32]	0,8	0,5
Factor of energy recovery processes	B [33]	0	0
Recycling (or reuse) fraction of material	R2 [32]	0,11	0,29
Proportion of material in the product that is used for energy recovery	R3	Country specific	Country speciific
Dimensionless ratio taken as an approximation for any differences in quality between outgoing secondary material and primary material	Qs_{out}/Qp	-	-

For T-shirt and plastic bag, the quality ratio associated to the recycled content (Qs_{in}/Qp) is considered due to $Ev \neq E^*v$.

7 PEF results

7.1 Benchmark values

The results of the benchmark for men T-shirts are available in the Table 51, Table 52, and Table 53.

Table 48. Characterised benchmark values for men T-shirts

Impact category	Unit	Life cycle excl. use stage	Use stage
Acidification	mol H^+_{eq}	3,54E-02	2,12E-03
Climate change, total	kg $CO_{2\,eq}$	5,43E+00	8,75E-01
Eutrophication, freshwater	kg P_{eq}	2,43E-03	1,24E-04
Eutrophication, marine	kg N_{eq}	7,39E-03	1,06E-03
Eutrophication, terrestrial	mol N_{eq}	7,35E-02	3,61E-03
Ionising radiation, human health	kBq U^{235}_{eq}	1,51E-01	2,93E-01
Land use	Dimensionless (pt)	1,95E+02	-4,83E+00 [21]
Ozone depletion	kg CFC-11 $_{eq}$	2,93E-07	6,35E-10
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	1,77E-02	1,27E-03

[21] The negative land use impact at use stage comes from the negative contribution of the process "EU-28+EFTA: Treatment of residential wastewater, small plant". It is due to the credit given to the fertilizer in this dataset.

Impact category	Unit	Life cycle excl. use stage	Use stage
Resource use, fossils	MJ	7,08E+01	1,24E+01
Resource use, minerals and metals	kg Sb $_{eq}$	2,21E-05	3,20E-07
Particulate matter	disease incidence	9,15E-07	9,35E-09
Water use	m^3 world $_{eq}$	8,24E+00	3,15E+00

Table 49. Normalised benchmark values for men T-shirts

Impact category	Life cycle excl. use stage	Use stage
Acidification	6,37E-04	3,82E-05
Climate change, total	6,99E-04	1,13E-04
Eutrophication, freshwater	9,54E-04	4,87E-05
Eutrophication, marine	2,61E-04	3,76E-05
Eutrophication, terrestrial	4,15E-04	2,04E-05
Ionising radiation, human health	3,58E-05	6,94E-05
Land use	1,47E-04	-3,63E-06
Ozone depletion	1,25E-05	2,71E-08
Photochemical ozone formation, human health	4,36E-04	3,14E-05
Resource use, fossils	1,08E-03	1,90E-04
Resource use, minerals and metals	3,81E-04	5,53E-06
Particulate matter	1,44E-03	1,47E-05
Water use	7,17E-04	2,74E-04

Table 50. Weighted benchmark values for men T-shirts

Impact category	Life cycle excl. use stage	Use stage
Acidification	4,23E-05	2,54E-06
Climate change, total	1,55E-04	2,50E-05
Eutrophication, freshwater	2,82E-05	1,44E-06
Eutrophication, marine	8,15E-06	1,17E-06
Eutrophication, terrestrial	1,62E-05	7,98E-07
Ionising radiation, human health	1,92E-06	3,73E-06
Land use	1,24E-05	-3,06E-07
Ozone depletion	8,44E-07	1,83E-09
Photochemical ozone formation, human health	2,23E-05	1,60E-06
Resource use, fossils	9,68E-05	1,70E-05
Resource use, minerals and metals	3,08E-05	4,47E-07
Particulate matter	1,37E-04	1,40E-06
Water use	6,47E-05	2,47E-05
Total result	6,17E-04	7,95E-05

The results of the benchmark for women T-shirts are available in the Table 51, Table 52 and Table 53.

Table 51. Characterised benchmark values for women T-shirts

Impact category	Unit	Life cycle excl. use stage	Use stage
Acidification	mol H^+_{eq}	3,35E-02	2,12E-03
Climate change, total	kg $CO_{2\,eq}$	5,17E+00	8,75E-01
Eutrophication, freshwater	kg P_{eq}	2,29E-03	1,24E-04
Eutrophication, marine	kg N_{eq}	7,04E-03	1,06E-03
Eutrophication, terrestrial	mol N_{eq}	7,01E-02	3,61E-03
Ionising radiation, human health	kBq U^{235}_{eq}	1,41E-01	2,93E-01
Land use	Dimensionless (pt)	1,85E+02	-4,83E+00 (cf. footnote 21, page 94)
Ozone depletion	kg CFC-11 $_{eq}$	2,75E-07	6,35E-10
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	1,69E-02	1,27E-03
Resource use, fossils	MJ	6,73E+01	1,24E+01
Resource use, minerals and metals	kg Sb $_{eq}$	2,08E-05	3,20E-07
Particulate matter	disease incidence	8,61E-07	9,35E-09
Water use	m^3 world $_{eq}$	7,75E+00	3,15E+00

Table 52. Normalised benchmark values for women T-shirts

Impact category	Life cycle excl. use stage	Use stage
Acidification	6,03E-04	3,82E-05
Climate change, total	6,67E-04	1,13E-04
Eutrophication, freshwater	8,97E-04	4,87E-05
Eutrophication, marine	2,49E-04	3,76E-05
Eutrophication, terrestrial	3,96E-04	2,04E-05
Ionising radiation, human health	3,34E-05	6,94E-05
Land use	1,39E-04	-3,63E-06
Ozone depletion	1,17E-05	2,71E-08
Photochemical ozone formation, human health	4,16E-04	3,14E-05
Resource use, fossils	1,03E-03	1,90E-04
Resource use, minerals and metals	3,59E-04	5,53E-06
Particulate matter	1,35E-03	1,47E-05
Water use	6,74E-04	2,74E-04

Table 53. Weighted benchmark values for women T-shirts

Impact category	Life cycle excl. use stage	Use stage
Acidification	4,01E-05	2,54E-06
Climate change, total	1,48E-04	2,50E-05
Eutrophication, freshwater	2,65E-05	1,44E-06
Eutrophication, marine	7,77E-06	1,17E-06
Eutrophication, terrestrial	1,55E-05	7,98E-07
Ionising radiation, human health	1,79E-06	3,73E-06
Land use	1,17E-05	-3,06E-07
Ozone depletion	7,93E-07	1,83E-09
Photochemical ozone formation, human health	2,12E-05	1,60E-06
Resource use, fossils	9,19E-05	1,70E-05
Resource use, minerals and metals	2,90E-05	4,47E-07
Particulate matter	1,29E-04	1,40E-06
Water use	6,08E-05	2,47E-05
Total result	5,84E-04	7,95E-05

The results of the benchmark for children (2 to 7 years old) T-shirts are available in the Table 54, Table 55 and Table 56.

Table 54. Characterised benchmark values for children (2 to 7 years old) T-shirts

Impact category	Unit	Life cycle excl. use stage	Use stage
Acidification	mol H^+_{eq}	2,37E-02	1,39E-03
Climate change, total	kg $CO_{2\,eq}$	3,81E+00	5,68E-01
Eutrophication, freshwater	kg P_{eq}	1,52E-03	7,77E-05
Eutrophication, marine	kg N_{eq}	5,18E-03	6,78E-04
Eutrophication, terrestrial	mol N_{eq}	5,24E-02	2,38E-03
Ionising radiation, human health	kBq U^{235}_{eq}	9,49E-02	1,92E-01
Land use	Dimensionless (pt)	1,29E+02	-2,87E+00 (cf. footnote 21, page 94)
Ozone depletion	kg CFC-11 $_{eq}$	1,82E-07	4,05E-10
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	1,24E-02	8,30E-04
Resource use, fossils	MJ	4,96E+01	8,13E+00
Resource use, minerals and metals	kg Sb_{eq}	1,40E-05	2,07E-07
Particulate matter	disease incidence	5,85E-07	6,48E-09
Water use	m^3 world $_{eq}$	5,18E+00	1,97E+00

Table 55. Normalised benchmark values for children (2 to 7 years old) T-shirts

Impact category	Life cycle excl. use stage	Use stage
Acidification	4,27E-04	2,50E-05
Climate change, total	4,91E-04	7,32E-05
Eutrophication, freshwater	5,97E-04	3,05E-05
Eutrophication, marine	1,83E-04	2,40E-05
Eutrophication, terrestrial	2,96E-04	1,35E-05
Ionising radiation, human health	2,25E-05	4,55E-05
Land use	9,73E-05	-2,16E-06
Ozone depletion	7,79E-06	1,73E-08
Photochemical ozone formation, human health	3,07E-04	2,05E-05
Resource use, fossils	7,60E-04	1,24E-04
Resource use, minerals and metals	2,42E-04	3,57E-06
Particulate matter	9,18E-04	1,02E-05
Water use	4,50E-04	1,71E-04

Table 56. Weighted benchmark values for children (2 to 7 years old) T-shirts

Impact category	Life cycle excl. use stage	Use stage
Acidification	2,84E-05	1,66E-06
Climate change, total	1,09E-04	1,62E-05
Eutrophication, freshwater	1,76E-05	8,99E-07
Eutrophication, marine	5,71E-06	7,48E-07
Eutrophication, terrestrial	1,16E-05	5,27E-07
Ionising radiation, human health	1,21E-06	2,44E-06
Land use	8,19E-06	-1,82E-07
Ozone depletion	5,26E-07	1,17E-09
Photochemical ozone formation, human health	1,56E-05	1,04E-06
Resource use, fossils	6,78E-05	1,11E-05
Resource use, minerals and metals	1,96E-05	2,89E-07
Particulate matter	8,75E-05	9,70E-07
Water use	4,06E-05	1,55E-05
Total result	4,13E-04	5,12E-05

The results of the benchmark for children (8 to 14 years old) T-shirts are available in the Table 57, Table 58 and Table 59.

Table 57. Characterised benchmark values for children (8 to 14 years old) T-shirts

Impact category	Unit	Life cycle excl. use stage	Use stage
Acidification	mol H^+_{eq}	2,95E-02	1,77E-03
Climate change, total	kg $CO_{2\,eq}$	4,62E+00	7,26E-01
Eutrophication, freshwater	kg P_{eq}	1,98E-03	1,01E-04

Impact category	Unit	Life cycle excl. use stage	Use stage
Eutrophication, marine	kg N_{eq}	6,29E-03	8,76E-04
Eutrophication, terrestrial	mol N_{eq}	6,29E-02	3,02E-03
Ionising radiation, human health	kBq U^{235}_{eq}	1,22E-01	2,44E-01
Land use	Dimensionless (pt)	1,62E+02	-3,87E+00 (cf. footnote 21, page 94)
Ozone depletion	kg CFC-11 $_{eq}$	2,38E-07	5,23E-10
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	1,51E-02	1,06E-03
Resource use, fossils	MJ	6,01E+01	1,03E+01
Resource use, minerals and metals	kg Sb $_{eq}$	1,80E-05	2,65E-07
Particulate matter	disease incidence	7,49E-07	7,98E-09
Water use	m^3 world $_{eq}$	6,71E+00	2,57E+00

Table 58. Normalised benchmark values for children (8 to 14 years old) T-shirts

Impact category	Life cycle excl. use stage	Use stage
Acidification	5,32E-04	3,18E-05
Climate change, total	5,95E-04	9,36E-05
Eutrophication, freshwater	7,75E-04	3,98E-05
Eutrophication, marine	2,22E-04	3,10E-05
Eutrophication, terrestrial	3,56E-04	1,71E-05
Ionising radiation, human health	2,90E-05	5,78E-05
Land use	1,22E-04	-2,91E-06
Ozone depletion	1,02E-05	2,23E-08
Photochemical ozone formation, human health	3,72E-04	2,61E-05
Resource use, fossils	9,21E-04	1,58E-04
Resource use, minerals and metals	3,11E-04	4,58E-06
Particulate matter	1,18E-03	1,25E-05
Water use	5,83E-04	2,24E-04

Table 59. Weighted benchmark values for children (8 to 14 years old) T-shirts

Impact category	Life cycle excl. use stage	Use stage
Acidification	3,53E-05	2,11E-06
Climate change, total	1,32E-04	2,08E-05
Eutrophication, freshwater	2,29E-05	1,17E-06
Eutrophication, marine	6,94E-06	9,66E-07
Eutrophication, terrestrial	1,39E-05	6,67E-07
Ionising radiation, human health	1,56E-06	3,11E-06
Land use	1,03E-05	-2,45E-07

Impact category	Life cycle excl. use stage	Use stage
Ozone depletion	6,85E-07	1,51E-09
Photochemical ozone formation, human health	1,90E-05	1,33E-06
Resource use, fossils	8,21E-05	1,41E-05
Resource use, minerals and metals	2,51E-05	3,70E-07
Particulate matter	1,12E-04	1,19E-06
Water use	5,27E-05	2,02E-05
Total result	5,15E-04	6,58E-05

The results of the benchmark for babies T-shirts are available in the Table 60, Table 61 and Table 62.

Table 60. Characterised benchmark values for babies T-shirts

Impact category	Unit	Life cycle excl. use stage	Use stage
Acidification	mol H^+_{eq}	1,92E-02	1,08E-03
Climate change, total	kg $CO_{2\,eq}$	3,18E+00	4,40E-01
Eutrophication, freshwater	kg P_{eq}	1,42E-03	5,83E-05
Eutrophication, marine	kg N_{eq}	4,32E-03	5,17E-04
Eutrophication, terrestrial	mol N_{eq}	4,30E-02	1,87E-03
Ionising radiation, human health	kBq U^{235}_{eq}	7,81E-02	1,50E-01
Land use	Dimensionless (pt)	1,15E+02	-2,05E+00 (cf. footnote 21, page 94)
Ozone depletion	kg CFC-11 $_{eq}$	1,46E-07	3,09E-10
Photochemical ozone formation, human health	kg $NMVOC_{eq}$	1,04E-02	6,45E-04
Resource use, fossils	MJ	4,07E+01	6,34E+00
Resource use, minerals and metals	kg Sb $_{eq}$	1,47E-05	1,60E-07
Particulate matter	disease incidence	4,46E-07	5,29E-09
Water use	m^3 world $_{eq}$	4,80E+00	1,48E+00

Table 61. Normalised benchmark values for babies T-shirts

Impact category	Life cycle excl. use stage	Use stage
Acidification	3,46E-04	1,95E-05
Climate change, total	4,09E-04	5,67E-05
Eutrophication, freshwater	5,56E-04	2,28E-05
Eutrophication, marine	1,53E-04	1,83E-05
Eutrophication, terrestrial	2,43E-04	1,06E-05
Ionising radiation, human health	1,85E-05	3,55E-05
Land use	8,64E-05	-1,54E-06
Ozone depletion	6,23E-06	1,32E-08

Impact category	Life cycle excl. use stage	Use stage
Photochemical ozone formation, human health	2,56E-04	1,59E-05
Resource use, fossils	6,23E-04	9,70E-05
Resource use, minerals and metals	2,54E-04	2,76E-06
Particulate matter	7,01E-04	8,31E-06
Water use	4,17E-04	1,29E-04

Table 62. Weighted benchmark values for babies T-shirts

Impact category	Life cycle excl. use stage	Use stage
Acidification	2,30E-05	1,30E-06
Climate change, total	9,08E-05	1,26E-05
Eutrophication, freshwater	1,64E-05	6,74E-07
Eutrophication, marine	4,76E-06	5,69E-07
Eutrophication, terrestrial	9,50E-06	4,14E-07
Ionising radiation, human health	9,93E-07	1,91E-06
Land use	7,27E-06	-1,29E-07
Ozone depletion	4,21E-07	8,90E-10
Photochemical ozone formation, human health	1,30E-05	8,11E-07
Resource use, fossils	5,56E-05	8,65E-06
Resource use, minerals and metals	2,06E-05	2,23E-07
Particulate matter	6,69E-05	7,93E-07
Water use	3,77E-05	1,16E-05
Total result	3,47E-04	3,94E-05

7.2 PEF profile

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

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

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

7.3 Additional technical information

No additional technical information shall be included.

7.4 Additional environmental information

No additional environmental information shall be included.

Activities related to T-shirt production contribute to impact on biodiversity. Mainly it is focus on the raw material extraction and production of natural and synthetic fibres. Five potential pressures constitute an important effect on biodiversity: loss and degradation of natural habitats, overexploitation of biological resources, pollution and excessive nutrient loads, climate change and invasive alien species on the ecosystem [29].

The relations between raw material and their consequences on biodiversity are described in the following list:

- Raw material for natural fibres (from crops) as cotton, hemp, flax, etc:
    - extensive area cropland could cause degradation and fragmentation of habitats;
    - use of large amount of water with a significant impact on the ecosystem, for instance cotton production use more water consumption than flax or hemp;
    - chemical product as fertilizers or pesticides and other agricultural chemicals contributing to excessive nutrient lead in soil and water.
- Raw material for natural fibres (from animals) as wool, silk, etc:
    - impact from multiple land uses affect to degradation and fragmentation of natural habitats, however for the production of silk the area extension impact is limited by the way of cultivation;
    - the livestock production pollution impact could come from pesticides used to protect animals from parasites (for wool);
    - climate change impact has as its source the fossil fuel used on the agrochemicals production, on the farming and distribution of feed grops, as well as the own livestock.
- Raw material for artificial or regenerated fibres as viscose:
    - lack of management of natural forest and plantation could occasion degradation and fragmentation of habitats;
    - utilisation of agrochemical in forest plantation and in the pulp mill could discharge pollutants in soil and water;
    - loss of forest and use of energy contribute to the climate change impact.
- Raw material for synthetic fibres as polyester: only the areas exploitation for non-renewable sources and energy use contribute to impact the pressures mentioned before.

There is currently no adequate indicator to express impacts on biodiversity [30]. The suggestions offered in the chapter 7.12 “Biodiversity” of the PEFCR guidance v6.3 were studied. To report the percentage of material that comes from ecosystems that have been managed to maintain or enhance conditions for

biodiversity, or the percentage of materials for which no chain of custody or traceability information can be found, is not suitable for the textile sector and cannot be used to express the biodiversity indicator. The use of certification systems as a proxy has also been studied. The analysis of available certificates has highlighted the difficulty of covering the various raw materials that can be used to produce T-shirts with information on performance in assuring biodiversity maintenance.

In the absence of a method, biodiversity is not integrated at this time. The possibility to take into account the biodiversity will be considered during the revision of the PEFCR as new methods may be available.

8 Verification

The verification of an EF study/report carried out in compliance with this PEFCR shall be done according to all the general requirements included in Section 8 of the PEFCR Guidance [enter version number] and the requirements listed below.

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

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

- the verifier shall check if the correct version of all impact assessment methods was used. For each of the most relevant impact categories, at least 50% of the characterisation factors (for each of the most relevant EF impact categories) shall be verified, while all normalisation and weighting factors of all ICs shall be verified. In particular, the verifier shall check that the characterisation factors correspond to those included in the EF impact assessment method the study declares compliance with[22];
- 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.

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

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.

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

1. Technical secretariat of the PEFCR pilot on T-shirts, Product Environmental Footprint (PEF) Category Rules (PEFCR) Pilot, T-shirts – Study of existing PCRs, draft scope, representative product, minutes of the consultation meeting, comments from stakeholder, June 2014
2. European Environment Agency, Comparing environmental impact data on cleaner technologies, Technical Report n°1, 1997
3. European Commission, JRC Scientific and Technical reports, Environmental improvement potential of textiles (IMPRO-Textiles), 2009
4. Boufateh I., Contribution à l'évaluation de la supply chain pour la filière textile : définition de critères de développement durable, Thèse de doctorat, 2011
5. De Saxcé M., Pesnel S., Perwuelz A., LCA of bed sheets – some relevant parameters for lifetime assessment, Journal of cleaner production, vol. 37, 221-228, 2012
6. Kalliala, E. M., 1997. The Ecology of Textiles and Textile Services - A LCA Assessment Study on Best Available Applications and Technologies for Hotel Textile Production and Services, Tampere University Technology Publications 214, 1-117, PhD thesis.
7. Working group 5 – Textile – Clothing, Minutes of the meeting, October 28, 2011, Environmental footprinting in France
8. ADEME-AFNOR, BP X30-323-23 : General principles for an environmental communication on mass market products Part 23: Methodology for the environmental impacts assessment of clothing, 2013, a reading guide will be available at http://www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=23735

9. Sustainable Apparel Coalition, PCR for Performance T-shirts, 2013, available at http://iere.org/wp-content/uploads/Performance-PCR-T-shirts.pdf
10. Technical secretariat of the PEFCR pilot on T-shirts, Consultation report - Virtual consultation on CEN, ISO or other tests available to quantify the lifetime of clothing, January 2015
11. European Standard, Size designation of clothes — Part 3: Measurements and intervals, prEN 13402-3:2011
12. 2ACR, DGE, ADEME, Etudes économiques – Analyse de la chaîne de valeur du recyclage des plastiques en France – Synthèse, 2014
13. PEFCR pilots: Heavy Duty Liquid Laundry Detergents (HDLLD) for machine wash, PEF screening report in the context of the EU Product Environmental Footprint Category Rules (PEFCR) Pilots – Household Heavy Duty Liquid Laundry Detergents (HDLLD) for machine wash, April 2015
14. Commissariat Général au Développement Durable, Etudes & Documents – Monétarisation des impacts environnementaux liés au recyclage, Le cas des papiers/cartons et des plastiques, n°44, mai 2011
15. European Commission, Integrated Pollution Prevention and Control (IPPC), Reference Document on Best Available Techniques for the Textiles Industry, July 2003
16. International Finance Corporation, Environmental, Health, and Safety Guidelines for Textile manufacturing, April 30, 2007
17. Zero Discharge of Hazardous Chemicals Programme, Wastewater Guidelines Draft V.3, 2016
18. SeaRates.com, Distances between ports (available at: http://www.searates.com/reference/portdistance/)
19. TV5MONDE, Distance between cities (available at: http://www.tv5.org/cms/chaine-francophone/voyageurs/outils/p-6717-Distance-entre-les-villes.htm)
20. Technical secretariat of the PEFCR pilot on T-shirts, PEF screening report in the context of the EU Product Environmental Footprint Category Rules Pilots, September 2015
21. « Household liquid laundry detergents » pilot, Description of the “representative product”, 2014
22. PricewaterhouseCoopers, Ecodesign of Laundry Dryers. Preparatory studies for Ecodesign requirements of Energy-using-Products (EuP) – Lot 16, Final Report, March 2009 (p°142)
23. COFREET, Meaning of symbols, available at http://www.lavermonlinge.com/FR/symboles_d_entretien/signification_des_symboles.asp
24. Commission des Communautés Européennes, Maîtrise de la demande électrique – Campagne de mesures par usage dans le secteur domestique, juillet 1996
25. Eurostats, Municipal waste generation and treatment, by type of treatment method, 2012, available at http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tsdpc240&language=en
26. ECO-TLC, Bilan de l’état de l’art réalisé en 2009 sur le tri et la valorisation des textiles d’habillement et du linge de maison consommés par les ménages, Octobre 2012
27. Woolridge A.C., Ward G. D., Phillips P. S., Collins M., Gandy S., Life cycle assessment for reuse/recycling of donated waste textiles compared to use of virgin material: An UK energy saving perspective, Resources, Conservation and Recycling 46 (2006) 94–103

28. Eurostat 2012 data, calculation based on Fraction of non-recycled municipal solid wastes that are incinerated ((1-R2)*Fraction of non-recycled municipal solid wastes that are incinerated), available at http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tsdpc240&language=en
29. IUCN (International Union for Conservation of Nature), Biodiversity Risk and Opportunities in the Apparel Sector, 2016
30. Technical Helpdesk, Mark Goedkoop, Issue Paper - Addressing biodiversity in the Environmental Footprint pilots, May 2015
31. Commission Européenne, Journal officiel de l'Union européenne, L 293/21, RÈGLEMENT (UE) N° 1015/2010 DE LA COMMISSION du 10 novembre 2010
32. European Commission, *PEFCR Guidance document*, - Guidance for the development of Product Environmental Footprint Category Rules (PEFCRs), version 6.3, December 2017 – Annex C (List of default values for A, R1, R2, R3 and Qs/Qp)
33. European Commission, *PEFCR Guidance document*, - Guidance for the development of Product Environmental Footprint Category Rules (PEFCRs), version 6.3, December 2017
34. Data coming from the retailers of the technical secretariat
35. Decathlon, Customer survey - Questionnaire "Customer Access in Stores Study", May 2014 (900 French customers surveyed with 600 responses)
36. Decathlon, Statistics of Decathlon stores, 2013 (number of visitors for one year, number of products sold in one year)

ANNEX 1 – List of EF normalisation and weighting factors

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

Impact category	Unit	Normalisation factor	Normalisation factor per person	Impact assessment robustness	Inventory coverage completeness	Inventory robustness	Comment
Climate change	kg $CO_{2\ eq}$	5.35E+13	7.76E+03	I	II	I	
Ozone depletion	kg CFC-11 $_{eq}$	1.61E+08	2.34E-02	I	III	II	
Human toxicity, cancer	CTUh	2.66E+05	3.85E-05	II/III	III	III	
Human toxicity, non-cancer	CTUh	3.27E+06	4.75E-04	II/III	III	III	
Particulate matter	disease incidence	4.39E+06	6.37E-04	I	I/II	I /II	NF calculation takes into account the emission height both in the emission inventory and in the impact assessment.
Ionising radiation, human health	kBq U^{235} $_{eq}$	2.91E+13	4.22E+03	II	II	III	
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	2.80E+11	4.06E+01	II	III	I/II	
Acidification	mol H^+ $_{eq}$	3.83E+11	5.55E+01	II	II	I/II	
Eutrophication, terrestrial	mol N $_{eq}$	1.22E+12	1.77E+02	II	II	I/II	
Eutrophication, freshwater	kg P $_{eq}$	1.76E+10	2.55E+00	II	II	III	
Eutrophication, marine	kg N $_{eq}$	1.95E+11	2.83E+01	II	II	II/III	

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

Weighting factors for Environmental Footprint

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

ANNEX 2 - check-list for the PEF study

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

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

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

ANNEX 3 - Critical review report of the PEFCR

Product Environmental Footprint Category Rules (PEFCR) for "T-shirts"

Version 8 of September 2018

CRITICAL REVIEW REPORT

Review Panel

Name of the member	***Affiliation***	***Role***
Ugo Pretato	Studio Fieschi & soci Srl	Chair of the review panel
Vanessa Pasquet	Quantis International	Member of the review panel
Jacques Poulenard	THAÏS Quality Consulting	Member of the review panel

Review Scope

The task of the review panel was to assess the compliance of the PEFCR document against the following requirements:

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

Review Process

The review has been performed in two distinct rounds.

The first round was carried out between December 2016 and January 2017 on a previous version of the PEFCR document and against the requirements of the PEFCR guidance version 5.2. The panel made several comments, which were satisfactorily addressed by the Technical Secretariat in an updated PEFCR version.

The second round was performed in August and September 2018 on the final PEFCR version. This version applies the requirements of the PEFCR guidance version 6.3 and the results of the remodelling carried out on the representative products during 2017 and 2018. The panel made other comments which were promptly addressed by the Technical Secretariat in the Final PEFCR version n.8

The full list of the comments made in the two review rounds and the related responses and corrective actions from the Technical Secretariat are documented in separate annexes.

Review Statement

We hereby confirm that, following the PEFCR examination, we have not established any relevant deviations by the above-referenced PEFCR document with respect to the requirements identified in the review scope.

We confirm we have been independent in our roles as reviewers, we have not been involved in the preparation of the PEFCR or related supporting studies and we have no conflicts of interest regarding this review.

The PEFCR validity is set until 31 December 2020.

We acknowledge the commitment undertaken by the Technical Secretariat in developing this PEFCR and the good and constructive collaboration with the TS members during the review.

Yours sincerely,

13 September 2018

Ugo Pretato	Vanessa Pasquet	Jacques Poulenard
		

Table of comments (2nd round)

Organization	*PEFCR Review Panel*
Commenter name	*Ugo Pretato (UPR), Vanessa Pasquet (VPQ), Jacques Poulenard (JPL)*
Date	**13 September, 2018**

0	1	2	3	4	5	6	7	8	9	10
N°	**Reviewer**	**Page**	**Line number**	**Clause No./ Subclause No./ Annex** (e.g. 3.1)	**Paragraph/ Figure/ Table/ Note** (e.g. Table 1)	**Type of comment**[1]	**Comment (justification for change)**	**Proposed change**	**Technical Secretariat observations** on each comment submitted	**Closure**
1	UPR	17-18	379, 388	2.3	Rewiew requirements	ed	Reference PEFCR guidance is missing	Add PEFCR Guidance v6.3	Reference PEFCR Guidance (v6.3) is added.	Approved
2	UPR	20	470-474	3.1	CPA code	ge	The explanation of the CPA code is not fully clear. Different categories are mentioned (e.g. C14.1, C14.14), another one is missing (wearing apparels, articles of fur). The paragraph is overall confusing.	Rewrite and simplify the paragraph	The paragraph is deleted.	Approved
3	UPR	21 and others	490 (example)	3.2 (example)	Table 3	ed	Throughout the PEFCR, the same numbers in superscript are used to identify both the references in §9 and the explanatory footnotes. This generates confusion in the reader	Differentiate symbols, for instance use number in square brackets for references	The PEFCR is modified: number in square brackets are used for references.	Approved
4	UPR	21	496	3.3	Table 4	ge	The aspects in table 4 could be also interpreted in a slightly different way. How well could be defined as “wearing a clean T-shirt until it becomes dirty” while How long could correspond to “52 times”. In this way all parameters would be characterized, whilst the issue of different life spans would remain.	No mandatory requirements, but consider amending table 4 as suggested.	The functional unit is modified.	Approved

5	UPR	22	506	3.3	Ref. flow	ed	The reference flow shall be 1 single T-shirt, not a generic number of T-shirts	Correct the reference flow	The reference flow is corrected.	Approved
6	UPR	24	560-566	3.3	Example	ge	The first example on communication is unclear. Why the results for all impact categories can cause misunderstanding for the consumers?	Explain or remove the example	The reference to the PEFCR guidance is deleted.	Approved
7	UPR	25	587-594	3.3	Life span	ed	The issue of life span is very important and represents one of the main limitations in applying the PEFCR. For this reason, this section should be more appropriate in the chapter on limitations.	Move the description of life span to section 3.6 on limitations	The description of life span is moved to section 3.6 “Limitations”.	Approved
8	UPR	26	600	3.4	Figure 4	ge	According to the following sections on life cycle inventory (e.g. see table 13), all processes in the core section could be characterized with primary company-specific data, including finishing, spinning and knitting.	Double-check and revise the identification of primary data in the system boundary diagram	The figure 4 identifies the steps for which some primary activity data is required, that is to say the processes listed in the Table 13. Spinning is now identified as a step for which some primary activity data is required, and the legend is modified.	Approved. Actually only spinning needs to be added
9	UPR	27	607	3.4	Table 6	ed	What is LCS?	Life Cycle Stage or add LCS to the acronym list	LCS is added to the acronym list.	Approved
10	UPR	28	616	3.4	Use stage	ed	The issue paper on the use stage is outdated	Refer to the PEFCR Guidance, use stage modelling §7.17	The reference is modified.	Approved
11	UPR	29	624	3.5	Table 7	ed	Remove unnecessary text under climate change biogenic and land use	Remove unnecessary text under climate change biogenic and land use	Unnecessary text under climate change biogenic and land use is removed.	Approved
12	UPR	30	639-647	3.6	General	te	The limitations section does not include the conditions under which comparisons or comparative assertions can be made against the benchmark or between T-shirts belonging to the same representative product	Add a guidance on comparison and comparative assertion. In doing this, consider the limitations associated to the T-shirts life span and possibly any additional limitations associated to the correction factors for the different sizes	A sentence is added. The use of a correction factor avoids having a limitation on the comparison of sizes.	Approved
13	UPR	31	690	4	Babies T-shirts	te	Unlike the other products, babies T-shirts has resource	Double-check the model and verify the relevant processes	For babies T-shirt, the buttons are 50% metal and 50%	Approved. Results for

							minerals/metals among the most relevant impact categories. Looking at the BoM in table 3, this could be due to the contribution from buttons (2.57 gr) but they should be made of metals	for babies T-shirt which contribute to the impact category	plastics. . The most relevant processes for the sub-category Babies T-shirts for the impact category “Resource use, mineral and metals” are: metal snaps (29,7%), cotton fibres (28%), fabric dyeing (18,1%) and yarn dyeing (6,3%). The results are consistent.	Babies T-shirts available in v.11. Metal snaps from accessories production is a relevant process
14	UPR	33	695	4	General	te	For all representative products, the car transport by consumer pops up as relevant process for many impact categories, e.g. 13-14 % for climate change. This is surprisingly high, since the distance covered by consumers is just a few kilometres, as from the default values in tables 36-37-38 of the PEFCR	Double-check the model and explain	The model has been verified. The same type of results were observed during the PEF screening. The customer travel is modelled based on transport by car and the customers are buying around 2,7 products. The customer travel corresponds to a transport by car of 4,56 km.	Approved
15	UPR	33-34	717-729	5	Sampling	te	The sampling procedure is overall confused, the reference to table 24 seems also wrong.	Improve the explanation, make a clearer reference to rules and examples in the PEFCR Guidance, §7.5	Explanation and reference to the guidance are added. The table 24 provides the unit for each process which is necessary to apply the sampling procedure.	Approved
16	UPR	34	738	5.1	Table 13	te	The T-shirt weight is missing in the list of mandatory-company specific data, it is only mentioned in the following note	Add T-shirt weight to table 13.	The note is moved to the Table 13.	Approved
17	UPR	35	742-745	5.1	Bullet point	te	The requirement is overall unclear	Provide clearer guidance to the PEFCR user on how to interpret this requirement (e.g. how to model restocking) also in relation to the excel file for data collection	The paragraph is modified.	Approved
18	UPR	57 and others	1265	6.1 and others	Table 26 and followings	ge	In general, the cycleco node https://node.cycleco.eu/node/ that should contain the secondary datasets looks empty	Double-check and justify	The secondary datasets are available on cycleco node. It is necessary to login to have access to the datasets.	Approved, I was unaware of this

19	UPR	60	1300	6.2	Agri modelling	ge	Many raw materials for T-shirts come from agricultural systems (e.g. cotton, wool, silk), therefore several agricultural modelling rules of the PEFCR guidance could be in principle applicable. On the other hand, raw material production is generally in situation 2 or 3 of the DNM, therefore the PEFCR user will normally apply secondary datasets in which modelling rules are already fixed.	Consider the option of adding the agricultural modelling section to the PEFCR, i.e. section B.6.2 of the PEFCR Guidance, especially if a user may have access to primary data on raw materials and cultivation	The production of the textile raw materials is not expected to be run by the company applying the PEFCR. The agricultural modelling section is not added to the PEFCR as the company will directly use the secondary datasets.	Approved
20	UPR	64÷67	1306-1317	6.2	Table 29, transport data	ge	All raw materials transport data should be moved to the raw materials section (6.1) as this life cycle stage stays between raw materials and manufacturing. Also The PEFCR template in the guidance puts transport under 6.1. Add also transport values for organic cotton. Move also the text on page 72	Move table 29 and related text to 6.1 before manufacturing.	The spinning secondary datasets take into account the transport of raw materials. According to the system boundary of spinning datasets it seems more relevant to consider the transport of raw materials in the part 6.2. Table 29 also deals with the transport of textile materials between the manufacturing processes (transport of yarn, transport of knitted fabric, transport of dyed fabric, transport of printed fabric and transport before assembly) which are relative to the manufacturing life cycle stage. Transport values are added for organic cotton.	Approved, transport data can stay in 6.2
21	UPR	64	1313	6.2	Table 29	te	Transport data of organic cotton are missing in the table	Add default distances and other parameters for organic cotton	Transport values are added for organic cotton.	Approved
22	UPR	71-72	1400	6.2	Figure 5	te	The selection of the level of performance of the wastewater treatment according to the threshold of emissions in figure 5 is not fully clear. My interpretation would be as follows:	Clarify with one or more illustrative examples	Some examples are added.	Approved

							1) If my COD emissions are 100 mg/l I shall apply an average WWT 2) If my COD emissions are 200 mg/l I shall apply a low WWT 3) If my COD emissions are 30 mg/l I shall apply an efficient WWT			
23	UPR	72	1408 and followings	6.2	Transport	ed	The paragraph on transportation processes default value and secondary datasets should be moved to section 6.1 along with table 29 (see above)	Move the section to 6.1 before manufacturing	Cf. comment n°20	Approved
24	UPR	74	1446	6.3	Table 34 and 35	te	There is no full consistency between the default values in table 34 and the assumptions in table 35. For instance, the default distances of 1173 km and 0.26 km between warehouse and store do not correspond to the modelling assumptions	Double-check and explain	The table 35 is modified to explain the calculation of the default values.	Approved
25	UPR	77	1508	6.4	Table 39 and following	te	It is unclear if the values in table 39 refer to 1 kg of laundry or 1 kg of T-shirt	Clarify	The table 39 refers to 1 kg of T-shirt. The information is added for washing and drying.	Approved
26	JPL	78	1513-1517	6.4	Drying	te	If drying of T-shirt is not only allowed but necessary (by air for example), Tumbler drying may be allowed.	**Drying** ~~If~~ **Drying** ~~is allowed~~ depends on care label instructions, **and** we consider 90% of air drying and 10% of tumble drier (the use rate is defined in Annex 4). **In the case of tumbler drying**, The energy consumption is 2.01 kWh/cycle (full load of 6 kg)[22]…….	There are two options for the drying: Option 1: the drying in tumble drier is allowed, then an energy consumption is taken into account, Option 2: the drying in tumble drier is not allowed, there is no impact for this step. The sentence is modified to better reflect that.	Approved

27	UPR	79 and excel LCI file	1535	6.4	Table 41	te	Why the use stage considers the consumption grid mix instead of the residual mix? This seems not in line with the electricity modelling rules of the PEFCR Guidance	Double-check and explain	The PEFCR Guidance mentions « For the use stage the consumption grid mix shall be used." (cf. part 7.13.6 "Electricity use at the use stage").	Approved
28	JPL	92	1674-1681	7.4	biodiversity	ed	According to the relations between raw material and their consequences on biodiversity the arguments for the production of silk aren't in my opinion relevant because if we can consider that the area extension impact is limited by the way of cultivation isn't not true because we don't cultivate silk but mulberries which are the only nutriment for the silkworms which produced cocoons from which is extracted raw silk Secondly in the second arguments about the livestock production pollution impact producers don't clean raw silk materials using use chemical products at the stage of production of the raw silk material. Moreover for silk production it'is impossible to use pesticides which are poison for the silkworms even of the mulberries leaves. The conditions for the production of raw animal fibers are so different.	• impact from multiple land uses affect to degradation and fragmentation of natural habitats, however for the production of silk the area extension impact is limited by the way of cultivation **of mulberries** ; • the livestock production pollution impact could come from pesticides used to protect animals from ~~parasites or chemical products used during the silk cleaning~~; **except for the production of raw sil**k	Concerning the first comment on silk (land uses), the report refers to silk and not cultivation of mulberries. Concerning the second comment, the sentence is modified.	Approved
29	UPR	Excel LCI file	-	-	General	te	There is not a clear identification of mandatory company-specific data required in the various processes. There is instead a longer list of "primary data" which seems to encompass both mandatory data (PEFCR 5.1) and data from processes run by the company (PEFCR 5.2)	Make a clear distinction between mandatory data and other primary data, at least in the first overarching datasheet.	A distinction is made between mandatory data and other primary data in the first overarching datasheet.	Approved. Mandatory data are in green font, but please add a caption

30	UPR	Excel LCI file	-	-	General	te	Some tables in the excel file are still incomplete. Add uuid in the excel file, like in the tables in the PEFCR text and complete the dataset list	Make sure information in the excel file are consistent with the inventory tables reported in the PEFCR text. Complete the secondary datasets list and add UUID for all datasets	The secondary datasets list is completed, the UUID are added.	Approved. All textile datasets have become ILCD datasets and considered as data gaps
31	UPR	Excel LCI file	-	-	General	te	In some datasheets (e.g. transport to stores, electricity) The DQR values are not the average of the 4 parameters TiR, TeR, GR and P	Double-check and amend as appropriate. Perhaps add a formula for an authomatic calculation. Check also in the other datasheets	The column « DQR » is completed with the « Overall quality » information as available in the datasets.	Approved
32	VPQ	17	375	2.3	Table 2	ge	Vanessa left avniR for Quantis meanwhile	Add Quantis affiliation for Vanessa	Quantis is added.	Approved
33	VPQ	18	403	2.5		ed	EFTA is not in acronym list	Precise EFTA in acronym list	EFTA is added in the acronym list.	Approved
34	VPQ	24	585	3.2		te	Some T-shirts may not have a 52 washes lifespan.	Please, precise this limitations in lign 585: “The use of a standard life span is a limitation of the study as some **T-shirts may have a shorter lifespan than 52 washes.**	The information is added.	Approved
35	VPQ	27	605	3.4		ed	LCS is not in acronym list	Precise LCS in acronym list	The acronym “LCS” is added.	Approved
36	VPQ	27	605	3.4		ge	Are transportation between several suppliers in “production of materials” stage taken into account? Ex: from crop cultivation to textile mill where cotton will be bleached.	Precise if transportation into this stage is considered or not.	The transport are integrated in the datasets. The system boundary is described in the datasets.	Approved
37	VPQ	30	637	3.6		ge	2 first paragraphs of this section were explained in “3.1 Product classification” and in “3.2 Representative product(s)”	Choose in which section they should be written. Product limitation may be kept in “product classification” section where boundaries are defined and explanation on lifespan may be put in “limitations”	Explanation on lifespan is moved to the part 3.6 Limitations. The paragraph on product limitation (scope) is deleted as information is already available in chapter “3. PEFCR scope”.	Approved

38	VPQ	32	700	4		ge	Results are missing	Add most relevant life cycle stages for all sub-categories	The results from remodelling are added.	Approved
39	VPQ	34	714	4	Table 8	ed	“Production T-shirt” should be replaced by “T-shirt production” or “Production of T-shirt”	“Production T-shirt” should be replaced by “T-shirt production” or “Production of T-shirt”	“Production T-shirt” is replaced by “Production of T-shirt”.	Approved
40	VPQ	34-37	714-728	4	Table 8, 9, 10, 11 and 12	ge	Results are missing for several impact indicators	Add most relevant processes for these indicators	The results from remodelling are added.	Approved
41	VPQ	38	743 - 755	5		ge	Explanation on how an applicant of this PEFCR should consider sampling procedure is confused	Please describe the procedure more clearly.	Explanation and reference to the guidance are added.	Approved
42	VPQ	38	763	5.1		ge	As recycled materials are in the scope of this PEFCR, they should appear in “product materials phase” in table 4 page 26.	Please, add production of recycled materials in table 4.	The recycled materials are added in the figure 4.	Approved
43	VPQ	39	773	5.2		ge	If a retail company does not run any of listed process, does it mean it cannot apply PEFCR?	Please, clarify this point.	If a retail company does not run any of listed process, it has to refer to other situations than situation 1.	Approved
44	VPQ	42	824	5.2	Table 17	te	Spinning steps for cotton and for wool are very different in term of processes, are these differences taken into account?	Please, clarify this point.	The two technologies are covered with two different datasets.	Approved
45	VPQ	63	1289	6.1	Table 26	ge	Results are missing for “plastic link” and “elastic”	Please, add results for these processes	There is no dataset available for plastic link and elastic. The two lines are deleted.	Approved
46	VPQ	73	1390	6.2		ge	What is your source for end of life of production waste distribution?	Add source for these recycling percentages	The sources are added.	Approved
47	VPQ	81	1529	6.4		Te	Does wastewater treatment is taken into account in this stage?	Please, explain if it is excluded or not and if not, why.	The wastewater treatment is included. A line is added in the table 39.	Approved
48	VPQ	82		6.4		te	Are dust emissions into air considered in this stage?	Please, explain if it is excluded or not and if not, why.	Dust emissions are not included. Tumble driers are equipped with filters to prevent dust emissions during normal operation.	Approved
49	VPQ	90	1643	7.1	Table 50	ge	Results are missing for “weighted benchmark values”	Please, add results	The results from remodelling are added.	Approved

50	VPQ	96	1725	7.4		ge	About biodiversity, it is written: “The possibility to take into account the biodiversity will be considered during the revision of the PEFCR as new methods may be available. For example, the EBP project (Empreinte Biodiversité Produit), led by the company I Care & Consult, will end in 2017. This project aims to develop a tool to quantify the impact of products on biodiversity.” Did you try to quantify impact of product on biodiversity with this tool?	Switch from future to past as we are in 2018 or delete the last parts of the paragraph.	The last part of the paragraph is deleted.	Approved
51	VPQ	All				ed	Numbers of page in table of contents do not correspond to real page	Please update table of contents	The table of contents is updated.	Approved
52	VPQ	Excel file					In “raw materials production” tab, there is no “recycled fibers” in column C	Please, add recycled fibers in this column	“Recycled fibres” is added.	Approved

ANNEX 4 - Background information on methodological choices taken during the development of the PEFCR

Calculation of the correction factor

For women

	Size	T2	T3
T-shirt with long sleeves	Weight (in g)	95,0	97,5
	Weight difference (%)		2,63%

	Size	T0 or 36	T1 or T40	T2 or T42	T3 or T44	T4 or T46	T5 or T48	T6 or T50
T-shirt with long sleeves	Weight (in g)	136,0	140,0	144,0	152,0	156,0	162,0	176,0
	Weight difference (%)		2,94%	2,86%	5,56%	2,63%	3,85%	8,64%

	Size	36	38	40	42
T-shirt with short sleeves	Weight (in g)	89,2	93,8	98,3	101,7
	Weight difference (%)		5,23%	4,80%	3,39%

	Size	T1	T2	T3	T4
T-shirt with short sleeves (polyester / metalized fibres)	Weight (in g)	123,0	130,0	139,3	147,0
	Weight difference (%)		5,69%	7,18%	5,50%

	Size	T0 or 36	T1 or T40	T2 or T42	T3 or T44	T4 or T46	T5 or T48	T6 or T50
T-shirt with short sleeves	Weight (in g)	120,0	125,0	130,0	138,0	148,0	154,0	162,0
	Weight difference (%)		4,17%	4,00%	6,15%	7,25%	4,05%	5,19%

	Size	T1	T2	T3	T4
T-shirt without sleeves (viscose/EA)	Weight (in g)	80,7	89,8	95,8	105,7
	Weight difference (%)		11,36%	6,68%	10,26%

	Size	T2	T3
T-shirt without sleeves (cotton)	Weight (in g)	74,0	79,0
	Weight difference (%)		6,8%

	Size	T0 or 36	T1 or T40	T2 or T42	T3 or T44	T4 or T46	T5 or T48	T6 or T50
T-shirt without sleeves	Weight (in g)	70,0	74,0	80,0	86,0	90,0	95,0	100,0
	Weight difference (%)		5,71%	8,11%	7,50%	4,65%	5,56%	5,26%

Average for long sleeves T-shirts	3,52%
Average for short sleeves T-shirts	5,24%
Average for T-shirt without sleeves	7,44%
Average for women T-shirts	**5,64%**

For men

	Size	M	L	XL
T-shirt with short sleeves (cotton)	Weight (in g)	132,0	136,0	142,0
	Weight difference (%)		3,03%	4,41%

	Size	M	L	XL
T-shirt with short sleeves (cotton)	Weight (in g)	132,0	139,0	148,0
	Weight difference (%)		5,30%	6,47%

	Size	M	L	XL
Polo (cotton)	Weight (in g)	208,0	220,0	234,0
	Weight difference (%)		5,77%	6,36%

Average for short sleeves T-shirts	4,80%
Average for Polo	6,07%
Average for men T-shirts	**5,23%**

Drying process: calculation of the rate of use

It is necessary to consider two information to define the distribution between air drying and tumble dryer:

- the equipment rate (percentage of population equipped with a tumble dryer)
- the tumble dryer use rate (i.e. how consumers use their tumble dryer).

The equipment rate was defined based on the average penetration rates for Western (34,4%) and Eastern Europe (1%)[22] weighted with the respective populations. This leads to an equipment rate of 27%.

The tumble dryer use rate is defined thanks to PricewaterhouseCoopers' study (2009). This study contains the results of a survey conducted on consumers in France, in the United Kingdom and in Poland[22]. 86% of the people being questioned (648 people) use a tumble dryer. This rate was deliberately ordered to be high from the company conducting the survey in order to ensure relevant results for dryer owners, but yet include some votes from people frequenting launderettes.

The study shows different consumer behaviours from one country to another, but on the average, the results presented in both figures hereunder are obtained.

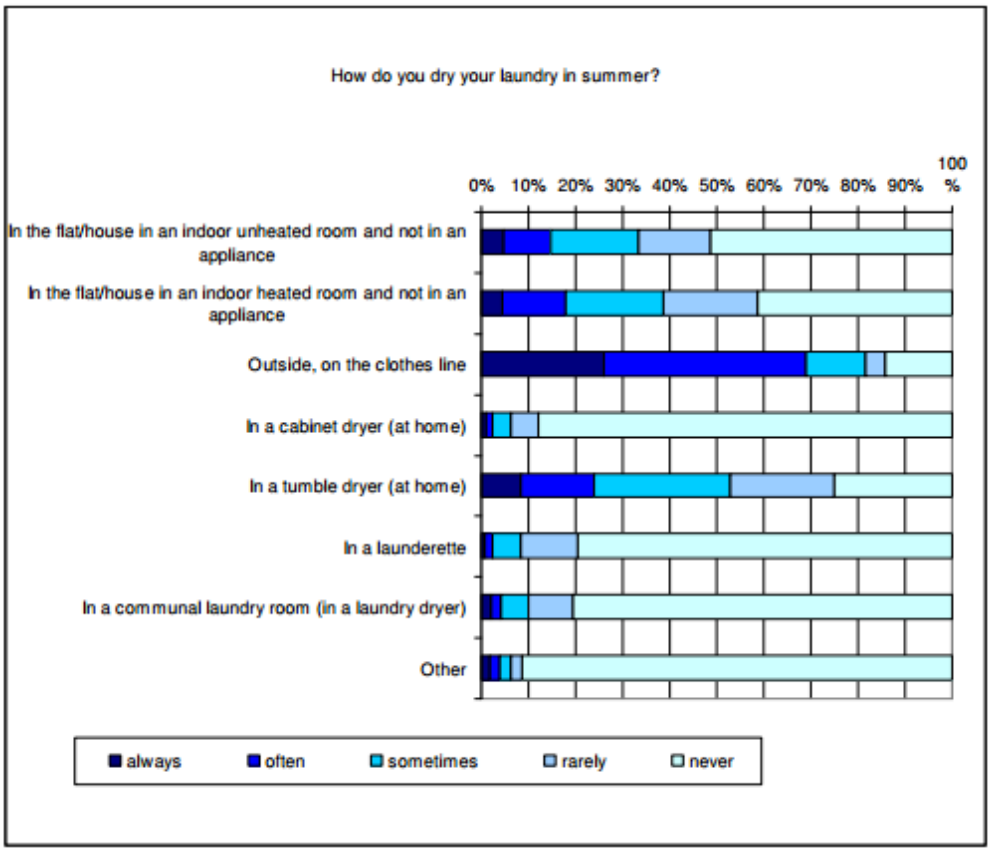

Figure 5. Results of PricewaterhouseCoopers' study: Drying laundry in summer

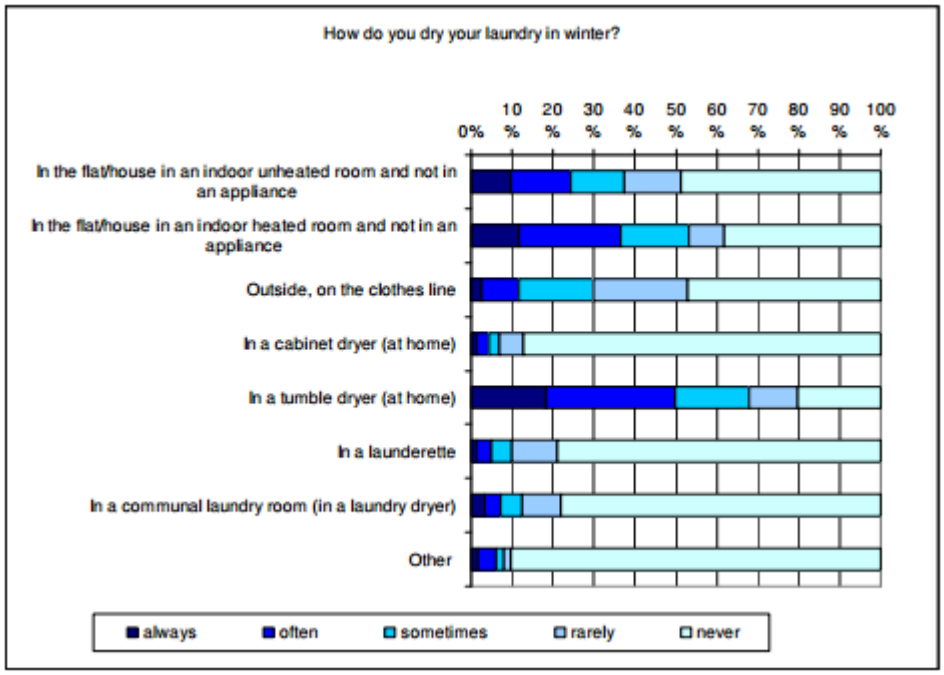

Figure 6. Results of PricewaterhouseCoopers' study: Drying laundry in winter

If we study the following choices, that are « Always » and « Often », the results hereafter are obtained (Table 63).

Table 63. Use of drying appliance in summer and winter

	Summer			Winter		
	Results extracted from the study (sum for "Always" et "Often")	Distribution without / with drying appliance	Results for 100%	Results extracted from the study (sum for "Always" et "Often")	Distribution without / with drying appliance	Results for 100%
In the flat/house in an indoor unheated room and not in an appliance	15%	102%	**72%**	24%	71%	**49%**
In the flat/house in an indoor heated room and not in an appliance	18%			36%		
Outside, on the clothes line	69%			11%		
In a cabinet dryer (at home)	3%	35%	**25%**	4%	67%	**46%**
In a tumble dryer (at home)	24%			50%		
In a launderette	3%			5%		
In a communal laundry room (in a laundry dryer)	5%			8%		
Other	4%	4%	**3%**	7%	7%	**5%**
TOTAL	141%	141%	**100%**	145%	145%	**100%**

On the average, over one year (hypothesis: 6 months in the summer, 6 months in the winter), this corresponds to the use of a tumble dryer (or other drying appliance) in 36% of the cases.

The PricewaterhouseCoopers' study (2009) also gives the average number of dryings in the summer and in the winter: 2,34 cycles/week/family in the summer versus 3,62 cycles/week/family in the winter. Based on this, and considering an average number of washings of 220 cycles per year[31], the IMPRO-TEX study concludes to a real utilization rate of 71%[3]. However, this 220 cycles/year average number of washings does not come from the same study and therefore raises a coherence issue.

The « Analysis and recovery of measurement campaigns on electric use in the residential sector » study published by ADEME, provides the average monthly ratio of the number of drying cycles compared to the number of washing cycles[28].

In July, the tumble dryer is used once for 4,3 washing cycles (23% use rate). And in December, once for 1,6 washing cycles (63% use rate). Over the year, the study shows an average use of the tumble dryer in 41% of the cases, i.e. one tumble dryer drying for 2,4 washing cycles.

Taking these results into account, the real rate of use was identified on the basis of the study conducted by PricewaterhouseCoopers (2009), leading to a real tumble dryer use rate of 36%. These results are consistent with the study published by ADEME and have an advantage: they were conducted on three European countries (France, the United Kingdom and Poland).

Assumptions:

- Equipment rate: 27%[22, 3]
- Tumble dryer use rate: 36%

i.e. a final tumble dryer use rate of 10%

ANNEX 5 - Examples on how to use the DNM

For each process, options are selected according to the situation being identified. The company applying the PEFCR shall determine its level of influence (situation 1, 2 or 3) for each process in its supply chain (step 1). Should several options be proposed for one situation (cf. Table 27), the company implementing the PEFCR shall choose between the different options (step 2).

Table 64 provides several examples. Company A is a knitted fabric manufacturer whereas Company B is a retailer. Both companies have a different level of influence over the supply chain.

Table 64. Examples on how to use the DNM for two different companies

	Company applying the PEFCR	
	Company A (manufacturer: production of knitted fabric)	Company B (retailer)
Sizing process (non-relevant process)	*Step No.1: select the appropriate situation* Situation 1: the process is run by the company applying the PEFCR ➔ Option 1 or 2 *Step No.2: select the corresponding option* ➔ Option 2 (a default process is to be used)	*Step No.1: select the appropriate situation* Situation 3: the process is not run by the company applying the PEFCR and this company has no access to company-specific (activity) data relating to that process/material. ➔ One option available: Option 2 (a default process is to be used)
Knitting (most relevant process)	*Step No.1: select the appropriate situation* Situation 1: the process is run by the company applying the PEFCR ➔ One option available: Option 1 (use of company specific data)	*Step No.1: select the appropriate situation* Situation 3: the process is not run by the company applying the PEFCR and the company does not have access to company-specific (activity) data relating to that process/material. ➔ One option available: Option 1 (a default process is to be used)
Dyeing process (most relevant process)	*Step No.1: select the appropriate situation* Situation 3: the process is not run by the company applying the PEFCR and the company does not have access to company-specific (activity) data relating to that process/material. ➔ One option available: Option 1 (a default process is to be used)	*Step No.1: select the appropriate situation* Situation 2: the process is not run by the company applying the PEFCR but it is possible to have access to company-specific (activity) data. ➔ Option 1 or 2

		Step No.2: select the corresponding option ➔ Option 1 (use of company specific data)
Transportation between assembly and warehouse (most relevant process)	*Step No.1: select the appropriate situation* Situation 3: the process is not run by the company applying the PEFCR and the company does not have access to company-specific (activity) data relating to that process/material ➔ One option available: Option 1 (a default process is to be used)	*Step No.1: select the appropriate situation* Situation 1: the process is run by the company applying the PEFCR ➔ One option available: Option 1 (use of company specific data)