

# PRODUCT ENVIRONMENTAL FOOTPRINT REPRESENTATIVE PRODUCT (PEF-RP) STUDY REPORT

## APPAREL AND FOOTWEAR

Version 3.1  
29 April 2025

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THIRD PEF-RP study INFORMATION	
Title	Product Environmental Footprint – Representative Product (PEF-RP) study report – Apparel and Footwear
Leading organization	Cascale (former Sustainable Apparel Coalition)
Liability statement	Information contained in this report has been compiled and/or computed from sources believed to be credible. Application of the data are strictly at the discretion and the responsibility of the reader. Quantis is not liable for any loss or damage arising from the use of the information in this document.
Validity	Geographic validity: EU27 + EFTA + UK These category rules are in full compliance with the PEF method (2021).
Version	Version 3.1 – Final PEF-RP, 29 <sup>th</sup> April 2025
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**How to read this document**

**Notes addressed to the reader** are presented in orange boxes, as shown below:

<b>Note</b>	This document is based on the template provided by in Part E, Annex II: PEF Report Template of the PEF method which shall be applied for all types of PEF studies including the PEF-RPs and the supporting studies.
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## Acronyms and abbreviations

µm	Micrometre
AWARE	Available WAtER REmaining
BOM	Bill Of Materials
BSI	British Standards Institution
CEC	European Footwear Confederation
CFCs	Chlorofluorocarbons
CELC	European Confederation of Flax and Hemp
CFs	Characterization Factors
CFF	Circular Footprint Formula
CNMI	Camera Nazionale della Moda Italiana
CMWG	Cattle Model Working Group
CO <sub>2</sub>	Carbon Dioxide
CPA	Classification of Products by Activity
CTUe	Comparative Toxic Units for ecosystems
CTUh	Comparative Toxic Units for human health
DC	Distribution Centre
DNM	Data Needs Matrix
DoS	Duration of Service
DQR	Data Quality Rating
EC/DG-ENV	European Commission/Directorate-General for the Environment
ECOS	Environmental Coalition on Standards
EEB	European Environmental Bureau
EF	Environmental Footprint
EFTA	European Free Trade Association
EVA	Ethylene Vinyl Acetate
ELCD	European reference Life Cycle Database
EOL	End Of Life
FAO	Food and Agriculture Organization of the United Nations
FESI	Federation of the European Sporting Goods Industry
FHCM	Fédération de la Haute Couture et de la Mode
F2C	Factory to Consumer
FU	Functional Unit
g	gram
GHGs	Greenhouse Gases
GeR	Geographical Representativeness
GeR <sub>SD</sub>	Geographical Representativeness evaluated at the level of the secondary dataset
Higg PM	Higg Product Module
IFF	International Fur Federation
ILCD	International reference Life Cycle Data system
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
IWTO	International Wool Textile Organisation
JRC	Joint Research Centre
kBq U <sup>235</sup> eq	kilobecquerel uranium-235 equivalent
kcal	kilocalorie

kg	kilogram
kg CFC-11 eq	kilogram of trichlorofluoromethane or freon-11 equivalent
kg CO <sub>2</sub> -eq	kilogram of carbon dioxide equivalent
kg N eq	kilogram of nitrogen equivalent
kg NMVOC eq	kilogram of non-methane volatile organic compounds equivalent
kg P eq	kilogram of phosphorus equivalent
kg Sb eq	kilogram of antimony equivalent
km	kilometre
kWh	kilowatt-hour
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Inventory Assessment
LCS	Life Cycle Stage
LHVs	Lower Heating Values
LUC	Land Use Change
m	metre
m <sup>2</sup>	metre squared
m <sup>3</sup>	cubic metre
ME	Metabolizable Energy
MJ	<i>Megajoule</i>
mol H <sup>+</sup>	mole of Hydrogen ion
mol N eq	mole of Nitrogen equivalent
NACE	Nomenclature Générale des Activités Economiques dans les Communautés Européennes
NO <sub>x</sub>	Nitrogen Oxides
ODP	Ozone Depletion Potential
P	Precision/uncertainty
P <sub>AD</sub>	Precision evaluated at the level of the Activity Data
PAF	Potentially Affected Fraction of Species
PDF	Potentially Disappeared Fraction of Species
PE	Polyethylene
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PET	Polyethylene Terephthalate
PM	Particulate Matter
PPP	Purchasing Power Parity
Pt	Point for dimensionless values
PTFE	Polytetrafluoroethylene
RC	Repair Cost
RRC	“Right to Repair” Communication
RP	Representative Product
RS	Repair Services
SFIP	Semi-finished and intermediate products
SME	Small and Medium-sized Enterprise
SMGP	Single Market for Green Products
SP	Spare Parts
t	tonne
TAB	Technical Advisory Board
TeR	Technological Representativeness

TeR <sub>SD</sub>	Technological Representativeness evaluated at the level of the secondary dataset
TiR	Time Representativeness
TiR <sub>AD</sub>	Time Representativeness evaluated at the level of the activity data
TiR <sub>SD</sub>	Time Representativeness evaluated at the level of the secondary dataset
tkm	tonne kilometre
TS	Technical Secretariat
UUID	Universally Unique Identifier
VOCs	Volatile Organic Compounds

## Definitions

### Life Cycle Assessment definitions

Definitions with an asterisk (\*) come from the European Commission recommendation C(2021) 9332 final, on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations and is herein referred to as the PEF method. For further clarifications, please refer to the PEF method<sup>1</sup>.

A factor of the CFF	Allocation factor of burdens and credits between supplier and user of recycled materials.
Activity data*	Information which is associated with processes while modelling Life Cycle Inventories (LCI). The aggregated LCI results of the process chains which represent the activities of a process are each multiplied by the corresponding activity data and then combined to derive the environmental footprint associated with that process. 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. Synonym of “non-elementary flow.
Acidification*	EF impact category that addresses impacts due to acidifying substances in the environment. Emissions of NO <sub>x</sub> , NH <sub>3</sub> and SO <sub>x</sub> lead to releases of hydrogen ions (H <sup>+</sup> ) when the gases are mineralised. The protons contribute to the acidification of soils and water when they are released in areas where the buffering capacity is low, resulting in forest decline and lake acidification.
Additional environmental information*	Environmental information outside the EF impact categories that is calculated and communicated alongside PEF results.
Aggregated dataset*	Complete or partial life cycle of a product system that next to the elementary flows (and possibly not relevant amounts of waste flows and radioactive wastes) – itemises only the product(s) of the process as reference flow(s) in the input/output list, but no other goods or services. Aggregated datasets are also called “LCI results” datasets. The aggregated dataset may have been aggregated horizontally and/or vertically.
Allocation*	An approach to solving multi-functionality problems. It refers to “partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems”.
Application specific*	Generic aspect of the specific application in which a material is used. For example, the average recycling rate of PET in bottles.
B factor of the CFF	Allocation factor of energy recovery processes: it applies both to burdens and credits.

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<sup>1</sup> [https://environment.ec.europa.eu/document/download/680503dc-5a19-4f6a-bb92-84d9bfc8f312\\_en?filename=Annexes%201%20to%202.pdf](https://environment.ec.europa.eu/document/download/680503dc-5a19-4f6a-bb92-84d9bfc8f312_en?filename=Annexes%201%20to%202.pdf)

Background processes*	Refers to those processes in the product life cycle for which no direct access to information is possible. For example, most of the upstream life-cycle processes and generally all processes further downstream will be considered part of the background processes.
Benchmark*	A standard or point of reference against which any comparison may 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.
CFF	Circular Footprint Formula. The CFF is an approach developed in the frame of the PEF to account for and allocate the impacts and benefits of the end-of-life of materials between different systems (the waste producer and the user of recycled or recovered products)
Characterisation*	Calculation of the magnitude of the contribution of each classified input/output to their respective EF impact categories, and aggregation of contributions within each category. This requires a linear multiplication of the inventory data with characterisation factors for each substance and EF impact category of concern. For example, with respect to the EF impact category "climate change", the reference substance is CO <sub>2</sub> and the reference unit is kg CO <sub>2</sub> -equivalents.
Characterisation factor*	Factor derived from a characterisation model which is applied to convert an assigned life cycle inventory result to the common unit of the EF impact category indicator.
Climate change*	EF impact category considering all inputs or outputs that result in greenhouse gas (GHG) emissions. The consequences include increased average global temperatures and sudden regional climatic changes. Climate change is an impact affecting the environment on a global scale.
Company-specific data*	Refers to directly measured or collected data from one or multiple facilities (site-specific data) that are representative for the activities of the company (company is used as synonym for organization). It is synonymous to "primary data". To determine the level of representativeness, a sampling procedure may be applied.
Company-specific dataset*	Refers to a dataset (disaggregated or aggregated) compiled with company-specific data. In most cases the activity data is company-specific while the underlying sub-processes are datasets derived from background databases.
Comparative assertion*	An environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function (including the benchmark of the product category).
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 PEFCR.
Consumer*	An individual member of the general public purchasing or using goods, property or services for private purposes.
Cradle to grave	A product's life cycle that includes raw material extraction, processing, distribution, storage, use, and disposal or recycling stages. All relevant inputs and outputs are considered for all of the stages of the life cycle.
Critical review*	Process intended to ensure consistency between a PEFCR and the principles and requirements of the PEF method.
Cut-off*	Any cut-off shall be avoided, unless under the following rules:  Processes and elementary flows may be excluded up to 3.0%, based on material and energy flows and the level of environmental significance (single

overall score). The processes subject to cut-off shall be made explicit and justified in the PEF report, in particular with reference to the environmental significance of the cut-off applied.

This cut-off has to be considered additionally to the cut-off already included in the background datasets. This rule is valid for both intermediate and final products.

The processes that in total account less than 3.0% of the material and energy flow and environmental impact for each impact category may be excluded from PEF studies (starting from the less relevant).

A screening study is recommended to identify processes that may be subject to cut-off.

Data Quality Rating*	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.
Disaggregation*	The process that breaks down an aggregated dataset into smaller unit process datasets (horizontal or vertical). The disaggregation may help making data more specific. The process of disaggregation should never compromise or threaten to compromise the quality and consistency of the original aggregated dataset.
Downstream*	Occurring along a product supply chain after the point of referral.
Ecotoxicity, freshwater*	Environmental footprint impact category that addresses the toxic impacts on an ecosystem, which damage individual species and change the structure and function of the ecosystem. Ecotoxicity is a result of a variety of different toxicological mechanisms caused by the release of substances with a direct effect on the health of the ecosystem.
ED factor of the CFF	specific emissions and resources consumed (per unit of analysis) arising from disposal of waste material at the EoL of the analysed product, without energy recovery.
EER factor of the CFF	Specific emissions and resources consumed (per unit of analysis) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, ...).
EF compliant dataset*	Dataset developed in compliance with the EF requirements, regularly updated by DG JRC <sup>2</sup> .
Electricity tracking*	The process of assigning electricity generation attributes to electricity consumption <sup>3</sup> .
Elementary flows*	In the life cycle inventory, elementary flows include “material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation”. Elementary flows include, for example, resources taken from nature or emissions into air, water, soil that are directly linked to the characterisation factors of the EF impact categories.

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<sup>2</sup> [https://eplca.jrc.ec.europa.eu/permalink/Guide\\_EF\\_DATA.pdf](https://eplca.jrc.ec.europa.eu/permalink/Guide_EF_DATA.pdf)

<sup>3</sup> <https://ec.europa.eu/energy/intelligent/projects/en/projects/e-track-ii>

$E_{\text{recycled}}$ ( $E_{\text{rec}}$ ) factor of the CFF formula	Specific emissions and resources consumed (per unit of analysis) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.
$E_{\text{recyclingEoL}}$ ( $E_{\text{recEoL}}$ ) factor of the CFF	Specific emissions and resources consumed (per unit of analysis) arising from the recycling process at EoL, including collection, sorting and transportation process.
$E_{\text{SE,heat}}$ and $E_{\text{SE,elec}}$ factor of the CFF	Specific emissions and resources consumed (per unit of analysis) that would have arisen from the specific substituted energy source, heat and electricity respectively.
Eutrophication*	EF impact category linked to nutrients (mainly nitrogen and phosphorus) from sewage outfalls and fertilised farmland that accelerate the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen, resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass. To assess the impacts due to eutrophication, three EF impact categories are used: Eutrophication, terrestrial; Eutrophication, freshwater; Eutrophication, marine.
$E_v$ factor of the CFF	Specific emissions and resources consumed (per unit of analysis) arising from the acquisition and pre-processing of virgin material.
$E^*_v$ factor of the CFF	Specific emissions and resources consumed (per unit of analysis) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials.
Foreground processes*	Those processes in the product life cycle for which direct access to information is available. For example, the producer's site and other processes operated by the producer or its contractors (e.g. goods transport, head-office services, etc.).
Functional unit*	Defines the qualitative and quantitative aspects of the function(s) and/or service(s) provided by the product being evaluated. The functional unit definition answers the questions "what?", "how much?", "how well?", and "for how long?".
Global warming potential*	An index measuring the radiative forcing of a unit mass of a given substance accumulated over a chosen time horizon. It is expressed in terms of a reference substance (for example, CO <sub>2</sub> -equivalent units) and specified time horizon (e.g. GWP 20, GWP 100, GWP 500 - for 20, 100, and 500 years respectively). By combining information on both radiative forcing (the energy flux caused by emission of the substance) and on the time it remains in the atmosphere, GWP gives a measure of a substance's capacity to influence the global average surface-air temperature and therefore subsequently influence various climate parameters and their effects, such as storm frequency and intensity, rainfall intensity and frequency of flooding, etc
Human toxicity – cancer*	EF impact category that accounts for adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to cancer.
Human toxicity – non cancer*	EF impact category that accounts for the adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to non-cancer effects that are not caused by particulate matter/respiratory inorganics or ionising radiation.
Input flows*	Product, material or energy flow that enters a unit process. Products and materials include raw materials, intermediate products and co-products.

Ionising radiations, human health*	EF impact category that accounts for the adverse health effects on human health caused by radioactive releases.
Land use*	EF impact category related to use (occupation) and conversion (transformation) of land area by activities such as agriculture, forestry, roads, housing, mining, etc. Land occupation considers the effects of the land use, the amount of area involved and the duration of its occupation (changes in soil quality multiplied by area and duration). Land transformation considers the extent of changes in land properties and the area affected (changes in soil quality multiplied by the area).
Life cycle*	Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal.
Life cycle approach*	Takes into consideration the spectrum of resource flows and environmental interventions associated with a product from a supply-chain perspective, including all stages from raw material acquisition through processing, distribution, use, and end of life processes, and all relevant related environmental impacts (instead of focusing on a single issue).
Life cycle assessment*	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.
Life cycle inventory*	The combined set of exchanges of elementary, waste and product flows in a LCI dataset.
Life cycle inventory 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.
LHV	Lower Heating Value of the material in the product that is used for energy recovery.
Normalisation*	After the characterisation step, normalisation is the step in which the life cycle impact assessment results are multiplied by normalisation factors that represent the overall inventory of a reference unit (e.g. a whole country or an average citizen). Normalised life cycle impact assessment results express the relative shares of the impacts of the analysed system in terms of the total contributions to each impact category per reference unit. When displaying the normalised life cycle impact assessment results of the different impact topics next to each other, it becomes evident which impact categories are affected most and least by the analysed system. Normalised life cycle impact assessment results reflect only the contribution of the analysed system to the total impact potential, not the severity/relevance of the respective total impact. Normalised results are dimensionless, but not additive.
Output flows*	Product, material or energy flow that leaves a unit process. Products and materials include raw materials, intermediate products, co-products and releases. Output flows are also considered to cover elementary flows.
Ozone depletion*	EF impact category that accounts for the degradation of stratospheric ozone due to emissions of ozone-depleting substances, for example long-lived chlorine and bromine containing gases (e.g. chlorofluorocarbons CFCs, hydrochlorofluorocarbons HCFCs, Halons).
Partially disaggregated dataset*	A dataset with a LCI that contains elementary flows and activity data, and that yields a complete aggregated LCI data set when combined with its complementing underlying datasets.

Partially disaggregated dataset at level-1*	A partially disaggregated dataset at level-1 contains elementary flows and activity data for one level down in the supply chain, while all complementing underlying datasets are in their aggregated form.
Particulate matter*	EF impact category that accounts for the adverse health effects on human health caused by emissions of Particulate Matter (PM) and its precursors (NO <sub>x</sub> , SO <sub>x</sub> , NH <sub>3</sub> ).
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 report.
PEF study*	Term used to identify the totality of actions needed to calculate the PEF results. It includes the modelling, the data collection, and the analysis of the results. PEF study results are the basis for drafting PEF reports.
Photochemical ozone formation*	EF impact category that accounts for the formation of ozone at the ground level of the troposphere caused by photochemical oxidation of volatile organic compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NO <sub>x</sub> ) and sunlight. High concentrations of ground-level tropospheric ozone damage vegetation, human respiratory tracts and manmade materials through reaction with organic materials.
Purchasing Power Parity (PPP)	Purchasing Power Parities (PPPs) are the rates of currency conversion that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries. In their simplest form, PPPs are simply price relatives that show the ratio of the prices in national currencies of the same good or service in different countries. PPPs are also calculated for product groups and for each of the various levels of aggregation up to and including Gross Domestic Product (source: <a href="#">OECD</a> ).
Primary data or site-specific data*	Data from specific processes within the supply chain of the user of the PEF method or user of the PEF CR. 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 user of the PEF method or user of the PEF CR. In this method, primary data is synonym of "company-specific data" or "supply-chain specific data".
Q <sub>p</sub> factor of the CFF	Quality of the primary material, i.e. quality of the virgin material.
Q <sub>sin</sub> factor of the CFF	Quality of the ingoing secondary material, i.e. the quality of the recycled material at the point of substitution.
Q <sub>sout</sub> factor of the CFF	Quality of the outgoing secondary material, i.e. the quality of the recyclable material at the point of substitution.
R <sub>1</sub> factor of the CFF	It is the proportion of material in the input to the production that has been recycled from a previous system.
R <sub>2</sub> factor of the CFF	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 <sub>3</sub> factor of the CFF	It is the proportion of the material in the product that is used for energy recovery at EoL.
Reference flow*	Measure of the outputs from processes in a given product system required to fulfil the function expressed by the functional unit.
Renewable energy	Renewable energy is defined as the contribution of renewables to total primary energy supply (TPES). Renewables include the primary energy equivalent of hydro (excluding pumped storage), geothermal, solar, wind, tide and wave sources. Energy derived from solid biofuels, biogasoline, biodiesels, other liquid biofuels, biogases and the renewable fraction of municipal waste are also included. Biofuels are defined as fuels derived directly or indirectly from biomass (material obtained from living or recently living organisms). This includes wood, vegetal waste (including wood waste and crops used for energy production), ethanol, animal materials/wastes and sulphite lyes. Municipal waste comprises wastes produced by the residential, commercial and public service sectors that are collected by local authorities for disposal in a central location for the production of heat and/or power. This indicator is measured in thousand toe (tonne of oil equivalent) as well as in percentage of total primary energy supply. (OECD)
Representative product (model)*	The RP may be a real or a virtual (non-existing) product. The virtual product should be calculated based on average European market sales-weighted characteristics of all existing technologies/materials covered by the product category or sub-category. Other weighting sets may be used, if justified, for example weighted average based on mass (ton of material) or weighted average based on product units (pieces).
Resource use, fossil*	EF impact category that addresses the use of non-renewable fossil natural resources (e.g. natural gas, coal, oil).
Resource use, minerals and metals*	EF impact category that addresses the use of non-renewable abiotic natural resources (minerals and metals).
Secondary data*	Data that is not from a specific process within the supply-chain of the company performing a PEF study. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third party LCI 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 may also be based on financial data, and contain proxy data, and other generic data. Primary data that go through a horizontal aggregation step are considered as secondary data.
Sensitivity analysis*	Systematic procedures for estimating the effects of the choices made regarding methods and data on the results of a PEF study.
Small and Medium-sized Enterprise (SME)	<p>An SME is defined as:</p> <ul style="list-style-type: none"> <li>• Any company below the threshold for a medium-sized enterprise from the EU definition in EU recommendation 2003/361: Enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million;</li> <li>• Unless a local legislation on transparency defines SMEs as enterprises having fewer employees or a lower turnover or a lower annual balance sheet, in which case, that definition shall be used instead.</li> </ul>

Sub-processes*	Processes used to represent the activities of the level 1 processes (= building blocks). Sub-processes may be presented in their (partially) aggregated form.
System boundary*	Definition of aspects included or excluded from the study. For example, for a “cradle-to-grave” EF analysis, the system boundary includes all activities from the extraction of raw materials through the processing, distribution, storage, use, and disposal or recycling stages.
Transport leg	Transport between 2 steps of the supply chain
Unit process *	Smallest element considered in the LCI for which input and output data are quantified.
Upstream*	Occurring along the supply chain of purchased goods/ services prior to entering the system boundary.
Water use*	EF impact category that represents the relative available water remaining per area in a watershed, after demand of humans and aquatic ecosystems has been met. It assesses the potential of water deprivation, to either humans or ecosystems, based on the assumption that the less water remaining available per area, the more likely another user will be deprived.
Weighting*	A step that supports the interpretation and communication of the analysis results. PEF results are multiplied by a set of weighting factors (in %), which reflect the perceived relative importance of the impact categories considered. Weighted EF results may be directly compared across impact categories, and also summed across impact categories to obtain a single overall score.
$X_{ER,heat}$ and $X_{ER,elec}$ factor of the CFF	The efficiency of the energy recovery process for both heat and electricity.

## Apparel and footwear definitions

Definitions come from:

- \* “Clothing Technology, from fibre to fashion” (Eberle, 2004)
- ☒ “How Shoes are Made” (Motawi, 2018)

Bast fibre extraction (originally for flax)*	After pulling and roughing out the plant. <b>Retting</b> degrades the woody part of the stems so that the fibres are loosened. The stalks are placed in tanks of warm water where they lay for 5 to 8 days. This is followed by drying. Breaking and <b>Scutching</b> : after loosening the fibres from the wood by retting, the straw is broken and the woody parts are removed by scutching. The products are line fibre, with a length of 45 to 90 cm, and scutcher tow, with a length of 10 to 25 cm.
Bill of Materials (BOM)	The Bill of Materials (BOM) is the list and amounts of finished materials and components needed to manufacture and assemble a product. Raw materials, as well as their manufacturing details to convert them into finished materials and components, are included in this definition. This means that the BOM shall include more detailed information such as yarn type (size and construction method), textile formation (average yarn size and textile type - knit/woven/nonwoven) and finishing techniques (chemical finishes such as water repellency, stain release, etc as well as mechanical or heat treatments such as calendaring, brushing, shearing, etc).
Colour fastness*	Fastness of dyes and prints to rubbing, washing, cross staining, light, weather, seawater, ironing and dry-cleaning solvents.
Commodity	Commodities are vital components of commerce that are standardised and hence easy to exchange for goods of the same type, have a fairly uniform price around the world (excluding transport costs and taxes) and help make other products (The Economist, 2017)
Defective products	Defective products can be classified into two types: <ul style="list-style-type: none"><li>• Defective products only once they have reached the brand’s distribution scheme (in the scope of unsold consumer products)</li><li>• Defective products in manufacturing, before reaching the brand’s distribution scheme (out of the scope of unsold consumer products)</li></ul>
Delasting	Delasting involves removing the shoe upper over a last (a foot-shaped tool). (Inspired from *, see Lasting)
Die cutting ☒	Most shoe parts are made by die cutting. The cutting die looks just like a big cookie cutter but has a sharpened steel edge. Each shoe part will require its own cutting die.
Dimensional stability*	Dimensional changes (shrinking, stretching or twisting) during aftercare laundering and cleaning procedures.
Dyeing and finishing*	Includes all fabric processes that are not included in fibre production, yarn production, and fabric formation. Finishing effectively means to improve or to beautify the material, ready for sale. There are generally three basic objectives in finishing

	<ul style="list-style-type: none"> <li>• Modification of the surface (raising, smoothing, embossing etc)</li> <li>• Modification of the wearing properties (staining, creasing, draping etc)</li> <li>• Modification of aftercare characteristics (ironing, shrinking etc)</li> </ul>
Exceptional pieces	<p>“Exceptional pieces” are defined as apparel or footwear products, non-industrially produced or handcraft and/or unique custom made and/or with a designation of Intangible Cultural Heritage (or others like Haute Couture in France, to be worn on specific occasions such as artistic representations, ceremonial or formal dress. These pieces can require the intervention of a skilled craftsman, or “artisan d’art”, such as embroiderer, feather worker, pleater, goldsmith, adornment maker, milliner, bootmaker, glovemaking etc. (interpretation from UNESCO Convention<sup>4</sup>, definition “métiers de l’artisanat d’art”<sup>5</sup>).</p>
Fibre fragment	<p>A short piece of textile fibre, broken from the main textile construction or through its subsequent breakage in the natural environment</p> <p>Source : TMC glossary</p>
Fur	<p>Hide or skin, exclusively of animal origin, different from that of bovine, sheep and goat, with its original fibrous structure more or less intact tanned to be rot-proof, which by its characteristic always retains hair or wool or both.</p> <p>(Definition of the International Fur Federation (IFF))</p>
Genuine fur or genuine leather products	<p>Apparel products or accessories containing at least 80% by weight of genuine fur and / or genuine leather.</p>
Grading*	<p>Grading means the stepwise increase or decrease of a master pattern piece to create larger or smaller sizes. The starting point can be the smallest size or the middle size. Grading alters the overall size of a design but not its general shape and appearance. Computer-aided grading systems utilise internal calculation algorithms (grading rules) for pattern construction.</p>
Hangtag	<p>A hangtag is a removable tag attached to a product which provides non-required information about the product and the brand (Inspired from Textile Labelling definition, Federal Trade Commission).</p>
Higg Product Module (PM)	<p>The Product Module is a sustainability assessment tool that considers a product’s environmental impact from creating materials all the way to product end-of-life, developed by Cascale</p>
Inventory glut	<p>Items that are made for a brand/retailer and sent to their distribution center, such as surplus, excessive inventory, overstock and deadstock.</p>
Knitting*	<p>Knitted fabrics are made from interlocking loops, formed from a single yarn or from many (ISO 7839:1984).</p> <p>Circular knitting - The fabric is manufactured on circular machines as long lengths in the form of a tube. The fabric can be maintained in its tubular form throughout processing or, after the preparation and dyeing operations, it can be cut open for final finishing and garment making.</p>

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<sup>4</sup> Text of the Convention for the Safeguarding of the Intangible Cultural Heritage, Article 2.

<sup>5</sup> Article 22, Loi n° 2014-626 du 18 juin 2014 relative à l'artisanat, au commerce et aux très petites entreprises; Arrêté du 24 décembre 2015 fixant la liste des métiers d'art, en application de l'article 20 de la loi n° 96-603 du 5 juillet 1996 relative au développement et à la promotion du commerce et de l'artisanat

Lasting	Lasting involves stretching the shoe upper over a last (a foot-shaped tool) and securing it in place. (Inspired from *)
Leather	<p>A general term for hide or skin, exclusively of animal origin, with its original fibrous structure more or less intact, tanned to be rot-proof. The hair or wool may or may not have been removed. Leather is also made from a hide or skin which has been split into layers or segmented either before or after tanning. If the leather has a surface coating, however applied, or a glued-on finish, such surface layers must not be thicker than 0,15 mm.</p> <p>However, if the tanned hide or skin is disintegrated mechanically and/or chemically into fibrous particles, small pieces or powders and then, with or without the combination of a binding agent, is made into sheets or other forms, such sheets or forms are not leather.</p> <p>(Definition of the International Council of Tanners (ICT)).</p>
Manufacturing leftovers	Deadstock fabrics (or surplus fabrics, fabric rolls leftovers). Deadstock fabric is excess fabric inventory, including roll ends, that will not be directly cut and/or used in the production of products.
Microfibre	<p>The textile industry definition of a microfibre is a synthetic fibre with a linear density of less than 1 denier. There is a different understanding of this term in the context of unintended release of fibres and thus subsequent microfibre pollution. The Microfibre Consortium, in this context does not determine the size nor the type. To avoid such confusion, fibre fragment / fibre fragmentation is the preferred terminology.</p> <p>Source : TMC glossary</p>
Microplastic	<p>A small piece of plastic debris measuring 5mm or less, found in the environment from the disposal or breakdown of consumer products and industrial waste. Synthetic fibre fragments are considered microplastics.</p> <p>Source : TMC glossary</p>
Pattern*	A pattern is a diagrammatic representation of the way a garment part is constructed. This forms the working plan for its manufacture.
Piling resistance*	Measurement of the number of pills that form during a defined period of surface rubbing.
Printing	Printing is the process of applying colour to fabric in definite patterns or designs. A placement print is a design that is placed in a specific location on a product, whereas all-over prints cover the whole fabric surface.
Product	For communication purposes, a product is defined by an individual and unique specific material composition, material construction, fabric weight or material density, dyeing method as well as fabric or material treatment and finishes
Repairability	The capacity of a product to be repaired. This should not be confused with the “likelihood that the product will be repaired”.
Retting*	See bast fibre extraction.
Scouring*	Removal of natural or adventitious impurities, or processing aids (waxes, lubricants) applied during yarn and fabric formation.
Small series	Small series are defined as series produced globally under 1,000 units by product reference (model-material), and also not exceeding 500 product

references (model-material) annually for the product sub-category for apparel and under 500 units by product reference (model-material) for footwear, by brand (i.e. all market categories, women and men), based on SMEs and creative fashion brands practices.

Sport segment	Product intended primarily for use in an organized or individual capacity related to physical activity and designed with functional elements specifically for the intended use and practiced activity. Product appearance shall not be the sole characteristic evaluated to determine inclusion in this segment.
Stockfitting <sup>⌘</sup>	Stockfitting is an assembly operation that is done away from the main assembly. The separate outsole components are assembled on the stock fitting line before they are taken to the main assembly line.
Treatments (finishing)* <i>Reworded for clarity</i>	Whereas mechanical (dry) finishing is concerned mainly with modifying the surface of the fabric, chemical finishing (wet) aims to effect a radical change in the basic fibre or fabric properties, in order to improve some aspect of its behaviour. <ul style="list-style-type: none"><li>• Examples of dry finishes are framing, raising, embossing, sanding.</li><li>• Examples of wet finishes are water repellence, stain resistance, flame resistance, anti-pilling.</li></ul>
Trims	A non-integral, often decorative, component that is part of a product. Trims include sewing thread, buttons, zippers, labels, edging, and hook and loop fastener. Embellishments including embroidery, heat transfers, and graphics which cover less than 15% of the surface area of a product are also considered trims (Cascale).
Unsold consumer products	Any consumer product that has not been sold including surplus, excessive inventory, overstock and deadstock, including products returned by a consumer in view of their right of withdrawal in accordance with Article 9 of Directive (EU) 2011/83/EU, or, where applicable, during any longer withdrawal period provided by the trader (as defined in Ecodesign for Sustainable Products Regulation (ESPR) compromise text, published on 19 December 2023). <sup>6</sup> See Section 5.4.1.2 for additional details.
Weaving*	Weaving is the name given to the interleaving of two sets of yarns, warp and weft, at right angles.

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<sup>6</sup> The ESPR definition should be applied to qualify unsold consumer products and may be updated if further precision is provided by the Implementing or Delegated Act adopted by the European Commission. Its scope is therefore to include all consumer products fit for sale that were not sold, with the following interpretation.

# 1. Summary

In October 2019, the European Commission approved the project to develop Product Environmental Footprint Category Rules (PEFCR) for apparel and footwear.

As part of the development of the PEFCR, a PEF study of the representative product (PEF-RP study) shall be carried out on the representative products with the intention of identifying the most relevant impact categories, life cycle stages, processes, elementary flows, and any other major requirements needed for the definition of the benchmark for the product sub-categories in scope of the PEFCR.

The goal of this apparel and footwear PEF-RP study is to test the PEFCR for apparel and footwear that is currently under development by calculating the environmental footprints (EFs) for the 13 virtual representative products (RPs) that were defined by the Technical Secretariat (TS):

1. T-shirts
2. Shirts and blouses
3. Sweaters and midlayers
4. Jackets and coats
5. Pants and shorts
6. Dresses, skirts and jumpsuits
7. Leggings, stockings, tights and socks
8. Underwear
9. Swimwear
10. Apparel accessories
11. Open-toed shoes
12. Closed-toed shoes
13. Boots

This report follows the PEF method requirements to identify the hotspots including the most relevant impact categories, life cycle stages and processes for each representative product.

The functional unit considered in this PEF study is to provide one apparel or footwear product to meet the consumer's specific needs for one use while in good condition with appropriate use for the given product per product sub-category.

The system boundaries considered include the full life cycle (cradle to grave) of apparel and footwear products divided into the following life cycle stages: the raw material acquisition and pre-processing (including packaging), manufacturing, distribution, use, and end of life.

The models for the representative products are built using information from different sources, expert assumptions, learnings from the PEF CR pilots and the PEF method. Data were provided directly by TS members, scientific articles, reports and the EF 3.1 database. In some instances, approximations are made based on the best judgment of the TS.

All product components and production processes have been included in cases where the necessary information is readily available, or a reasonable estimate could be made. All assumptions are clearly indicated in the relevant subsections below.

The main results of the life cycle impact assessment for all sixteen EF impact categories (PEF method) (characterized, normalized and weighted) for each representative product are shown in Table 41 through Table 53.

The following ten impact categories were determined to be the most relevant for apparel and footwear products:

- Climate change; particulate matter; acidification; terrestrial eutrophication; marine eutrophication; freshwater ecotoxicity; land use; water use; resource use, minerals and metals; and resource use, fossils.

In general, for most RPs, the most relevant life cycle stages (LCSs) include:

- Raw material acquisition and pre-processing (LCS1); and
- Manufacturing (LCS2).

The most impacting processes per life cycle stage across all RPs are as follows:

- Raw materials acquisition and pre-processing (LCS1):

- Cashmere fiber {GLO} | raw | production mix | LCI result
- Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- Leather, cattle, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- Leather, veal/calf, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- Leather, ovine (sheep), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- Leather, caprine (goat), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- Leather, swine, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- Nylon 6, fossil fuel-based {GLO} | hydrolytic polymerisation of caprolactam | production mix, at plant | petrochemical based | LCI result
- PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- Silk {GLO} | drying, immersion, brushing, reeling | production mix, at plant | 1 kg | LCI result
- Wool {GLO} | sheep | production mix, at farm | 1 kg wool | LCI result
- Dressed mink fur, farmed, global origin except china {GLO} | technology mix | production mix, at plant | 1kg | LCI result
- Acrylic fiber {GLO} | polymerisation of acrylonitrile with the ethyl acetate, spinning, post-spinning treatment | production mix, at plant | petrochemical based | LCI result
- Styrene-butadiene rubber (SBR) fiber {EU+EFTA+UK} | Emulsion polymerization of styrene and butadiene | production mix, at plant | 23.5 % styrene | LCI result
- Ethylene vinyl acetate copolymer {GLO} | Technology mix | Production mix, at plant | LCI result

- Thermoplastic polyurethane (TPU) {GLO} | reaction of diisocyanates (hard segment) with diols (soft segment) | production mix, at plant | petrochemical based | LCI result
- Viscose fibre {GLO} | virgin production from hardwood sulphite pulp | production mix, at plant | 1kg of product | LCI result
- Elastane fibre / spandex {GLO} | dry spinning, extrusion, texturising | production mix, at plant | 1kg of product | LCI result
- Latex production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
- Zipper tape and puller, metal {GLO} | production, at plant | 1kg of product, brass zipper | LCI result
- Stainless steel hot rolled {RoW} | hot rolling | production mix, at plant | stainless steel | LCI result
- Shoe eyelet, metal {GLO} | production, at plant | 1kg of product, brass based | LCI result
- Cardboard, production mix, at plant {GLO} | Kraft Pulping Process | production mix, at plant | 180- 300 kg/m<sup>3</sup> | LCI result
- Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result
- Plastic bag, LDPE {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | thickness: 0.03 mm, grammage: 0.0275 kg/m<sup>2</sup> | LCI result
- Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result
- Manufacturing (LCS2):
  - Spinning, for knit, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
  - Spinning, for woven, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result

- Spinning, continuous filament (dry) {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- Knitting, flat {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO} | Pre-treatment | production mix, at plant | textile service | LCI result
- Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- Dyeing, batch (incl. piece, jet, jig, kier [fiber], paddle, pad-batch, yarn), direct, sulfur, vat or reactive dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- Printing, screen {GLO} | printing service | production, at plant | service of printing, Screen on 1m<sup>2</sup> of fabric | LCI result
- Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- Injection molding, for foam {GLO} | injection process | production mix, at plant | item(s) = pair | LCI result
- Lamination, water based glue {GLO} | lamination process | average service, at plant | 1 kg of water based glue laminated fabric | LCI result
- Coating, water based emulsion {GLO} | Finishing | technology mix | textile service for 1 kg of fabric | LCI result
- Cementing/gluing {GLO} | cementing process | production mix, at plant | service of glueing 1 pair of shoes | LCI result

- Vulcanizing {GLO} | vulcanizing, press vulcanisation- injection molding | production mix, at plant | service for 1 pair | LCI result
- Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result
- Distribution (LCS3):
  - Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result
  - Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result
  - Residual grid mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | 1kV - 60kV | LCI result
  - Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result
- Use (LCS4):
  - Handwashing {EU+EFTA+UK} | handwashing process | production mix, at plant | service | LCI result
  - Washing, 40 degrees C, average {EU+EFTA+UK} | washing, warm water | production mix, at plant | service | LCI result
  - Washing, 60 degrees C, average {EU+EFTA+UK} | washing, warm water | production mix, at plant | service | LCI result
  - Washing, dry cleaning {EU+EFTA+UK} | washing process | production mix, at plant | service | LCI result
  - Tumble drying {EU+EFTA+UK} | drying, condenser tumble dryer | production mix, at plant | service | LCI result

The most relevant life cycle stages per RP and per most relevant impact category are shown in Table 1.

Table 1 - Most relevant life cycle stages per RP and impact category

Impact category	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Climate change	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2, 4	1, 2, 4	1, 2	1, 2	1, 2	1, 2
Ozone depletion	--	--	--	--	--	--	--	--	--	--	--	--	--
Human toxicity, cancer	--	--	--	--	--	--	--	--	--	--	--	--	--
Human toxicity, non-cancer	--	--	--	--	--	--	--	--	--	--	--	--	--
Particulate matter	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1	1, 2
Ionising radiation	--	--	--	--	--	--	--	--	--	--	--	--	--
Photochemical ozone formation	--	--	--	--	--	--	--	--	--	--	--	--	--
Acidification	1, 2	1, 2	1	1	1, 2	1, 2	1, 2	1, 2, 4	1, 2, 4	1	1	1	1
Eutrophication, terrestrial	--	--	1	1	--	--	--	--	--	1	1	1	1
Eutrophication, freshwater	--	--	--	--	--	--	--	--	--	--	--	--	--
Eutrophication, marine	1, 2	--	1	1	--	1, 2	--	1, 2	--	1	1	1	1
Ecotoxicity, freshwater	--	--	1	1	--	--	1, 2	--	--	1	1	1	1
Land use	--	--	1	--	--	--	--	--	--	--	--	--	--
Water use	1, 2	1	1	1	1	1	1, 2	1	2, 4	1	--	--	--
Resource use, minerals and metals	1, 2	1, 2	--	--	1, 2	1, 2	1, 2	1, 2, 4	1, 2	--	1	1	1
Resource use, fossils	1, 2	1, 2	--	1, 2	1, 2	1, 2	1, 2	1, 2, 4	1, 2	--	1, 2	1, 2	1, 2

Note: RP1. T-shirts, RP2. Shirts and blouses, RP 3. Sweaters and midlayers, RP4. Jackets and coats, RP5. Pants and shorts, RP6. Dresses, skirts and jumpsuits, RP7. Leggings, stockings, tights and socks, RP8. Underwear, RP9. Swimwear, RP10. Apparel accessories, RP11. Open-toed shoes, RP12. Closed-toed shoes, RP13. Boots.

1: LCS1. Raw materials extraction and pre-processing, 2: LCS2. Manufacturing, 3: LCS3. Distribution, 4: LCS4. Use, 5: LCS5. End of life.

The most impacting processes across all impact categories per RP and life cycle stage are included in Table 2.

Table 2 - Most impacting processes per RP

Process per life cycle stage (LCS)	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
<b>LCS1: Raw material acquisition and pre-processing</b>													
Cashmere fiber {GLO}   raw   production mix   LCI result	--	--	X	X	--	--	--	--	--	--	--	--	--
Cotton fibre {GLO}   technology mix   production mix, at farm   "as is" delinted product   LCI result	X	X	X	X	X	X	X	X	--	X	--	--	--
Leather, cattle, chrome tanned (wet-blue) {GLO}   technology mix   production mix, at tannery   m2   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Leather, veal/calf, chrome tanned (wet-blue) {GLO}   technology mix   production mix, at tannery   m2   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Leather, ovine (sheep), chrome tanned (wet- blue) {GLO}   technology mix   production mix, at tannery   m2   LCI result	--	--	--	--	X	--	--	--	--	X	X	--	X
Leather, caprine (goat), chrome tanned (wet- blue) {GLO}   technology mix   production mix, at tannery   m2   LCI result	--	--	--	--	X	--	--	--	--	X	X	X	X
Leather, swine, chrome tanned (wet-blue) {GLO}   technology mix   production mix, at tannery   m2   LCI result	--	--	--	--	--	--	--	--	--	X	--	--	--
Nylon 6, fossil fuel-based {GLO}   hydrolytic polymerisation of caprolactam   production mix, at plant   petrochemical based   LCI result	--	--	--	X	X	--	X	X	X	--	--	--	--
PET granulates, bottle grade {EU+EFTA+UK}   via purified terephthalic acid (PTA) and ethylene glycol   production mix, at plant   192.17 g/mol per repeating unit   LCI result	X	X	--	X	X	X	X	X	X	--	X	X	X
Silk {GLO}   drying, immersion, brushing, reeling   production mix, at plant   1 kg   LCI result	--	--	--	--	--	--	--	--	--	X	--	--	--
Wool {GLO}   sheep   production mix, at farm   1 kg wool   LCI result	--	--	X	X	--	X	X	--	--	X	--	X	--

Process per life cycle stage (LCS)	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Dressed mink fur, farmed, global origin except china {GLO}   technology mix   production mix, at plant   1kg   LCI result	--	--	--	X	--	--	--	--	--	--	--	--	--
Acrylic fiber {GLO}   polymerisation of acrylonitrile with the ethyl acetate, spinning, post-spinning treatment   production mix, at plant   petrochemical based   LCI result	--	--	--	X	--	--	X	--	--	X	--	--	--
Styrene-butadiene rubber (SBR) fiber {EU+EFTA+UK}   Emulsion polymerization of styrene and butadiene   production mix, at plant   23.5 % styrene   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Ethylene vinyl acetate copolymer {GLO}   Technology mix   Production mix, at plant   LCI result	--	--	--	--	--	--	--	--	--	--	X	--	--
Thermoplastic polyurethane (TPU) {GLO}   reaction of diisocyanates (hard segment) with diols (soft segment)   production mix, at plant   petrochemical based   LCI result	--	--	--	--	--	--	--	--	--	--	--	--	X
Viscose fibre {GLO}   virgin production from hardwood sulphite pulp   production mix, at plant   1kg of product   LCI result	--	--	--	X	--	--	X	--	--	--	--	--	--
Elastane fibre / spandex {GLO}   dry spinning, extrusion, texturising   production mix, at plant   1kg of product   LCI result	--	--	--	--	--	--	X	--	X	--	X	X	X
Latex production {GLO}   technology mix   production mix, at plant   100% active substance   LCI result	--	--	--	--	--	--	--	--	--	--	X	--	--
Zipper tape and puller, metal {GLO}   production, at plant   1kg of product, brass zipper   LCI result	--	--	--	--	X	--	--	--	--	--	--	--	X
Stainless steel hot rolled {RoW}   hot rolling   production mix, at plant   stainless steel   LCI result	--	--	--	--	--	--	--	--	--	--	--	--	X
Shoe eyelet, metal {GLO}   production, at plant   1kg of product, brass based   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Plastic bag, LDPE {EU+EFTA+UK}   raw material production, plastic extrusion   production mix, at plant   thickness: 0.03 mm, grammage: 0.0275 kg/m2   LCI result	X	--	--	--	--	--	X	X	--	--	--	--	--
Cardboard, production mix, at plant {GLO}   Kraft Pulping Process   production mix, at plant   180- 300 kg/m3   LCI result	--	--	--	--	--	--	--	X	--	--	X	--	--
Cargo plane {GLO}   technology mix, kerosene driven, cargo   consumption mix, to consumer   65 t payload   LCI result	X	X	--	--	X	--	--	--	--	--	--	--	--

Process per life cycle stage (LCS)	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Transoceanic ship, containers {GLO}   heavy fuel oil driven, cargo   consumption mix, to consumer   27.500 dwt payload capacity, ocean going   LCI result	--	X	--	--	X	--	--	--	--	--	--	--	--
LCS2: Manufacturing													
Spinning, for knit, ring-spun {GLO}   spinning process   production mix   service of spinning 1kg of yarn (raw material excluded)   LCI result	X	X	X	--	X	X	X	X	--	--	--	--	--
Spinning, for woven, ring-spun {GLO}   spinning process   production mix   service of spinning 1kg of yarn (raw material excluded)   LCI result	--	X	--	X	X	X	--	X	--	X	--	X	--
Spinning, continuous filament (dry) {GLO}   spinning process   production mix   service of spinning 1kg of yarn (raw material excluded)   LCI result	--	--	--	X	X	--	X	--	X	--	--	X	--
Knitting, circular {GLO}   knitting process   production, at plant   service of knitting fabric   LCI result	X	X	X	X	X	X	X	X	X	X	--	--	--
Knitting, flat {GLO}   knitting process   production, at plant   service of knitting fabric   LCI result	--	--	X	--	--	--	--	--	--	X	--	--	--
Weaving (different fabric counts) {GLO}   service, Fabric, Weaved, Mix of different counts   production mix, at plant   service, Fabric, Weaved, Mix of different counts   LCI result	--	X	--	X	X	X	--	X	X	X	X	X	X
Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO}   Pre-treatment   production mix, at plant   textile service   LCI result	X	X	--	X	X	X	X	X	X	--	--	--	--
Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO}   Dyeing   production mix, at plant   textile service for 1 kg of fabric   LCI result	--	--	--	X	X	--	X	X	X	X	--	X	--
Dyeing, batch (incl. piece, jet, jig, kier [fiber], paddle, pad-batch, yarn), direct, sulfur, vat or reactive dyes {GLO}   Dyeing   production mix, at plant   textile service for 1 kg of fabric   LCI result	X	X	--	--	X	X	X	X	--	--	--	--	--
Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO}   Dyeing   production mix, at plant   textile service for 1 kg of fabric   LCI result	X	X	--	X	X	X	X	--	X	--	--	X	--
Printing, screen {GLO}   printing service   production, at plant   service of printing, Screen on 1m2 of fabric   LCI result	--	--	--	--	--	--	--	X	--	--	--	--	--

Process per life cycle stage (LCS)	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Finishing, stain resistant/stain release {GLO}   pad dry-cure method   production mix, at plant   service   LCI result	X	X	--	X	X	X	X	X	X	X	--	X	X
Injection molding, for foam {GLO}   injection process   production mix, at plant   item(s) = pair   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Lamination, water based glue {GLO}   lamination process   average service, at plant   1 kg of water based glue laminated fabric   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Coating, water based emulsion {GLO}   Finishing   technology mix   textile service for 1 kg of fabric   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Cementing/gluing {GLO}   cementing process   production mix, at plant   service of glueing 1 pair of shoes   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	--
Vulcanizing {GLO}   vulcanizing, press vulcanisation- injection molding   production mix, at plant   service for 1 pair   LCI result	--	--	--	--	--	--	--	--	--	--	--	X	--
Transoceanic ship, containers {GLO}   heavy fuel oil driven, cargo   consumption mix, to consumer   27.500 dwt payload capacity, ocean going   LCI result	--	--	--	--	X	--	--	--	--	--	--	--	--
<b>LCS3: Distribution</b>													
Cargo plane {GLO}   technology mix, kerosene driven, cargo   consumption mix, to consumer   65 t payload   LCI result	X	X	--	X	X	X	X	X	X	X	X	X	X
Transoceanic ship, containers {GLO}   heavy fuel oil driven, cargo   consumption mix, to consumer   27.500 dwt payload capacity, ocean going   LCI result	X	X	--	--	X	--	--	X	X	--	X	--	--
Electricity grid mix 1kV-60kV {EU+EFTA+UK}   technology mix   consumption mix, to consumer   1kV - 60kV   LCI result	--	X	--	--	--	X	--	--	--	--	--	X	X
Thermal energy from natural gas {EU+EFTA+UK}   technology mix regarding firing and flue gas cleaning   production mix, at heat plant   MJ, 100% efficiency   LCI result	--	X	--	--	--	X	--	--	--	--	--	X	X
<b>LCS4: Use stage</b>													
Handwashing {EU+EFTA+UK}   handwashing process   production mix, at plant   service   LCI result	--	--	--	--	--	--	--	X	X	--	--	--	--

Process per life cycle stage (LCS)	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Washing, 40 degrees C, average {EU+EFTA+UK}   washing, warm water   production mix, at plant   service   LCI result	X	X	--	--	X	X	X	--	--	--	--	--	--
Washing, 60 degrees C, average {EU+EFTA+UK}   washing, warm water   production mix, at plant   service   LCI result	--	--	--	--	--	--	--	X	--	--	--	--	--
Washing, dry cleaning {EU+EFTA+UK}   washing process   production mix, at plant   service   LCI result	--	--	--	--	X	X	--	--	--	--	--	--	--
Tumble drying {EU+EFTA+UK}   drying, condenser tumble dryer   production mix, at plant   service   LCI result	X	--	--	--	X	X	X	X	X	--	--	--	--

Note: RP1. T-shirts, RP2. Shirts and blouses, RP 3. Sweaters and midlayers, RP4. Jackets and coats, RP5. Pants and shorts, RP6. Dresses, skirts and jumpsuits, RP7. Leggings, stockings, tights and socks, RP8. Underwear, RP9. Swimwear, RP10. Apparel accessories, RP11. Open-toed shoes, RP12. Closed-toed shoes, RP13. Boots.

**Note**

To keep to the summary length requirement of 3-4 pages, the characterised, normalised and weighted results which include 13 full-page tables are not included here but in Section 6.1 below. Due to the inaccessibility of disaggregated datasets in the EF 3.1 database, the most relevant direct elementary flows could not be identified at this stage.

This study aims to better understand the impacts related to apparel and footwear products by identifying hotspots. The second draft PEF-RP results have been used to refine the PEF-CR for apparel and footwear.

The study is not intended to be used to make statements about the product sub-category impacts as such, nor is it intended to be used in the context of comparison or for comparative assertions to be disclosed to the public.

## 2. General

### 2.1. General product information

The product category for this PEF-RP is apparel and footwear sold in Europe, which is defined as follows:

- **An apparel or footwear product to meet the consumer’s specific needs, as defined per sub-category**

This PEF-RP study, published on 29<sup>th</sup> April 2025, has been conducted based on 13 virtual representative products per the products sub-categories defined in Table 3, and complies with PEFCR v3.1.

Table 3 - Product sub-categories and descriptions

No.	Sub-category/ representative product	Typical products included	Description and intended function
1	T-shirts	Singlets, t-shirts, polo shirts, other short-sleeved shirts	Garment to cover the upper body to the elbow
2	Shirts and blouses	Long-sleeved shirts, blouses, tunics, base layers	Garment to cover the upper body including the entire arm
3	Sweaters and midlayers	Pullovers, cardigans, hoodies, jerseys, sweatshirts, knitted and wool sweaters, vests	Garment to keep the upper body warm and covered
4	Jackets and coats	Blazers, suit jackets, overcoats, other light jackets, rain jackets, outdoor winter jackets, parkas, down jackets, fur jackets, outdoor vests, leather jackets	Garment to put on top of a shirt or sweater or to protect from the elements
5	Pants and shorts	Casual pants, outdoor pants, dress pants, jeans, sports pants, capri pants, shorts	Garment to cover the lower body, may protect from the elements
6	Dresses, skirts and jumpsuits	Short- and long-sleeved, strapless, wrap, long and short, one-piece suits	One-piece garment that covers both the upper and lower body, or the lower body only, other than pants and shorts
7	Leggings, stockings, tights and socks	Opaque and sheer tights, pantyhose, fishnets, ankle socks, knee socks, low-cut socks	Tight garment to cover the legs and/or feet
8	Underwear	Boxers, briefs, panties, bras, body-shaping suits	Garment worn under clothes, often next to the skin of the upper or lower body
9	Swimwear	Bikinis, bathing suits, racing-style swimwear, board shorts	Garment worn for water-based or sun-based activities
10	Apparel accessories	<b>Hats:</b> Caps, flat caps, woollen hats/beanies, fedoras, panamas, bowlers, newsboys, berets	Garment to cover the head

No.	Sub-category/ representative product	Typical products included	Description and intended function
		<b>Scarves and ties:</b> Warm and light scarves, buffs, neckerchiefs, headscarves, shawls, bowties	Garment worn around the neck
		<b>Belts:</b> Dress belts, casual belts, buckle belts, tie-up belts, suspenders	Flexible band or strap worn around the waist or over the shoulders used to secure or to hold up clothing such as pants
		<b>Gloves and mittens:</b> fingerless gloves, fashion gloves, outdoor sports gloves, mittens	Articles of clothing that protect hands and wrists from the elements. Used in pairs.
11	Open-toed shoes	Flip-flops, casual /fashion sandals, sports sandals, slippers	Open-toed shoes, providing protection from the ground. Used in pairs.
12	Closed-toed shoes	Slippers, tennis shoes, moccasins, espadrilles, sneakers, cleats, athletic shoes, dress shoes, protective toecap – toed shoes	Closed-toed shoes, providing protection from the ground. They may protect against water, the elements and/or heavy objects. Used in pairs.
13	Boots	Polymer boots, winter boots, hiking boots, dress boots, protective toecap - toed boots	Boots that cover the ankle, providing protection from the ground. They may protect against water, the elements, heavy objects and/or ankle injuries. Used in pairs.

The Classification of Products by Activity (CPA)/NACE codes per product sub-category are provided in Table 4. Due to the categorization of products in the CPA/NACE system, some codes are listed (for the reason of completeness) containing products that belong to the respective sub-category, but also products that belong to other sub-categories.

Table 4 - CPA/NACE codes per product sub-category

Product sub-category	CPA/NACE code
<b>1. T-shirts</b>	14.14.30 T-shirts, singlets and other vests, knitted or crocheted
	14.14.22 Men's or boys' singlets and other vests, underpants, briefs, nightshirts, pyjamas, bathrobes, dressing gowns, of textile fabric not knitted or crocheted
	14.14.24 Women's and girls' singlets and other vests, slips, petticoats, briefs, panties, nightdresses, pyjamas, negligees, bathrobes, dressing gowns and similar articles, of textile fabric not knitted or crocheted
<b>2. Shirts and blouses</b>	14.14.11 Men's or boys' shirts, knitted or crocheted
	14.14.13 Women's or girls' blouses, shirts and shirt- blouses, knitted or crocheted
	14.14.21 Men's or boys' shirts, of textile fabric not knitted or crocheted
	14.14.22 Men's or boys' singlets and other vests, underpants, briefs, nightshirts, pyjamas, bathrobes, dressing gowns, of textile fabric not knitted or crocheted

	14.14.23 Women's or girls' blouses, shirts and shirt- blouses, of textile fabric not knitted or crocheted
	14.14.24 Women's and girls' singlets and other vests, slips, petticoats, briefs, panties, nightdresses, pyjamas, negligees, bathrobes, dressing gowns and similar articles, of textile fabric not knitted or crocheted
<b>3. Sweaters and midlayers</b>	14.19.12 Tracksuits, ski suits, swimwear and other garments, knitted or crocheted
	14.39.10 Jerseys, pullovers, cardigans, waistcoats and similar articles, knitted or crocheted
<b>4. Jackets and coats</b>	14.12.11 Men's ensembles, jackets and blazers, industrial and occupational
	14.12.21 Women' s ensembles, jackets and blazers, industrial and occupational
	14.13.11 Men's or boys' overcoats, car coats, capes, cloaks, anoraks, windcheaters, wind-jackets and similar articles, knitted or crocheted
	14.13.12 Men's or boys' suits, ensembles, jackets, blazers, trousers, bib and brace overalls, breeches and shorts, knitted or crocheted
	14.13.13 Women's or girls' overcoats, car coats, capes, cloaks, anoraks, windcheaters, wind-jackets and similar articles, knitted or crocheted
	14.13.14 Women's or girls' suits, ensembles, jackets, blazers, dresses, skirts, divided skirts, trousers, bib and brace overalls, breeches and shorts, knitted or crocheted
	14.13.21 Men's or boys' overcoats, raincoats, car coats, capes, cloaks, anoraks, wind-cheaters, wind-jackets and similar articles of textile fabrics, not knitted or crocheted
	14.13.22 Men's or boys' suits and ensembles of textile fabrics, not knitted or crocheted
	14.13.23 Men's or boys' jackets and blazers, of textile fabrics, not knitted or crocheted
	14.13.31 Women's or girls' overcoats, car coats, capes, cloaks, anoraks, wind-cheaters, wind-jackets and similar articles of textile fabrics, not knitted or crocheted
	14.13.32 Women's or girls' suits and ensembles of textile fabrics, not knitted or crocheted
	14.13.33 Women's or girls' jackets and blazers of textile fabrics, not knitted or crocheted
	14.14.22 Men's or boys' singlets and other vests, underpants, briefs, nightshirts, pyjamas, bathrobes, dressing gowns, of textile fabric not knitted or crocheted
	14.14.24 Women's and girls' singlets and other vests, slips, petticoats, briefs, panties, nightdresses, pyjamas, negligees, bathrobes, dressing gowns and similar articles, of textile fabric not knitted or crocheted
	14.14.30 T-shirts, singlets and other vests, knitted or crocheted
	14.19.12 Tracksuits, ski suits, swimwear and other garments, knitted or crocheted
<b>5. Pants and shorts</b>	14.12.11 Men's ensembles, jackets and blazers, industrial and occupational
	14.12.12 Men's trousers, bib and brace overalls, breeches and shorts, industrial and occupational
	14.12.21 Women' s ensembles, jackets and blazers, industrial and occupational
	14.12.22 Women's trousers, bib and brace overalls, breeches and sorts, industrial and occupational
	14.13.12 Men's or boys' suits, ensembles, jackets, blazers, trousers, bib and brace overalls, breeches and shorts, knitted or crocheted
	14.13.14 Women's or girls' suits, ensembles, jackets, blazers, dresses, skirts, divided skirts, trousers, bib and brace overalls, breeches and shorts, knitted or crocheted

	14.13.22 Men's or boys' suits and ensembles of textile fabrics, not knitted or crocheted
	14.13.24 Men's or boys' trousers, bib and brace overalls, breeches and shorts of textile fabrics, not knitted or crocheted
	14.13.32 Women's or girls' suits and ensembles of textile fabrics, not knitted or crocheted
	14.13.35 Women's or girls' trousers, bib and brace overalls, breeches and shorts of textile fabrics, not knitted or crocheted
	14.14.22 Men's or boys' singlets and other vests, underpants, briefs, nightshirts, pyjamas, bathrobes, dressing gowns, of textile fabric not knitted or crocheted
	14.14.24 Women's and girls' singlets and other vests, slips, petticoats, briefs, panties, nightdresses, pyjamas, negligees, bathrobes, dressing gowns and similar articles, of textile fabric not knitted or crocheted
	14.19.12 Tracksuits, ski suits, swimwear and other garments, knitted or crocheted
	14.19.22 Tracksuits, ski suits and swimwear; other garments of textile fabric, not knitted or crocheted
<b>6. Dresses, skirts and jumpsuits</b>	14.12.11 Men's ensembles, jackets and blazers, industrial and occupational
	14.12.21 Women's ensembles, jackets and blazers, industrial and occupational
	14.13.14 Women's or girls' suits, ensembles, jackets, blazers, dresses, skirts, divided skirts, trousers, bib and brace overalls, breeches and shorts, knitted or crocheted
	14.13.22 Men's or boys' suits and ensembles of textile fabrics, not knitted or crocheted
	14.13.32 Women's or girls' suits and ensembles of textile fabrics, not knitted or crocheted
	14.13.34 Women's or girls' dresses, skirts and divided skirts of textile fabrics, not knitted or crocheted
	14.14.12 Men's or boys' underpants, briefs, nightshirts, pyjamas, bathrobes, dressing gowns and similar articles, knitted or crocheted
	14.14.14 Women's or girls' slips, petticoats, briefs, panties, nightdresses, pyjamas, dressing gowns, negligees, bathrobes and similar articles, knitted or crocheted
	14.14.22 Men's or boys' singlets and other vests, underpants, briefs, nightshirts, pyjamas, bathrobes, dressing gowns, of textile fabric not knitted or crocheted
	14.14.24 Women's and girls' singlets and other vests, slips, petticoats, briefs, panties, nightdresses, pyjamas, negligees, bathrobes, dressing gowns and similar articles, of textile fabric not knitted or crocheted
<b>7. Leggings, stockings, tights and socks</b>	14.31.10 Panty hose, tights, stockings, socks and other hosiery, knitted or crocheted
	15.20.40 Parts of footwear of leather; removable insoles, heel cushions and similar articles; gaiters, leggings and similar articles, and parts thereof
<b>8. Underwear</b>	14.14.12 Men's or boys' underpants, briefs, nightshirts, pyjamas, bathrobes, dressing gowns and similar articles, knitted or crocheted
	14.14.14 Women's or girls' slips, petticoats, briefs, panties, nightdresses, pyjamas, dressing gowns, negligees, bathrobes and similar articles, knitted or crocheted
	14.14.22 Men's or boys' singlets and other vests, underpants, briefs, nightshirts, pyjamas, bathrobes, dressing gowns, of textile fabric not knitted or crocheted
	14.14.24 Women's and girls' singlets and other vests, slips, petticoats, briefs, panties, nightdresses, pyjamas, negligees, bathrobes, dressing gowns and similar articles, of textile fabric not knitted or crocheted

	14.14.25 Brassieres, girdles, corsets, braces, suspenders, garters and similar articles and parts thereof, whether or not knitted or crocheted
	17.22.12 Sanitary towels and tampons, napkins and napkin liners for babies and similar sanitary articles and articles of apparel and clothing accessories, of paper pulp, paper, cellulose wadding or webs of cellulose fibres
<b>9. Swimwear</b>	14.19.12 Tracksuits, ski suits, swimwear and other garments, knitted or crocheted
	14.19.22 Tracksuits, ski suits and swimwear; other garments of textile fabric, not knitted or crocheted
<b>10. Apparel accessories</b>	14.14.25 Brassieres, girdles, corsets, braces, suspenders, garters and similar articles and parts thereof, whether or not knitted or crocheted
	14.19.13 Gloves, mittens and mitts, knitted or crocheted
	14.19.19 Other made-up clothing accessories and parts of garments or of clothing accessories, knitted or crocheted
	14.19.23 Handkerchiefs, shawls, scarves, veils, ties, cravats, gloves and other made-up clothing accessories; parts of garments or of clothing accessories, of textile fabric, not knitted or crocheted, n.e.c.
	14.19.31 Clothing accessories of leather or of composition leather, except sports gloves
	14.19.41 Hat forms, hat bodies and hoods of felt; plateaux and manchons of felt; hat shapes, plaited or made by assembling strips of any material
	14.19.42 Hats and other headgear, of felt, or plaited or made by assembling strips of any material, or knitted or crocheted or made up from lace or other textile fabric in the piece; hairnets
	22.29.10 Apparel and clothing accessories (including gloves), of plastics
<b>11. Open-toed shoes</b>	15.20.12 Footwear with outer soles and uppers of rubber or plastics, other than waterproof or sports footwear
	15.20.13 Footwear with uppers of leather, other than sports footwear, footwear incorporating a protective metal toe-cap and miscellaneous special footwear
	15.20.14 Footwear with uppers of textile materials, other than sports footwear
	15.20.32 Wooden footwear, miscellaneous special footwear and other footwear n.e.c.
<b>12. Closed-toed shoes</b>	15.20.12 Footwear with outer soles and uppers of rubber or plastics, other than waterproof or sports footwear
	15.20.13 Footwear with uppers of leather, other than sports footwear, footwear incorporating a protective metal toe-cap and miscellaneous special footwear
	15.20.14 Footwear with uppers of textile materials, other than sports footwear
	15.20.32 Wooden footwear, miscellaneous special footwear and other footwear n.e.c.
	15.20.11 Waterproof footwear, with outer soles and uppers of rubber or plastics, other than footwear incorporating a protective metal toe-cap
	15.20.21 Tennis shoes, basketball shoes, gym shoes, training shoes and the like
	15.20.29 Other sports footwear, except snow-ski footwear and skating boots
	15.20.31 Footwear incorporating a protective metal toe-cap
<b>13. Boots</b>	15.20.11 Waterproof footwear, with outer soles and uppers of rubber or plastics, other than footwear incorporating a protective metal toe-cap

15.20.12 Footwear with outer soles and uppers of rubber or plastics, other than waterproof or sports footwear
15.20.13 Footwear with uppers of leather, other than sports footwear, footwear incorporating a protective metal toe-cap and miscellaneous special footwear
15.20.14 Footwear with uppers of textile materials, other than sports footwear
15.20.21 Tennis shoes, basketball shoes, gym shoes, training shoes and the like
15.20.29 Other sports footwear, except snow-ski footwear and skating boots
15.20.31 Footwear incorporating a protective metal toe-cap

The following codes apply to several product categories and have not been added to this table, but are included in this PEFCR:

- 14.11.10 Apparel of leather or of composition of leather
- 14.19.11 Babies' garments and clothing accessories, knitted or crocheted
- 14.19.21 Babies' garments and clothing accessories, of textile fabric, not knitted or crocheted
- 14.19.32 Garments made up of felt or nonwovens, textile fabrics impregnated or coated
- 14.20.10 Articles of apparel, clothing accessories and other articles of fur skin, except headgear

## 2.2. Apparel and Footwear Technical Secretariat

The commissioner of this study is the Technical Secretariat (TS) responsible for the development of the PEFCR for Apparel and Footwear which is composed of the organizations and representatives listed in Table 5.

Table 5 - PEF Apparel and Footwear TS members

No.	Name of the organization	Type of organisation	Main contact(s)	Member status
1	Cascale	Industry association	Joël Mertens Baptiste Carriere-Pradal	Secretariat lead Voting
2	ADEME	Government agency	Maurine Poirier	Non-voting
3	Alliance for European Flax-Linen & Hemp	Industry association	Marie Demaegdt	Voting
4	C&A	Industry	Petra Fausten	Voting
5	Cotton Incorporated	Industry association	Michele Wallace	Voting
6	Décathlon	Industry	Laure Boissier Quentin Badonnel	Voting
7	ECOS	NGO	Valeria Botta Luca Boniolo	Non-voting

No.	Name of the organization	Type of organisation	Main contact(s)	Member status
8	FHCM	Industry association	Léonore Garnier	Voting
9	H&M	Industry	İpek Kurtoglu	Voting
10	Inditex	Industry	Beatriz Beaza Lopez De La Osa Natalia Capelan Teijido Germán García Ibáñez	Voting
11	IWTO	Industry association	Jeanette Cook	Non-Voting
12	Lacoste	Industry	Steve Duhamel Frédéric LeCoq Raynald Anquet	Voting
13	Nike Inc	Industry	Adam Brundage Julia Riss	Voting
14	Refashion (Eco-TLC)	Industry association	Maud Hardy Véronique Allaire Spitzer	Voting
15	Sympatex	Industry	Rüdiger Fox	Voting
16	VF Corporation	Industry	David Quass Niccolo Gervasoni	Voting
17	W.L. Gore & Associates	Industry	Benjamin Bowers Marie Mawe	Voting
18	CEC	Industry association	Carmen Arias Matthieu Vicard Maria Jose Ferreira	Non-voting
19	CNMI	Industry association	Chiara Luisi	Non-voting
20	COTANCE <sup>7</sup>	Industry association	Gustavo Gonzalez-Quijano	Non-voting
21	EURATEX	Industry association	Mauro Scalia	Non-voting
22	FESI	Industry association	Katarzyna Sulisz	Non-voting
23	IFF (Fur Europe)	Industry association	Marianne Coulavin	Non-voting
24	European Commission EF Team	Government	Alicia Boyano Larriba	Observer
25	European Environmental Bureau (EEB)	NGO	Jean-Pierre Schweitzer	Observer
26	Ministry of Infrastructure and Watermanagement and its executive agency Rijkswaterstaat	Government	Madelon de Leeuw Marije Slump	Observer
27	2BPolicy	Consultant	Baptiste Carriere-Pradal Svenja Fröhlich Balkhausen	Technical facilitation
28	Quantis	Consultant	Conrad Leuthold Mireille Faist	Technical expert

<sup>7</sup> COTANCE withdrew their membership from the Technical Secretariat in April 2025

## 2.3. Statement of conformity

This study has been conducted according to the requirements of the PEF method. In case there are deviations to these reference documents, these are clearly highlighted and justified.

This PEF-RP study is valid for products in scope sold or consumed in the European Union (EU27), the UK and the European Free Trade Association (EFTA).

## 3. Goal of the study

The goal of this PEF-RP study is to test the PEFCR for apparel and footwear by calculating the PEFs for 13 virtual representative products. This report follows the PEF method requirements in order to identify the hotspots including the most relevant impact categories, life cycle stages and processes for each representative product.

### Note

Due to the inaccessibility of disaggregated datasets in the EF 3.1 database, the most relevant direct elementary flows could not be identified at this stage.

The main limitations of the study are presented in Section 4.5.

The target audience is mainly:

- The European Commission, the Technical Advisory Board, the EF-subgroup of the Sustainable Consumption and Production expert group;
- The TS and the external review panel; as well as
- Any stakeholder interested in completing a PEF study on apparel and footwear.

The PEF-RP study is not intended to make statements about the product sub-category impacts as such.

# 4. Scope of the study

## 4.1. Functional unit and reference flow

The functional unit (FU) is to provide an apparel or footwear product to meet the user’s specific needs for one use, as defined per sub-category. Table 6 defines the key aspects of the functional unit.

Table 6 - Key aspects of the functional unit

Aspect	Aspect detail	Description
What?	Function provided	To provide an apparel or footwear product to meet the consumer’s needs, as defined per sub-category in Table 3.
How much?	Magnitude of the function	One apparel product, one pair of socks or one pair of footwear as defined by a bill of materials.
How well?	Expected level of quality	Wear in good condition with appropriate use for the given product, as defined per sub-category in Section 3.3.3.1 of the PEFCR.
How long?	Duration of the product provided	One use which includes aspects such as duration of service, or lifetime, care cycles per lifetime and quality, as defined per sub-category.

The consumers’ needs can vary quite widely for an apparel or footwear product, as they can for example be related to work, to performing sports, enjoying leisure, to protection purposes, or simply to the needs of the consumers to express themselves.

«In good condition» means that the product does not present any of the defects that would trigger the consumer to discard it, as defined by the intrinsic durability tests presented in Annex V – Detailed requirements regarding intrinsic durability of the PEFCR.

A use is defined as a 24-hour period, regardless how many hours the apparel or footwear product is worn within this 24-hour period. A use may not always include a washing step as some products only require washing after a few uses as described in Table 34. Both the “how well” and “how long” aspects will be dependent on the intrinsic and extrinsic quality of the product, and its reparability. With an extended lifetime, the impact of the use stage could be higher (e.g. more washes), however the impact of the production stages (LCS 1 + LCS 2) will be lower per use. Products that fail to meet baseline quality requirements will have a higher overall impact (see Section 3.3.2 of

PEFCR v3.1 for more information). Durability aspects aren't taken into account in the PEF-RP study as it analyses average products with an average durability.

The average product lifetime per sub-category is defined in Section 4.1.1. The final weight for each representative product is included in Section 5.4.1.1.

The reference flow is the amount of product needed to fulfil the defined function and is measured in the fraction of the life cycle of the specific apparel or footwear product studied.

For example, for a t-shirt with a lifetime of 45 uses, the reference flow will be 1/45<sup>th</sup> of the t-shirt.

All quantitative input and output data collected in the study are be calculated in relation to this reference flow.

#### Note

As indicated in the PEF method, *“If the product lifetime is extended into a product with original product specifications (providing the same function) these processes shall be included in the FU and reference flow. [...]The user of the PEF method shall describe how reuse or refurbishment is included in the calculations of the reference flow and the full life cycle model, taking into account the “how long” of the FU”.*

#### 4.1.1. Product lifetime: standard duration of service

The PEF method defines the lifetime as the “how long” of the function provided. This parameter is used in the calculation of the reference flow where the single garment or footwear product is divided by the product lifetime in terms of days of wear. This variable is therefore of high importance as it will scale the overall results (Pasquet, 2012; De Saxcé, 2012).

For the lifetime, the concept of the “duration of service” (DoS) from the Higg Product Module (PM) methodology is used where the duration of service is defined as *“the lifetime of the product with appropriate use for its intended function”*. According to this definition, the standard duration of service is independent from the number of users.

The lifetime or duration of service of apparel and footwear can vary greatly. In the PEF-RP study, the number of wears (uses) during the lifetime of each representative

product per sub-category are considered as shown in Table 7 based on Cascale (2020) for apparel, and expert judgement for footwear. The values used in the PEF-RP study represent the average duration of service as presented in the PEF-CR and considers that the intrinsic, extrinsic and repairability multipliers are 1 for all representative products (see Sections 3.3.2, 3.3.3 and 3.3.4 of PEF-CR v3.1).

Table 7 - Number of wears per product duration of service per product sub-category

No.	Product sub-category	Number of wears per product duration of service
1	T-shirts	45
2	Shirts and blouses	40
3	Sweaters and midlayers	85
4	Jackets and coats	100
5	Pants and shorts	70
6	Dresses, skirts and jumpsuits	70
7	Leggings, stockings, tights and socks	55
8	Underwear	60
9	Swimwear	30
10	Apparel accessories	100
11	Open-toed shoes	50
12	Closed-toed shoes	100
13	Boots	100

## 4.2. System boundaries

The following life cycle stages (LCS) and processes are included in the system boundary: the entire life cycle (from cradle to grave) of apparel and footwear products including the raw material acquisition and pre-processing (including packaging production wherever it is used), manufacturing, distribution, use and end-of-life stages. The system boundaries considered in this study are shown in Figure 1 for apparel and Figure 2 for footwear. The main processes for each life cycle stage are indicated in Table 8.

Figure 1 - System boundary diagram for apparel

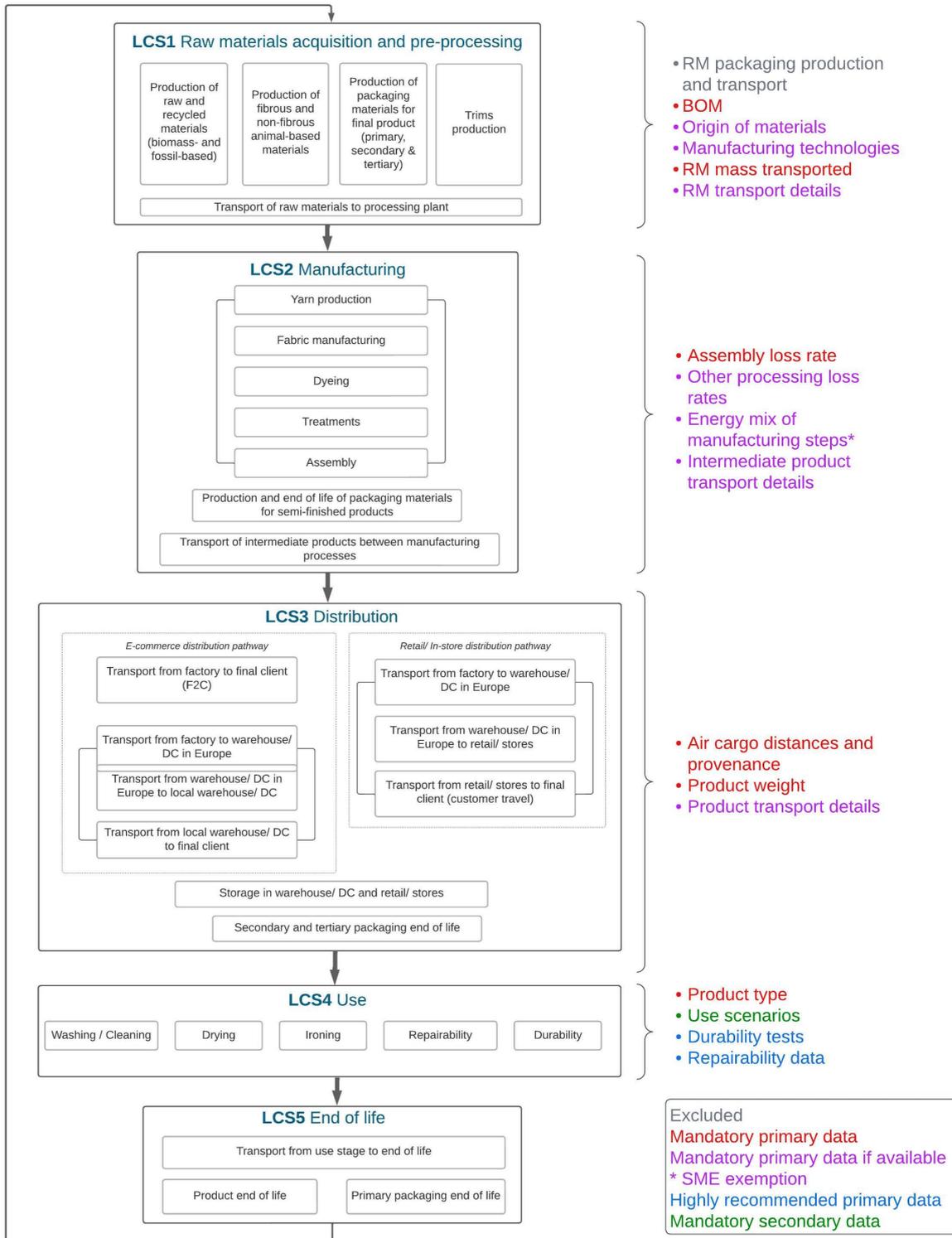


Figure 2 - System boundary diagram for footwear

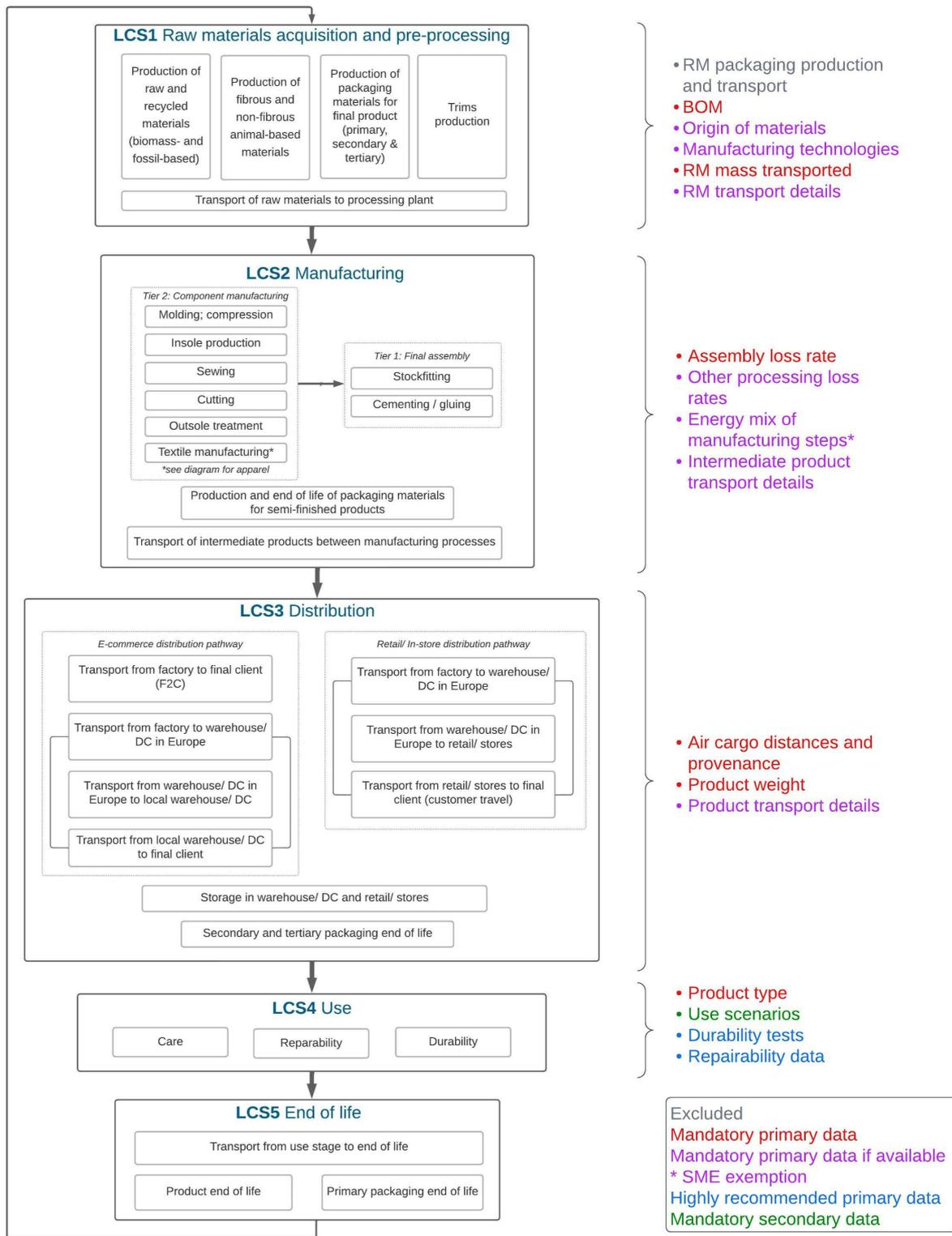


Table 8 - Processes included per life cycle stage

Life cycle stage	Short description of the processes included (non-exhaustive list)
LCS1 Raw materials acquisition and pre-processing	<ul style="list-style-type: none"> <li>• Production or extraction of raw textile, rubber, and plastic materials; fibrous and non-fibrous animal-based materials (including leather materials, tanning and finishing); packaging materials and trims; including the production of filament yarn</li> <li>• Transport of raw material transport to manufacturing plant (see Section 5.4.1.6)</li> </ul>
LCS2 Manufacturing	<p>Apparel and footwear</p> <ul style="list-style-type: none"> <li>• Raw wool scouring</li> <li>• Combing, carding, hackling</li> <li>• Production of yarn through spinning (production of yarn from staple fibres) and melt / solution spinning (production of filament)</li> <li>• Production of knitted fabric (e.g. knitting circular, knitting flat)</li> <li>• Production of woven fabric</li> <li>• Production of seamless fabric</li> <li>• Dyeing: Bleaching, dyeing and printing processes</li> <li>• Treatments, both wet and dry (includes scouring, pre-dye treatments, finishing, chemical treatments (e.g. moisture management and water repellence), coating, lamination, heat treatments (e.g. curing, drying, heat setting, calendaring), mechanical treatments (e.g. raising, brushing))</li> <li>• Assembly (includes sewing)</li> <li>• Any other manufacturing process</li> <li>• Transport of intermediate products between manufacturing processes (see Section 5.4.2.2)</li> <li>• Production of semi-finished and intermediate products packaging</li> <li>• Recycling, incineration (with and without energy recovery) and landfilling of the semi-finished and intermediate products packaging and manufacturing losses and leftovers</li> </ul> <p>Footwear:</p> <ul style="list-style-type: none"> <li>• Compound forming</li> <li>• Die-cutting</li> <li>• In-sole production and assembly</li> <li>• Lasting &amp; delasting</li> <li>• Out-sole treatment (e.g. vulcanisation)</li> <li>• Sewing, fusing</li> <li>• Stockfitting</li> </ul>
LCS3 Distribution	<p>E-commerce:</p> <ul style="list-style-type: none"> <li>• Transport from factory to the final client (factory to consumer)</li> <li>• Transport from factory to warehouse/ distribution centre located in Europe</li> <li>• Transport from a warehouse/ distribution centre located in Europe to a local warehouse/ distribution centre</li> <li>• Transport from local warehouse/ distribution centre to final client</li> <li>• Transport of distribution losses and unsold consumer products</li> <li>• Recycling, incineration (with and without energy recovery) and landfilling of the secondary, tertiary packaging, unsold consumer products and distribution losses</li> </ul> <p>Retail/ in-store:</p> <ul style="list-style-type: none"> <li>• Transport from factory to warehouse/ distribution centre located in Europe</li> <li>• Transport from warehouse/ distribution centre located in Europe to retail/ stores</li> <li>• Transport from retail/ stores to final client (consumer travel)</li> <li>• Distribution losses and unsold consumer products</li> </ul>

Life cycle stage	Short description of the processes included (non-exhaustive list)
	<ul style="list-style-type: none"> <li>Recycling, incineration (with and without energy recovery) and landfilling of the secondary, tertiary packaging and distribution losses</li> </ul>
LCS4 Use	<p>Apparel</p> <ul style="list-style-type: none"> <li>Washing / cleaning</li> <li>Drying</li> <li>Ironing</li> </ul> <p>Footwear</p> <ul style="list-style-type: none"> <li>Care</li> </ul> <p>Both</p> <ul style="list-style-type: none"> <li>Repair</li> </ul>
LCS5 End of life	<ul style="list-style-type: none"> <li>Transportation from user to collection point</li> <li>Transportation from collection point to sorting point (incl. transport for reuse inside and outside of Europe)</li> <li>Transportation from sorting point to recycling</li> <li>Transportation from user to disposal</li> <li>Recycling, incineration (with and without energy recovery) and landfilling of the products as well as of primary packaging</li> </ul>

Hangers are exceptionally given away to consumers (expert judgment). They are thus considered as capital goods and are excluded from the study.

Temporary displays are very seldom recommended by apparel and footwear brands (expert judgement). As such, they are excluded from the system boundaries of apparel and footwear products in this study.

Efforts have been made to include as many processes as possible to ensure that an important hotspot has not been overlooked. However, some processes have not been modelled in the PEF-RP study and are included in Table 9.

Table 9 - Processes excluded per life cycle stage

Life cycle stage	Exclusions
LCS1: Raw materials acquisition and pre-processing	<ul style="list-style-type: none"> <li>Research and development</li> <li>Production and distribution of packaging for raw materials (cut-off according to PEFCR v3.1)</li> </ul>
LCS2: Manufacturing	<ul style="list-style-type: none"> <li>Infrastructure and overheads related to the manufacturing stage are not specifically included</li> </ul>
LCS3: Distribution	<ul style="list-style-type: none"> <li>Storage at home</li> <li>Energy use of customer devices during online shopping</li> </ul>
LCS4: Use	<ul style="list-style-type: none"> <li>Detergent packaging waste treatment</li> </ul>
LCS5: End of life	<ul style="list-style-type: none"> <li>None</li> </ul>

Because the PEF-RP study is conducted on virtual products, every process is in situation 3.

## 4.3. Environmental Footprint impact categories

Each PEF study carried out in compliance with the apparel and footwear PEFCR shall calculate the PEF-profile including all EF impact categories listed in Table 10. As climate change was identified as a most-relevant impact category, and the sub-categories 'Climate change - biogenic' and 'Climate change - land use and land transformation' contribute more than 5% each to the total impact of some RPs, these sub-categories shall be reported separately.

Table 10 - Impact categories for the PEF profile

EF impact category	Impact indicator	Unit	Characterization model	Robustness
Climate change, total <sup>8</sup>	Global Warming Potential (GWP100)	kg CO <sub>2</sub> -eq	Bern model - Global warming potential (GWP) over a 100-year time horizon based on IPCC 2021 (Forster et al., 2021).	I
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11-eq	EDIP model based on the ODPs of the World Meteorological Organisation (WMO) over an infinite time horizon (WMO 2014 + integrations)	I
Human toxicity, cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	Based on USEtox2.1 model (Fantke et al. 2017), adapted as in Saouter et al., 2018	III
Human toxicity, non-cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	Based on USEtox2.1 model (Fantke et al. 2017), adapted as in Saouter et al., 2018	III
Particulate matter	Impact on human health	disease incidence	PM model (Fantke et al., 2016 in UNEP 2016)	I
Ionising radiation, human health	Human exposure efficiency relative to U235	kBq U <sup>235</sup> - eq	Human health effect model as developed by Dreicer et al., 1995 (Frischknecht et al, 2000)	II
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC - eq	LOTOS-EUROS model (Van Zelm et al, 2008) as applied in ReCiPe 2008	II
Acidification	Accumulated Exceedance (AE)	mol H <sup>+</sup> - eq	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II

<sup>8</sup> The indicator "Climate Change, total" is a combination of three sub-indicators: Climate change – Change fossil; Climate change –Change biogenic; Climate change – land use and land use change. The sub-indicators are further described in section 4.4.10 of Annex I. The sub-categories 'Climate change –fossil', 'Climate change – biogenic' and 'Climate change - land use and land use change' shall be reported separately, if they show a contribution of more than 5% each to the total score of climate change.

EF impact category	Impact indicator	Unit	Characterization model	Robustness
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N -eq	Accumulated Exceedance (Seppälä et al., 2006, Posch et al, 2008)	II
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P -eq	EUTREND model (Struijs et al, 2009) as applied in ReCiPe	II
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N -eq	EUTREND model (Struijs et al, 2009) as applied in ReCiPe	II
Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTUe)	CTUe	Based on USEtox2.1 model (Fantke et al. 2017), adapted as in Saouter et al., 2018	III
Land use (occupation and transformation)	Soil quality index (dimensionless) <sup>9</sup> <ul style="list-style-type: none"> <li>•</li> </ul>	Dimensionless (pt)	Soil quality index based on LANCA model (De Laurentiis et al. 2019) and on the LANCA CF version 2.5 (Horn and Maier, 2018)	III
Water use	User deprivation potential (deprivation-weighted consumption)	m <sup>3</sup> world -eq	Available WATER REMaining (AWARE) model (Boulay et al., 2018; UNEP 2016)	III
Resource use <sup>10</sup> , minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb -eq	van Oers et al., 2002 as in CML 2002 method, v.4.8	III
Resource use, fossils	biotic resource depletion – fossil fuels (ADP-fossil)	MJ	van Oers et al., 2002 as in CML 2002 method, v.4.8	III

## 4.4. Additional information

Biodiversity is relevant for each product sub-category in scope of the PEFCR based on expert judgement of the TS. None of the RPs contain certified organic materials.

<sup>9</sup> This index is the result of the aggregation, performed by JRC, of 4 indicators (biotic production, erosion resistance, mechanical filtration, and groundwater replenishment) provided by the LANCA model for assessing impacts due to land use as reported in De Laurentiis et al, 2019.

<sup>10</sup> The results of this impact category shall be interpreted with caution, because the results of ADP after normalization may be overestimated. The European Commission intends to develop a new method moving from depletion to dissipation model to better quantify the potential for conservation of resources.

#### 4.4.1. Fibre fragment impact calculation

##### Note

Due to the novelty of the fibre fragment assessment approach proposed in the PEFCR v3.1, the methodology has only been applied to one representative product (RP 1) to avoid significant delays to the publication of the PEFCR. It is however sufficient to confirm that the approach is applicable.

##### 4.4.1.1. Fibre fragment inventory for one care cycle

First, a fibre fragment inventory for the product's care cycle needs to be calculated. For each textile material used (based on the product's BOM and the associated manufacturing processes (e.g. circular or flat knitting, weaving, etc.)), the best available proxy from The Microfibre Consortium's (TMC) 2024 Microfibre Data Portal Annual Insights<sup>11</sup> is identified. Trims and footwear components are excluded from the inventory, making up the remaining 1% of the BOM.

The following closest specific proxies in TMC's 2024 Microfibre Data Portal Annual Insights for composition and fabric structure are used:

- For cotton, the closest proxy for the composition is "Staple fibre" and for the fabric structure "Weft knit";
- For polyester, the closest proxy for the composition is "Staple fibre" and for the fabric structure "Weft knit";
- For recycled polyester, the closest proxy for the composition is "Staple fibre" and for the fabric structure "Weft knit";
- For viscose/modal, the closest proxy for the composition is "Staple fibre" and for the fabric structure "Weft knit".

The fibre fragment inventory for each material is obtained using Equation 1.

$$FFLoss_i = \frac{Weight_{product}}{UsesPerCareCycle} * (MaterialShare_i * AvgFFLoss_i)$$

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<sup>11</sup> <https://www.microfibreconsortium.com/resources-1>

#### Equation 1

With the following parameters:

**FFLoss<sub>i</sub>** (g fibre fragment emitted/use): the fibre fragments emitted from material *i* for 1 use

**Weight<sub>Product</sub>** (kg) : weight of the product

**UsesPerCareCycle** (units): number of uses of the product prior to a care cycle. Default values from

Table 34 are used.

**MaterialShare<sub>i</sub>** (%): share of material *i* according to the Bill of Materials

**AvgFFLoss<sub>i</sub>** (g fibre fragment emitted/kg of product/wash): the average fibre fragment quantity emitted for 1kg of material *i* and 1 care cycle for the relevant material and fabric construction, based on secondary data from the TMC 2024 Microfibre Data Portal Annual Insights.

#### 4.4.1.2. Fibre fragment impact on marine biota

The impact of the fibre fragments shed during the care cycle are calculated based on the inventory following Section 4.4.1.1, using the most relevant characterisation factor from the MarILCA publications (Corella-Puertas, 2023 and Saadi, 2024). Both the midpoint (PAF\*m<sup>3</sup>\*day/use, representing the ecosystem quality impact based on affected fraction of species) and the endpoint (PDF\*m<sup>2</sup>\*year/ use, representing the ecosystem quality damage based on disappeared fraction of species) impacts are calculated to evaluate the physical effects on biota from fibre fragment emissions to marine environments.

The fibre fragment inventory of each material is multiplied by the characterisation factor of each material (or closest proxy) and then summed to obtain the total fibre fragment impact as per Equation 2 for the midpoint impact and Equation 3 for the endpoint impact. The characterisation factor selection was straightforward for RP1.

$$MidpointImpact = \sum_{i=1}^n MidpointImpact_i = \sum_{i=1}^n \left( \frac{FFLoss_i}{1000} * MidpointCF_i \right)$$

Equation 2

$$EndpointImpact = \sum_{i=1}^n EndpointImpact_i = \sum_{i=1}^n \left( \frac{FFLoss_i}{1000} * EndpointCF_i \right)$$

Equation 3

With the following parameters:

**FFLoss<sub>i</sub>** (g fibre fragment emitted/use): the amount of fibre fragments emitted during 1 use

**MidpointImpact** (PAF\*m<sup>3</sup>\*day/use): the midpoint impact of the product for 1 use

**n**: number of materials in the Bill of Materials

**MidpointImpact<sub>i</sub>** (PAF\*m<sup>3</sup>\*day/kg emitted): the midpoint impact of material *i* for 1 use

**MidpointCF<sub>i</sub>** (PAF\*m<sup>3</sup>\*day/ kg fibre fragment emitted): the characterisation factor of the midpoint impact for 1 kg of fibre fragment emitted for material *i*, based on MariLCA data. The default initial fibre diameter of 10 µm is used.

**EndpointImpact** (PDF\*m<sup>2</sup>\*year/ use): the endpoint impact of the product for 1 use

**EnddpointImpact<sub>i</sub>** (PDF\*m<sup>2</sup>\*year/use): the endpoint impact of raw material *i* for 1 use

**EndpointCF<sub>i</sub>** (PDF\*m<sup>2</sup>\*year/ kg fibre fragment emitted): the characterisation factor of the endpoint impact for 1 kg of fibre fragment emitted for material *i*, based on MariLCA data. The default initial fibre diameter of 10 µm is used.

#### Note

No other additional environmental information is available for the virtual representative products. The list of additional environmental information that can be added to this section is available in Section 3.7 of the PEFCR.

## 4.5. Assumptions and limitations

All assumptions made for this PEF-RP study are listed in Section 5, either in the body of the text or in the detailed Excel tables. All assumptions have been defined in collaboration with the TS.

As this study follows the Apparel and Footwear PEFCR v3.1, it also has the same limitations as the ones listed in Section 3.8 of the PEFCR:

- The representative products being “virtual” products constructed out of an average of various products of the same sub-category, their composition doesn’t correspond to a realistic product.
- Because the PEF method is product- and not user- centric, this PEF-RP study does not allow for differentiation between the impact of a new or second-hand item.
- The allocation for raw material and product transport is mass-based. This may underestimate the environmental impacts from the transport of products with a low density (high volume per mass). To evaluate this, more information on product volume and weight is needed. We recommend investigating this topic by gathering data in a next version of this PEFCR.
- The duration of service of items included in the PEFCR is integrated in this PEF-RP study, but its granularity regarding garment characteristics is low, as there is a lack of robust data assessing the duration of services in number of uses, correlating it with such garment attributes like garment type, fibre composition, fabric structure or garment construction. Intrinsic durability calculations have limitations, as the link between product performance in laboratory tests and the associated performance thresholds, and how a product breaks down due to wearing and domestic care is still being studied. Additionally, the assessment of colour damage could be further refined with more granularity regarding different colour effects (dark, light, solid, shot, etc.). Further studies should also aim to precisely define the levels of degradation which the majority of consumers would consider end of life and use these endpoints to set relevant thresholds for laboratory testing. Furthermore, the methodology to measure the duration of service is highly debated and may be refined in the future. Non-physical durability attributes such as design (use of adjustable design features such as adjustable waist, enabling detaching and replacing parts such as pockets), or making the garment fit for different purposes, which may have an impact on how long a single user will use a product, are not included in this PEFCR. See more details in Section 3.3.2.1 of PEFCR v3.1 and ANNEX VI –

Exploring the extrinsic durability of apparel and footwear products of PEFCR v3.1.

- Toxicity aspects are measured with the LCIA method USEtox, which includes human toxicity (cancer and non-cancer effects) and freshwater ecotoxicity, but no marine water or terrestrial ecotoxicity for the moment. This method therefore does not cover the full impacts of chemicals on humans and ecosystems, which are covered by chemical legislation and other methodologies in Europe.
- The initial fibre fragment impact assessment applied in this RP-study is limited and embeds a high uncertainty (both from the inventory data and the modelling used), but reflects the best practice and the currently most up to date scientific knowledge on the matter. The TMC test method is a quantification of fibre release from fabrics during **simulated domestic laundering**, reflecting the **initial** washing cycle. The total fibre shedding through domestic laundry or other apparel care is, therefore, only an approximation. Furthermore, no inventory data is available on fibre shedding during the use phase nor on fibre emissions in the manufacturing process. It is recommended for the approach to be updated as soon as more information is available to:
  - Cover the entire lifecycle of apparel and footwear products, including production of raw materials, and shedding during use (wear) and end-of-life.
  - Include the impact of fibre fragments on the entire marine compartment, as well as on any other relevant environmental compartment such as freshwater, air and land.

Note

Due to the inaccessibility of disaggregated datasets in the EF 3.1 database, the most relevant direct elementary flows could not be identified at this stage.

The main limitations of this study are listed below per life cycle stage:

**LCS1: Raw material acquisition and pre-processing:**

- Global datasets have been used.

- The documentation of the raw materials datasets doesn't clearly indicate if the dataset includes packaging or not, so packaging was added and might be double counted.

### **LCS2: Manufacturing:**

- Due to the lack of specific data and high variability of manufacturing processes in each representative product's value chain, the most common processes have been considered in the manufacturing stage.
- The documentation of the manufacturing processes datasets doesn't clearly indicate if the dataset includes packaging or not, so packaging was added and might be double counted.
- No global waste treatment datasets were available, so all end-of-life processes were considered to occur in EU+EFTA+UK.
- The pre-dye treatment for knit was also used for pre-dye treatment for woven as the pre-dye treatment for woven dataset was considered to be significantly overestimated.

### **LCS3: Distribution:**

- Minor elements related to the infrastructure during distribution such as specific harbour and port activities are only partially taken into account in the background data.
- Storage at home is excluded.
- Impacts of the energy use of customer devices during online shopping are excluded.
- No dataset for pallet recycling was available, therefore only incineration and landfilling were considered for the end-of-life of pallets.
- The PEF Method includes a recommended utilisation ratio for Van transport. Due to the fact that the default utilisation ratio differs in the dataset and it is not parameterizable, a linear correlation between the impact and the utilisation ratio is assumed, and the activity data was scaled accordingly.
- No global waste treatment datasets were available, so all end-of-life processes were considered to occur in EU+EFTA+UK

#### **LCS4: Use:**

- Care frequency is an important parameter to consider when evaluating the environmental performance of products because it can significantly influence the impact results. Additionally, care frequency may affect the product lifetime due to wear and tear from frequent washing and drying (IWTO, 2020). Data on care frequency are difficult to obtain and are often sourced from consumer surveys.
- Consumer behaviour can be taken into account through surveys. In the future, more primary data might be made available to increase the robustness of key parameters such as the number of wears before a care cycle.
- Product repair and maintenance during use, such as the addition of a lost button; replacement of a zipper; or specific footwear care such as the application of Durable Water Repellent (DWR) spray is not included.

#### **LCS5: End of life:**

- The avoided product is represented with only one option per pathway (e.g., only stone wool for insulation) and it does not take into account the variability of recycled products.
- Little data are available for the recycling efficiency in the recycling pathways, which affects the impacts and benefits from avoided products.
- No global waste treatment datasets were available, so all end-of-life processes were considered to occur in EU+EFTA+UK

## 5. Life cycle inventory analysis

### 5.1. Screening step

This section is not applicable for the apparel and footwear PEF-RP study.

### 5.2. Modelling choices

This study uses the EF3.1 database. When no data are available, the best available proxy from the EF3.1 database is used. Further details of modelling of each life cycle stage are provided in the relevant subsections in Section 5.4.

#### **5.2.1. Modelling of end of life and recycled content**

In this PEF-RP study, the default parameters for the circular footprint formula as defined in the PEFCR are used. The formula is described in Section 4.4.8.1 of the PEF method and Section 5.10 of the PEFCR and is used to model the end of life of products as well as the recycled content.

According to the PEF method (Section 4.4.8.6.), the default value for  $R_1$  is 0%.

The general parameters for end-of-life in the CFF, as defined in Table 28 of the PEFCR, are applied in the PEF-RP study as described in Table 11. The recycling rate listed already takes into account the presence of recycling disruptors in the representative products. For the end of life of trims, the corresponding waste management datasets for the incineration and landfill scenarios of the same materials is used. For the recycling scenario, the end-of-life treatment of trims is considered to be included in the recycling process for the wipers and insulation scenarios.

Table 11 - Definition of the circular footprint formula parameters for apparel end-of-life

Recycling pathway	Scope for $E_v^*$	A	$R_2$ for pathway	$Q_{Sout}/Q_p$	$E_{rec}$	$R_3$
<i>Mechanical recycling</i>						
Wipers	Production of wipers from virgin cotton	0.8	5%	0.3 <sup>12</sup> ,	Collection, sorting of clothes, clothes preparation for recycling and production of wipers from used clothes	39%
Insulation	Production of virgin mineral wool	0.8	12%	1 <sup>13</sup>	Collection, sorting of clothes, clothes preparation for recycling and production of insulation from used clothes	
Total:		17%				

The datasets used for  $E_v^*$  and  $E_{rec}$  are defined in Table 12:

Table 12 -  $E_v^*$  and  $E_{rec}$  datasets in the PEF-RP study

$E_v^* / E_{rec}$	Dataset	Source
Production of wipers from virgin cotton	Cotton-polyester textile, for wipers	Proxy (see Annex VII of PEFCR, tab "Textile DS (Footwear and wipers)")
Production of virgin mineral wool	Stone wool {GLO}   technology mix   production mix, at plant   LCI result	EF Database 3.1
Collection, sorting of clothes and production of wipers from used clothes	Recycling, downcycling {GLO}   collection, sorting, transport, washing, granulation, pelletization   production mix, at plant   LCI result	EF Database 3.1
Collection, sorting of clothes and production of insulation from used clothes	Recycling {GLO}   recycling of textile   production mix, at plant   recycling of 1kg of textile   LCI result	EF Database 3.1

### 5.3. Handling multi-functional processes

The main allocation rules considered in this study are listed in Table 13.

<sup>12</sup> Based on prices from MSC Industrial Direct, this ratio goes from 0.2 for jean-based rags, to 0.5 for good state white t-shirt-based rags, with mixed reclaimed wipers having a ratio of 0.3. Considering most garments are reused in the European context, the value recommended is 0.3.

<sup>13</sup> Mineral wool has a lower insulation quality. As per the PEF Method 2021 (p. 52), the quality ratio is set to 1

Table 13 - Allocation rules

Life cycle stage	Allocation rule	Allocation details	Source
Distribution: intermediate storage at warehouse/ distribution centre and retail/ stores	Based on the space (in m <sup>3</sup> ) and time (in weeks) occupied by the representative product	The allocation factor is calculated as the ratio between the product volume*time and storage capacity volume*time. To adjust for additional space the product takes in the storage facility, a storage volume factor of 4 is used for ambient storage, thus the product volume is multiplied by 4.	PEF method, 2021 OEFSR Retail, 2018
Distribution: all transport processes related to the distribution of the final product to the final client	Mass allocation	The distribution impacts (trucks, vans, etc.) are based on the distance travelled and the mass of the product being transported (tonne-kilometre (tkm)).	TS judgment
Distribution: consumer travel	Volume allocation	The allocation factor is calculated as the volume of the product divided by the maximum volume (0.2 m <sup>3</sup> for a passenger car).	PEF method, 2021
Use: washing	Mass allocation	The mass fraction of the load is used.	TS judgment
Use: energy	Market share allocation	The allocation is assumed to be 100% European electricity mix.	TS judgment
End of life	Market share allocation	The allocation is assumed to be 100% European end-of-life treatment.	Expert judgement

## 5.4. Data collection

The models for the representative products are built using information from different sources, expert assumptions, learnings from the PEFCR pilots and the updated PEF method. Data are mainly provided directly by TS members, scientific articles, reports and Quantis' expertise. In some instances, approximations are made based on the best judgment of the TS.

All product components and production processes have been included in cases where the necessary information is readily available, or a reasonable estimate could be made.

### 5.4.1. Raw material acquisition and pre-processing

The raw materials acquisition and pre-processing life cycle stage includes the processes starting with the extraction of the resources up to the gate of the material's production facility or pre-processing plant, according to Table 8.

This life cycle stage usually includes the extraction and processing of fibres. The following production, pre-processing and transport processes are included in the raw material datasets provided in the most recent version of the EF database:

- Mining, extraction, and refining of resources (e.g. including raw oil);
- Pre-processing of all material inputs to the studied product, including recycled materials;
- Agricultural and forestry activities;
- Transportation within and between the extraction and pre-processing facilities, and to the component's production facility (manufacturing plant) according to Section 5.4.1.6; and
- Packaging production.

For both apparel and footwear products, the following processes are considered:

- Production of raw textile materials (plant-based and synthetic);
- Production of fibrous and non-fibrous animal-based materials;
- Trims production;
- Product packaging (primary, secondary and tertiary) materials production and processing; and
- Transportation between the extraction and pre-processing facilities and to the production facility (manufacturing plant).

#### **5.4.1.1. Bill of materials (BOMs)**

For each sub-category, key products were identified based on market shares of apparel and footwear products sold in Europe (EURATEX data, 2018).

The market splits used within this study are representative of apparel and footwear products produced in and imported to Europe, minus products that were exported from Europe, and were calculated based on product volumes. The main product groups identified per sub-category based on the market shares data from EURATEX are shown in Table 14 below.

Table 14 - Market sales share of top products per sub-category

No.	Product sub-category	Products included	Market shares
1	T-shirts	T-shirts	99.6%
		Collared short-sleeved shirts	0.4%
2	Shirts and blouses	Long-sleeved shirts	75.8%
		Blouses	24.2%
3	Sweaters and midlayers	Jerseys and pullovers	50.9%
		Sweatshirts	17.1%
		Cardigans	22.3%
		Waistcoats	9.7%
4	Jackets and coats	Blazers/suit jackets	31.4%
		Rain jackets	11.0%
		Overcoats	7.3%
		Outdoor winter jackets	38.0%
		Light short jackets	12.3%
5	Pants and shorts	Pants	80.6%
		Shorts	19.4%
6	Dresses, skirts and jumpsuits	Dresses	60.0%
		One-piece suits	14.1%
		Skirts	14.4%
		Robes	11.4%
7	Leggings, stockings, tights and socks	Pantyhose and tights	28.8%
		Hosiery	49.1%
		Socks	22.1%
8	Underwear	Underwear	81.2%
		Bras	18.1%
		Body-shaping suits	0.8%
9	Swimwear	Women's swimwear	76.6%
		Men's swimwear	23.4%
10	Apparel accessories	Hats	42.2%
		Scarves and ties	2.1%
		Belts	9.9%
		Gloves and mittens	45.9%
11	Open-toed shoes	Casual /fashion sandals	57.0%
		Flip-flops	15.0%
		Open-toed slippers	19.8%
		Athletic sandals	8.2%
12	Closed-toed shoes	Casual /fashion shoes	70.0%
		Slippers	23.5%
		Protective shoes	1.0%
		Athletic shoes	5.5%
13	Boots	Casual /fashion boots	51.4%
		Protective boots	16.4%
		Polymer boots	14.0%
		Athletic boots	18.2%

Note: Totals per RP may not reach 100% due to rounding.

The shares of each material in the average final product weight (g/product for apparel and g/pair for footwear) per functional unit are given in Table 15 for apparel (representative products 1-10) and Table 16 for the footwear product sub-categories (representative products 11-13).

Primary data at product level were collected from TS members for each product sub-category. TS members provided raw material inputs for key products, based on either highest volume products or average product data per product sold in Europe, using average sizes. Data collected from TS members were weighted based on their representativeness of an average product sold in the European market using market sales data provided by EURATEX, as well as the average fibre data from the TE Market Report on preferred fibre and materials (2020a).

RP4 contains fur, which was modelled by 82% mink, 16% fox and 2% rabbits (from Hansen, 2023).<sup>14</sup> Leather shares per animal and per product subcategory were provided by the Italian Tanner's Association (UNIC). For accessories (RP10), the leather shares per animal were calculated based on a weighted average of the market split between belts and gloves/mittens (see Table 14). Due to lack of data, "Leather, other" was approximated by "Leather, swine".

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<sup>14</sup> Based on data in European fur industry: Socio-economic dimension – updates and recent trends with focus on secondary and tertiary sector, by Henning Otte Hansen, Ph.D. senior advisor, Department of Food and Resource Economics, University of Copenhagen, published on 25. April 2023

Table 15 - Bill of materials for the apparel representative products with the share (%) of each material based on the average product weight

List of materials	RP1 T-shirts	RP2 Shirts & blouses	RP3 Sweaters & midlayers	RP4 Jackets & coats	RP5 Pants & shorts	RP6 Dresses, skirts and jumpsuits	RP7 Leggings, stockings, tights and socks	RP8 Underwea r	RP9 Swimwear	RP10 Apparel accessorie s
<b>Average weight [g/product]</b>	<b>170</b>	<b>250</b>	<b>500</b>	<b>950</b>	<b>450</b>	<b>300</b>	<b>130</b>	<b>80</b>	<b>120</b>	<b>110</b>
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Acrylic	-	-	5%	11%	-	-	7%	-	-	16%
Cashmere and camel hair	-	-	4%	0.9%	-	-	-	-	-	-
Cotton <sup>1</sup>	70%	55%	34%	15%	47%	54%	22%	70.5%	-	15%
Duck down	-	-	-	0.9%	-	-	-	-	-	-
Elastane	-	-	-	-	4%	-	9%	7%	9%	-
Fur, mink	-	-	-	0.246%	-	-	-	-	-	-
Fur, fox	-	-	-	0.048%	-	-	-	-	-	-
Fur, rabbit	-	-	-	0.006%	-	-	-	-	-	-
Leather, cow	-	-	-	0.21%	0.2%	-	-	-	-	7%
Leather, calf	-	-	-	0.14%	0.1%	-	-	-	-	-
Leather, sheep	-	-	-	0.44%	0.6%	-	-	-	-	-
Leather, goat	-	-	-	0.10%	0.1%	-	-	-	-	-
Leather, other (proxy: swine)	-	-	-	0.01%	0.004%	-	-	-	-	-
Linen	-	5%	-	-	4%	-	-	-	-	-
Polyamide	-	-	2%	15%	7%	4%	27%	10%	51%	4%
Polyamide recycled	-	-	-	-	-	-	4%	2%	-	-
Polyester and other synthetics <sup>2</sup>	21.3%	23.2%	21.7%	35.6%	30.9%	24.5%	18.8%	5.1%	37.6%	30.3%
Polyester recycled	2%	3%	4%	4%	3%	2%	2%	-	2%	-
Polytetrafluoroethylene (PTFE)	-	-	-	1.8%	-	-	-	-	-	-
Silk	-	-	-	-	-	-	-	-	-	1%
Viscose/ Modal/ Lyocell <sup>3</sup>	6%	13%	5%	4%	2%	13%	8%	5%	-	-
Wool	-	-	24%	9%	-	2%	2%	-	-	26%

List of materials	RP1 T-shirts	RP2 Shirts & blouses	RP3 Sweaters & midlayers	RP4 Jackets & coats	RP5 Pants & shorts	RP6 Dresses, skirts and jumpsuits	RP7 Leggings, stockings, tights and socks	RP8 Underwear	RP9 Swimwear	RP10 Apparel accessories
Trims <sup>4</sup>	0.7%	0.8%	0.3%	1.6%	1.1%	0.5%	0.2%	0.4%	0.4%	0.7%

<sup>1</sup> Although data from the past years indicate an increased share of organic cotton on the European market (Textile Exchange, 2020b), the actual share of organic cotton in 2019 was 0.93% globally. Because of this very low share, organic cotton is included here in the cotton category.

<sup>2</sup> Other synthetics include aramid, copolyester, elastodiene, elastolefin, EVA, polyethylene, rubber synthetic.

<sup>3</sup> Because of the very similar production processes of viscose and Modal as well as the overall low share of Lyocell, these materials are grouped in the same category.

<sup>4</sup> The assumed material composition of trims is an equal share of care labels (PES), buttons (PET) and zippers (metal for RP4, RP5 and RP10 and nylon for RP1, RP2, RP3, RP6, RP7, RP8, RP9 as a proxy for other plastic trims).

Note: Totals per RP may not reach 100% due to rounding.

Table 16 - Bill of materials for the footwear representative products with the share (%) of each material based on the average product weight

List of materials	RP11 Open-toed shoes	RP12 Closed-toed shoes	RP13 Boots
<b>Average weight [g/pair]</b>	<b>350</b>	<b>900</b>	<b>1100</b>
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Wood-based non woven	-	-	2%
Cork	5%	-	-
Cotton <sup>1</sup>	-	3%	-
EVA	28%	7%	-
Leather, cow	13%	7%	12%
Leather, calf	1.7%	1.4%	4.9%
Leather, sheep	1.1%	0.5%	2.6%
Leather, goat	1.1%	1.3%	1.4%
Leather, other (proxy: swine)	0.3%	0.3%	0.2%
Metal	-	-	2%
Polyamide	-	3%	3%
Polyester and other synthetics <sup>2</sup>	3%	26%	13%
Polyester recycled	-	3%	2%
Polyurethane	8%	6%	10%
Polyvinyl chloride (PVC)	6%	6%	14%
Rubber natural	13%	8%	5%
Rubber synthetic	19%	16%	11%
Thermoplastic polyurethane	-	3%	14%
Viscose/ Modal <sup>3</sup>	-	2%	-
Wool	-	4%	-
Trims <sup>4</sup>	1%	2%	3%

<sup>1</sup> Although data from the past years indicate an increased share of organic cotton on the European market (Textile Exchange, 2020b), the actual share of organic cotton in 2019 was 0.93% globally. Because of this very low share, organic cotton is included here in the cotton category.

<sup>2</sup> Other synthetics include aramid, copolyester, elastodiene, elastolefin, EVA, polyethylene, rubber synthetic.

<sup>3</sup> Because of the very similar production processes of viscose and modal these materials are grouped in the same category.

<sup>4</sup> The assumed material composition of trims is shoe laces for RP11, an equal share of shoe laces, shoe eyelets (nylon) and shoe eyelets (metal) for RP12 and an equal share of zippers (metal), shoe laces, shoe eyelets (nylon) and shoe eyelets (metal) for RP13

Note: Totals per RP may not reach 100% due to rounding.

The average final product weights presented in Table 15 and Table 16 correspond to the weight of the final product after raw materials acquisition and pre-processing, manufacturing and assembly. The sum of all raw material inputs needed per representative product are higher than the final product weight due to losses along the production and value chain. The input amount per functional unit is therefore calculated data and the quantities are determined according to residual losses during the production processes as described in Section 5.4.1.3.

For leather, the datasets available are in m<sup>2</sup>. To convert the BOM values from kg to m<sup>2</sup>, the conversion factors in Table 17 are used (EF 3.1 documentation).

Table 17 - Conversion factors for leather

Leather	Conversion factor (kg/m <sup>2</sup> )
Cattle	1.5
Veal	1.2
Caprine	0.5
Ovine	0.4
Other (proxy: swine)	0.4

For exclusions, see Table 9.

**5.4.1.2. Raw materials and unsold consumer products**

Unsold consumer products, like losses, decrease the efficiency of the supply chain and therefore are be included in the modelling. They will not only affect the amount of raw materials needed for one final garment at the consumer, but will also generate additional amounts processed and transported. Unsold consumer products are “any consumer product that has not been sold including surplus, excessive inventory, overstock and deadstock, including products returned by a consumer in view of their right of withdrawal in accordance with Article 9 of Directive (EU) 2011/83/EU, or, where applicable, during any longer withdrawal period provided by the trader”, as defined in

Ecodesign for Sustainable Products Regulation (ESPR) compromise text, published on 19 December 2023<sup>1516</sup>. It shall **include**:

- Surplus, excessive inventory, overstock and deadstock at any point of the distribution scheme;
- Defective products only once they have reached the brand's distribution scheme;
- Product returns by consumer in view of their right of withdrawal in accordance with Article 9 of Directive (EU) 2011/83/EU.

It shall **exclude**:

- Prototypes;
- Samples;
- Manufacturing leftovers (e.g. deadstock fabrics);
- Manufacturing losses;
- Defective products in manufacturing, before reaching the brand's distribution scheme;
- Resale (e.g. Through outlets, wholesalers).

Items that could not be sold are defined as items that have either been written off from the company's inventory or have remained in stock in a warehouse for more than 3 annual administration periods.

Unsold consumer products are accounted for in the following life cycle stages:

- LCS 1 – raw materials acquisition and processing
- LCS 2 – manufacturing
- LCS 3 – distribution

In the raw materials acquisition and pre-processing stage, unsold consumer products and all other losses (distribution losses, manufacturing losses, manufacturing

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<sup>15</sup> The ESPR definition should be applied to qualify unsold consumer products and may be updated if further precision is provided by the Implementing or Delegated Act adopted by the Commission. Its scope is therefore to include all consumer product fit for sale that were not sold, with the following interpretation.

<sup>16</sup> For guidance, Article 20 1 c) refers to management modes on unsold consumer products as ::“whether directly or through a third party, to each of the following activities preparing for re use, remanufacturing, recycling, other recovery including energy recovery and disposal operations in accordance with the waste hierarchy as defined by Article 4 of Directive 2008 98 /EC

leftovers, etc.) are used as a direct multiplier of the input of raw materials as reported in Section 5.4.1.3 and 5.4.2.1. The end of life of unsold consumer products takes place in LCS5. The end of life of unsold consumer products is modelled according to the product's end of life (Section 5.2).

### 5.4.1.3. Amount of raw materials

The amount of raw materials needed to create one product takes into account all the losses that occur throughout the product's life cycle (pre-processing losses, manufacturing leftovers, manufacturing losses (including assembly losses), unsold consumer products and distribution losses).

This means that each pre-processing and manufacturing process must be disaggregated in single steps, including specific losses for each step. As pre-processing losses are already included in the raw material datasets used in this study, they are not considered in the calculation. More information on manufacturing losses is available in Section 5.4.2.1.

For each raw material, the relevant amount is calculated using Equation 4.

$$RawMat = mBOM * \left( \prod_{i=1}^{NPrePro} (1 + PreProLoss_i) \right) * (1 + ManuLeft) * \left( \prod_{j=1}^{NManuPro} (1 + ManuLoss_j) \right) * (1 + UnsoldProducts) * (1 + DistribLoss)$$

Equation 4

with the following parameters:

- **RawMat**: is the total mass of the raw material produced (kg).
- **mBOM**: is the mass of the raw material in the BOM found in Table 15 for apparel and Table 16 for footwear(kg).
- **PreProLoss<sub>i</sub>**: this part of the equation is considered as equal to 1 in the PEF-RP study, as all the pre-processing losses are already included in the corresponding dataset itself.
- **ManuLeft**: is the fraction of the raw material lost through manufacturing leftovers (%).
- **ManuLoss<sub>j</sub>**: is the fraction of the raw material lost during manufacturing process *j*, and **NManuPro** is the number of manufacturing processes. The manufacturing losses considered in this study are available in Table 26 and Table 27.

- **UnsoldProducts**: is the fraction of the raw material used to create unsold consumer products (see Section 5.4.3 for more details).
- **DistribLoss**: is the fraction of the raw material lost through distribution losses (see Section 5.4.3 for more details)

Equation 4 was applied to calculate the amount of pre-processed raw material for the calculation of the full LCS1 inventory as well as for the calculation of the mass of raw material transported required in Section 5.4.1.6. An example of the application of the equation is provided in section 6.1.2 of the PEFCR.

Note: Equation 4 is used for the calculation of the amounts at each step of the manufacturing chain to select the correct value per processing dataset by deleting the term  $(\prod_{i=1}^{N_{PrePro}}(1 + PreProLoss_i))$  – see Equation 5.

#### 5.4.1.4. Raw material circularity

Circularity of raw materials is addressed in the following two cases:

- The apparel or footwear product uses recycled materials, which can be of textile or non-textile origin; or
- The apparel or footwear product is recycled after use; this includes recycling apparel and footwear into raw materials for chemicals or other materials such as rubber, plastic, composites, etc.

In these two cases, the credits and impacts associated to these flows are modelled and allocated to the raw material using the Circular Footprint Formula (CFF), presented in detail in Section 5.2.1. Additional details regarding the CFF are described in Section 4.4.8.1 of the PEF method 2021.

#### 5.4.1.5. Packaging production and distribution

Different types of packaging need to be produced to ensure safe shipping and storage of:

- Raw materials, semi-finished & intermediate products; and
- Apparel and footwear products.

The documentation of the raw materials and manufacturing datasets not specifying if packaging was included, packaging has been modelled according to Section 6.1.5 of the PEFCR v3.1.

It is assumed that all packaging comes from the same continent as the plant where it is used. The transportation modes listed are additive.

Packaging transport is assumed to be weight-limited for all packaging types. The default parameters (from the PEF method) for packaging transport in Table 18 below is used. These parameters were also used to model the return of reusable packaging such as pallets.

Table 18 - Default transport parameters for all packaging materials

Supply chain	Distance (km)	Utilisation ratio	Share of product mass transported (%)	Transportation mode
Supplier located within the continent of the manufacturing plant	230	64%	100%	Truck (>32 t, EURO 4)
	280	n/a		Train (average freight train)
	360	n/a		Ship (barge)

A first iteration of PEF-RP study v2.0 demonstrated that the production and distribution of the packaging of raw materials represents less than 3% of the impact for all relevant impact categories for all RPs. It has therefore been cut off.

The default packaging amounts and materials reported in Table 19 have been used, based on secondary and tertiary packaging of apparel and footwear products, divided by the average RP weight and a volume factor of 4 to account for transport volume inefficiencies (proxy based on ambient volume storage volume factor, OEFSR Retail, 2018). None of the manufacturing datasets already contained packaging and therefore the default values have been used in their entirety.

Table 19 - Default packaging materials per kilogram of semi-finished and intermediate product transported

Packaging	Mass kg/kg semi-finished and intermediate products	Material
Corrugated cardboard	0.040	Corrugated cardboard

Pallets	0.00002*	Pallets
Shrink film	0.001	Shrink film

\* including default reuse factor (PEF method, 2021, 4.4.9.5 Average reuse rates for third party operated pools).

The default pallet mass value was used to account for the production impact of the pallets, multiplied by the default reuse factor of 25 trips to obtain the total weight necessary to calculate the transport impact for one product as calculated in Table 19.

The total mass of semi-finished & intermediate products transported was calculated at the gate of the assembly step as explained in Section 5.4.2.1.

The end of life of the semi-finished & intermediate products packaging was be accounted for in LCS2. In this study, the default CFF parameters for the recycling, incineration and landfilling of paper/cardboard, LDPE and polypropylene from Part C of Annex II of the PEF method were used for the end-of-life of primary packaging. As no wood recycling dataset was available, the end-of-life of wood pallets was estimated to consist only of incineration and landfill. The datasets used to model the end-of-life of packaging already included collection.

The differentiation between primary, secondary and tertiary packaging is defined as follows:

- **Primary packaging:** Material that immediately covers the product. For example, primary packaging can consist of a plastic film or bag, or paper wrapping. The hangtag is also considered to be primary packaging as well as cellulose paper for footwear.
- **Secondary packaging:** Packaging or containment of a primary package. Packaging for multiple products and their labels are also considered to be secondary packaging.
- **Tertiary packaging:** Packaging conceived to facilitate handling and transport of a number of sales units, or grouped packaging to prevent physical handling and transport damage.

Two aspects were taken into consideration when determining the average packaging for each RP (Sandin et al., 2019, T-shirt PEFCR, 2019):

- Quantity of material and
- Type of material.

In the T-shirt PEFCR (2019), the primary packaging considered is a polybag-Polypropylene (PP) and the secondary packaging is a corrugated cardboard box.

As referenced in the study conducted by Sandin et al. (2019) based on the individual products package weights, an estimation for a generic packaging was taken, considering a packaging of 0.02 kg of plastic packaging and 0.06 kg of corrugated board box per kg of garment.

The raw materials inputs for packaging (primary, secondary and tertiary) considered in this study for all apparel and footwear sub-categories per piece of garment and per different business scenarios (Figure 3) are given in Table 20, Table 21 and Table 22.

Table 20 – Default packaging materials per piece of garment, for retail / in-store business scenario

Sub-category	Packaging type	Raw material	Amount	Unit
Apparel	Primary	Polybag <sup>17</sup>	0.020	kg
		Polybag <sup>17</sup>	0.010	kg
		Paper bag	0.022	kg
		Paper (hangtag)	0.001	kg
		Plastic (hangtag)	0.001	kg
	Secondary	Corrugated cardboard	0.060	kg
	Tertiary	Wood pallets	0.001*	kg
		Shrink film	0.0010	kg
Footwear	Primary	Polybag	0.010	kg
		Paper bag	0.022	kg
		Corrugated cardboard	0.200	kg
		Paper (hangtag)	0.001	kg
		Plastic (hangtag)	0.001	kg
		Cellulose paper	0.100	kg
	Secondary	Corrugated cardboard	0.060	kg

<sup>17</sup> One polybag is for the film directly around the product and the other polybag is a proxy for the bag received in store

Sub-category	Packaging type	Raw material	Amount	Unit
	Tertiary	Wood pallets	0.001*	kg
		Shrink film	0.001	kg

\* Including default reuse factor (PEF method, 2021, 4.4.9.5 Average reuse rates for third party operated pools).

Table 21 - Default packaging materials per piece of garment, for e-commerce business scenario

Sub-category	Packaging type	Raw material	Amount	Unit
Apparel	Primary	Corrugated cardboard	0.060	kg
		Polybag	0.020	kg
		Paper bag <sup>18</sup>	0.022	kg
		Paper (hangtag)	0.001	kg
		Plastic (hangtag)	0.001	kg
	Secondary	Corrugated cardboard	0.060	kg
	Tertiary	Wood pallets	0.001*	kg
Shrink film		0.001	kg	
Footwear	Primary	Corrugated cardboard	0.200	kg
		Paper bag <sup>18</sup>	0.022	kg
		Paper (hangtag)	0.001	kg
		Plastic (hangtag)	0.001	kg
		Cellulose paper	0.100	kg
	Secondary	Corrugated cardboard	0.060	kg
	Tertiary	Wood pallets	0.001*	kg
		Shrink film	0.001	kg

\* Including default reuse factor (PEF method, 2021, 4.4.9.5 Average reuse rates for third party operated pools).

Table 22 - Default packaging materials per piece of garment, for F2C business scenario

<sup>18</sup> Refers to online outer bags

Sub-category	Packaging type	Raw material	Amount	Unit
Apparel	Primary	Polybag	0.020	kg
		Paper (hangtag)	0.001	kg
		Plastic (hangtag)	0.001	kg
	Secondary	Corrugated cardboard	0.060	kg
	Tertiary	Wood pallets	0.001*	kg
		Shrink film	0.001	kg
Footwear	Primary	Corrugated cardboard	0.200	kg
		Paper (hangtag)	0.001	kg
		Plastic (hangtag)	0.001	kg
		Cellulose paper	0.100	kg
	Secondary	Corrugated cardboard	0.060	kg
	Tertiary	Wood pallets	0.001*	kg
		Shrink film	0.001	kg

\* Including default reuse factor (PEF method, 2021 4.4.9.5 Average reuse rates for third party operated pools).

Similarly to the intermediate and semi-finished product packaging, the default pallet mass value was used to account for the production impact of the pallets, and was multiplied by the default reuse factor to obtain the total weight necessary to calculate the transport impact for one product as calculated in Table 20, Table 21 and Table 22.

The end of life of primary packaging was accounted for in LCS5, and the end of life of secondary and tertiary packaging was accounted for in LCS3. The default CFF parameters for the recycling, incineration and landfilling of paper/cardboard, LDPE and polypropylene from Part C of Annex II of the PEF method were used for the end-of-life of primary packaging. As no wood recycling dataset was available, the end-of-life of wood pallets was estimated to consist only of incineration and landfill, as for the intermediate and semi-finished products. Based on the data available from previous studies, plastic film and corrugated cardboard are identified as the main materials for average packaging for all apparel and footwear products. For the conversion of polybag mass into polybag area (default unit of the used dataset), an area density of

27.5 g/m<sup>2</sup> is used. For the conversion of hangtag mass into hangtag area (default unit of the used dataset), an area density of 90.0 g/m<sup>2</sup> and 94.3 g/m<sup>2</sup> are used for paper and plastic hangtags respectively. For the conversion of shrink wrap mass into shrink wrap area (default unit of the used dataset), an area density of 110.16 g/m<sup>2</sup> is used. The collection of the packaging at the end of life is already considered in the EF dataset used.

**5.4.1.6. Raw materials and packaging transport**

The transportation of raw materials used for apparel and footwear products from a supplier to the tier 1 manufacturing plant are also included in the raw materials life cycle stage (LCS 1). The impact of the transport is calculated per tonne kilometre (tkm), which is equivalent to the transport of 1 tonne (t) of product over 1 kilometre (km). In this study the default values given in Table 23 are used which are adapted from the PEF method, values based on Eurostat (2015a) and shares of product mass transported for each transport leg are based on TS expertise. The mass transported considers the mass of the raw materials at the entry gate of LCS2 as explained in Section 5.4.1.2. The distance and transportation modes in Table 23 were used and weight-limited transport is considered for all materials transported.

Table 23 - Transport scenarios and parameters for raw materials, semi-finished & intermediate products

Supply chain location	Distance (km)	Utilisation ratio	Share of product mass transported (%)	Calculation (Mass (t) x distance (km) x Share of product mass transported (%))	Transportation mode
Supplier located in the same continent as the processing plant	1'000	64%	40%	Mass transported x 1'000 x 0.4	Truck (>32t, EURO 4)
	1'000	n/a		Mass transported x 1'000 x 0.4	Train (average freight train)
	800	n/a		Mass transported x 800 x 0.4	Ship (barge)
Supplier located outside the continent of the	1'000	64%	55%	Mass transported x 1'000 x 0.55	Truck (>32t, EURO 4)

Supply chain location	Distance (km)	Utilisation ratio	Share of product mass transported (%)	Calculation (Mass (t) x distance (km) x Share of product mass transported (%))	Transportation mode
processing plant (ship)	18'000	n/a		Mass transported x 18'000 x 0.55	Ship (transoceanic container)
Supplier located outside the continent of the processing plant (plane)	1'000	64%	5%	Mass transported x 1'000 x 0.05	Truck (>32t, EURO 4)
	10'000	n/a		Mass transported x 10'000 x 0.05	Air freight (cargo plane)

**5.4.2. Manufacturing of the final product**

The manufacturing life cycle stages are different between apparel and footwear products and thus include different manufacturing processes, which are described separately below. In both cases, the supply chains have been broken into a system of “tiers” based on closeness to the apparel and footwear manufacturer (tier 1 being directly in contact with the manufacturer). In this study, no manual processes were considered.

Apparel manufacturing (including apparel accessories) includes the following processes per tier:

- Processing of raw materials, both from virgin and recycled content. This includes various processes such as pre-spinning processes (scouring, carding, combing, hackling, etc.), spinning fibres into yarn as well as processing non-fibrous products (for example leather, down or foam) into other intermediate products, for example padding (tier 3).
- Manufacturing processes, such as knitting and weaving textiles, preparation, dyeing (fibre, yarn, fabric) and finishing of fabric (tier 2).
- Component consolidation and final assembly of the product. This includes various processes such as cutting, assembly (cutting/sewing), garment wet

processing/washing, dry treatment processes (e.g. laser), and the packaging for sale (tier 1).

The split of the knitting and weaving processes included for apparel representative products are listed in Table 24, based on expert judgement.

Table 24 - Knitting and weaving processes included for apparel manufacturing per RP

No.	Product sub-category	Knitting, circular	Knitting, flat	Weaving
1	T-shirts	100%	0%	0%
2	Shirts and blouses	20%	0%	80%
3	Sweaters and midlayers	40%	60%	0%
4	Jackets and coats	15%	0%	85%
5	Pants and shorts	30%	0%	70%
6	Dresses, skirts and jumpsuits	25%	5%	70%
7	Leggings, stockings, tights and socks	100%	0%	0%
8	Underwear	60%	0%	40%
9	Swimwear	60%	0%	40%
10	Apparel accessories	20%	20%	60%

For all dyeing processes, a pre-dye treatment was added. The share of acid, reactive and disperse dyeing technologies are split according to the materials in Table 15 (for apparel) and Table 16 (for footwear), where each technology is associated with each dyeable material:

- Reactive dyeing: cotton, viscose and linen
- Disperse dyeing: polyester, acetate and acrylic
- Acid dyeing: nylon, wool and all other materials which are dyed

All-over prints are considered as part of dyeing. Placements prints were included as screen printing for 15% of fabrics for each RP (Cascale), with an average surface of 400 cm<sup>2</sup> per product (Higg<sup>19</sup>).

Footwear manufacturing includes the following processes:

<sup>19</sup> <https://howtohigg.org/higg-product-module/completing-finished-goods-manufacturing/garment-printing/>

- Component manufacturing including manufacturing of the individual parts of the shoe (bottom, mid and upper parts) as well as compound forming (sole production), in-sole production, lamination die-cutting and sewing.
- Component consolidation and final assembly of the product. Processes included are: lasting, delasting, stockfitting, assembly, treatments (e.g. coating and waterproofing) and the packaging for sale.

Footwear manufacturing can be very complex and variable, with different manufacturing pathways found for the same type of shoe and brand. The processes above have been selected due to their applicability for most types of footwear products and manufacturing pathways, covering the most environmentally intensive processes. Table 25 (Quantis expertise) shows the share of each process per footwear RP.

Table 25 - Processes included for footwear manufacturing per RP

Process	Open-toed shoes	Closed-toed shoes	Boots
Injection molding	46%	35%	52%
Molding, compression	54%	65%	48%
In-sole assembly	60%	100%	100%
Lamination	50%	50%	50%
Sewing	100%	100%	100%
Cutting	100%	100%	100%
Lasting	100%	100%	100%
Delasting	100%	100%	100%
Stockfitting	100%	100%	100%
Cementing	100%	100%	100%
Vulcanisation	5%	30%	15%
Coating	75%	75%	75%
Waterproofing	0%	50%	75%

Both apparel and footwear manufacturing life cycle stages include the transportation of semi-finished and intermediate products between manufacturing stages. The mass transported considers the mass of the semi-finished & intermediate products at the entry gate of the assembly step.

All apparel and footwear manufacturing processes are modelled in a global context. Therefore, the energy mix used is in a global context as well, considering a market mix of different countries and regions.

#### 5.4.2.1. Amount of semi-finished & intermediate products

The amount of semi-finished & intermediate products needed to create one product takes into account all the losses that occur throughout the product's life cycle (pre-processing losses, manufacturing leftovers, manufacturing losses (including assembly losses), unsold consumer products and distribution losses).

This means that each manufacturing process must be disaggregated in single steps, including specific losses for each step. More information on manufacturing losses is available in Section 5.4.2.1.1.

For each semi-finished & intermediate product, the relevant amount for the service process<sup>20</sup> was calculated using Equation 5.

$$SFIP_i = mBOM_i * (1 + ManuLeft) * \left( \prod_{j=1}^{NManuPro} (1 + ManuLoss_j) \right) * (1 + UnsoldProducts) * (1 + DistribLoss)$$

Equation 5

Where:

- ***SFIP<sub>i</sub>*** : is the total mass of the considered Semi-Finished & Intermediate Products (kg)
- ***mBOM<sub>i</sub>*** : is the mass of the considered SFIP in the BOM found in Table 15 for apparel and Table 16 for footwear (kg)
- ***ManuLeft***: is the fraction of the raw material lost through manufacturing leftovers (%). The manufacturing leftovers used in this study are 5% (Cascale).
- ***ManuLoss<sub>j</sub>*** is the fraction of the raw material lost during manufacturing process *j*, and *NManuPro* is the number of manufacturing processes. The manufacturing losses used in this study are available in Table 26 and Table 27.
- ***UnsoldProducts***: is the fraction of the raw material used to create unsold consumer products (see Section 5.4.3 for more details).
- ***DistribLoss***: is the fraction of the raw material lost through distribution losses (see Section 5.4.3 for more details)

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<sup>20</sup> Service activities have inputs and outputs required to perform a service on another product, without the actual input and output of the product receiving the service. Services are therefore defined as immaterial exchanges, i.e., without a physical good changing ownership (<https://support.ecoinvent.org/activities-products>).

Equation 5 was fully or partially applied depending on the mass that should be calculated. To calculate how much input material a manufacturing process  $i$  requires, the equation is applied up to the manufacturing step assessed ( $ManuLoss_i$ ).

As indicated in the PEFCR v3.1, the transport of semi-finished and intermediate products is represented by a single transportation step between the last manufacturing step and assembly. To calculate the mass of semi-finished products transported, the equation is applied up to the entry gate of the assembly step, i.e. without the manufacturing losses (Section 5.4.2.2).

For textile processes that require a conversion between  $m^2$  and kg, either the specific grammage of the fabric or the default value of  $200g/m^2$  was used.

#### 5.4.2.1.1. Manufacturing losses

Manufacturing losses are of two kinds:

- Processing losses
- Assembly losses and manufacturing leftovers

The end of life of these losses have been considered in LCS2 according to the CFF (Section 5.2.1).

For semi-finished & intermediate products manufacturing losses, the input and output amounts were calculated based on the bill of materials according to Section 5.4.1.1. Losses are understood as the waste produced during a pre-processing step.

Losses considered in this study for apparels and footwears are reported in Table 26 and Table 27.

The following hypothesis was considered: the amount of input material for process  $n$  is equal to the amount of output material for process  $n-1$  (T-shirt PEFCR, 2019).

Therefore, the output material and the processing losses can be used to calculate the amount of input raw material. Equation 6 was used to determine the amount of input material:

$$\begin{aligned} \text{Amount of input material}_n &= \text{Amount of output material}_n + \text{Waste}_n = \\ &\text{Amount of output material}_n * (1 + \text{LossRate}_n) \end{aligned}$$

Equation 6

Where the input and output are measured in kg and the waste is measured as a percentage.

Apparel losses

The overall losses in the material manufacturing processes and the finishing of garment from fabric is presented in Table 26. Losses are included in the EF3.1 datasets. The only exception was for scouring, where the documentation didn’t include any information on losses. A 15% default loss rate as indicated in the PEFCR v3.1 was used instead.

Table 26 - Losses along the garment manufacturing value chain

Manufacturing process	Losses
Scouring (default loss rate)	15%
Spinning, continuous filament	3%
Spinning, for knit, natural fibres	38.1%
Spinning, for woven, natural fibres	26.9%
Knitting, flat	3%
Knitting, circular	3%
Pre-dye treatment	0.8%
Weaving	5%
Dyeing (acid, reactive and disperse)	9.2%
Printing	1.25%
Finishing	0%
Cutting	20%

Footwear losses

Losses during footwear manufacturing can occur along the whole manufacturing value chain. Depending on the type of shoe and processes applied, the losses between each step can vary significantly. Losses are included in the EF3.1 datasets. It’s worth noting that losses are considered insignificant for all the footwear manufacturing processes used in the PEF-RP study aside from cutting.

The defaults provided in Table 27 are applied for the footwear manufacturing steps included in this study. Note that for the open-toed shoes, in-sole production is not included in the manufacturing; therefore, no losses are considered.

Table 27 - Losses along the footwear manufacturing value chain

Manufacturing step	Process	Losses
Component making	Insole production	15%
Component making	Lamination	0.1%
Component making	Cutting	20%

Unsold consumer products are included in the manufacturing through an increased amount of raw materials used in LCS1. See Section 5.4.1.2. An example of the application of the equation is provided in Section 6.2.1 of the PEFCR.

#### 5.4.2.1.2. Assembly losses and manufacturing leftovers

The mass of the assembly losses is determined as the difference between the mass of the BOM for one product and the mass of the product. The end of life of these losses is be considered in LCS2 according to the CFF (Section 5.2.1).

In this life cycle stage, intermediary products that were not used, here defined as leftovers, are taken into account with an additional input of raw materials included in LCS1 and additional amounts manufactured, taken into account in LCS2. The end of life of leftovers takes place in LCS2 and the default end of life corresponds to the product's end of life (Section 5.2.1). A 5% rate of manufacturing leftovers is used (TS expertise judgement).

#### 5.4.2.2. Transport of semi-finished and intermediate products

The production of the packaging required for the transportation of semi-finished & intermediate products was accounted for in LCS1 (see Section 5.4.1.5), while its end of life was accounted for in LCS2. The packaging distribution (freight train, truck, ship or plane) is the same as the distribution of the raw materials (see Section 5.4.1.5), but it was accounted for in LCS2.

The mass transported considers the mass of the semi-finished & intermediate products at the entry gate of the assembly step (see Section 5.4.2.1), as well as their packaging mass (see Section 5.4.1.5). The distance and transportation modes in Table 23 were used, and weight-limited transport is considered for all semi-finished and intermediate products transported.

### 5.4.2.3. Semi-finished and intermediate products packaging end-of-life

In this study, the default CFF parameters for the recycling, incineration and landfilling of paper/cardboard, LDPE and polypropylene from Part C of Annex II of the PEF method were used for the end-of-life of semi-finished and intermediate products packaging. As no wood recycling dataset was available, the end-of-life of wood pallets was estimated to consist only of incineration and landfill. The collection of the packaging at the end of life is already considered in the EF dataset used.

## 5.4.3. Distribution

### 5.4.3.1. Distribution models and transport legs

The distribution life cycle stage is representative of a product sold on the European market (Section 3 of PEFCR v3.1). It includes the impacts related to the transport of final apparel and footwear products to the final client, including the impacts related to intermediate storage and distribution losses. The final client is defined as a private individual. Considerations for the distribution stage are similar for all products categories because the transport modes and distances are not necessarily product-specific.

Three distribution models are illustrated in Figure 3:

- The factory-to-consumer e-commerce scenario, referred to as 'F2C' below: [1a1] + [1a3] (see Figure 4);
- The 'classic' e-commerce scenario, using classic distribution pathways (warehouses and distribution centers), but no stores, referred to as 'classic e-commerce' below: [2a1] + [3a] + [3b1] + [3b3] (see Figure 5);
- The retail scenario, where consumers visit brick and mortar stores, referred to as 'retail' below: [2a2] + [4a] + [4b1] + [4b3] (see Figure 6).

The numbers in brackets refer to the transport legs described in Section 5.4.3.1.3 further below.

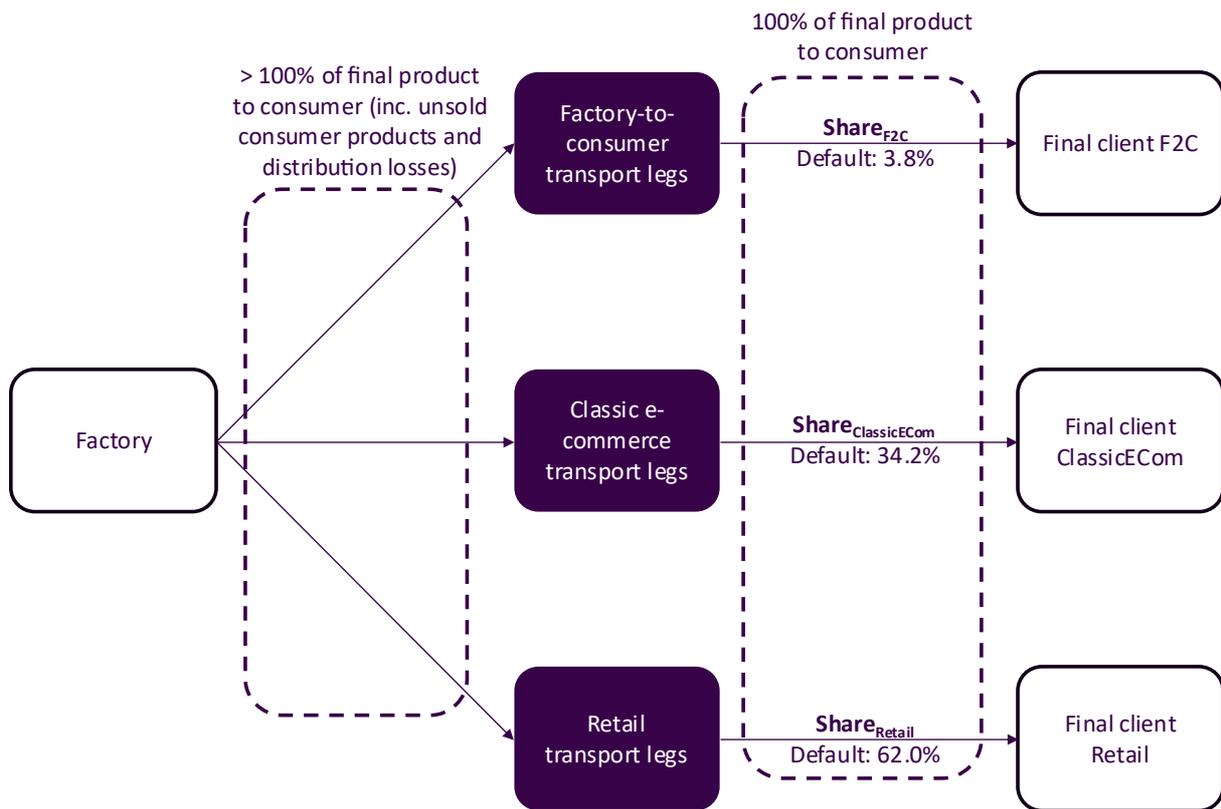


Figure 3 - Transport legs and scenarios distribution (TS expertise)

The functional unit in Figure 3 refers to a final product sold to consumers, which is the sum of the shares of the different distribution scenarios (factory-to-consumer as per Figure 4, classic e-commerce as per Figure 5 and retail as per Figure 6). Due to unsold consumer products and distribution losses, more than 1 product will need to be manufactured, to have 1 final product reach the consumer.

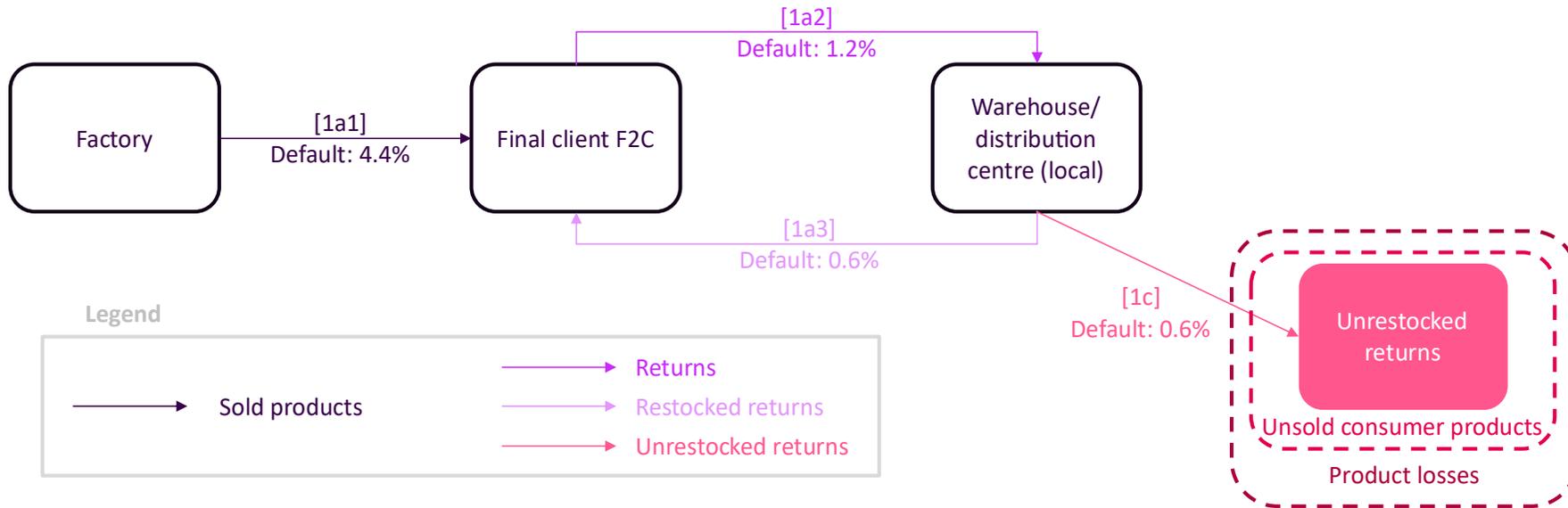


Figure 4 - Transport legs for the factory-to-consumer e-commerce scenario.

For F2C, factories are considered as the point of sale and therefore no distribution losses occur. Percentages may not add up due to rounding.

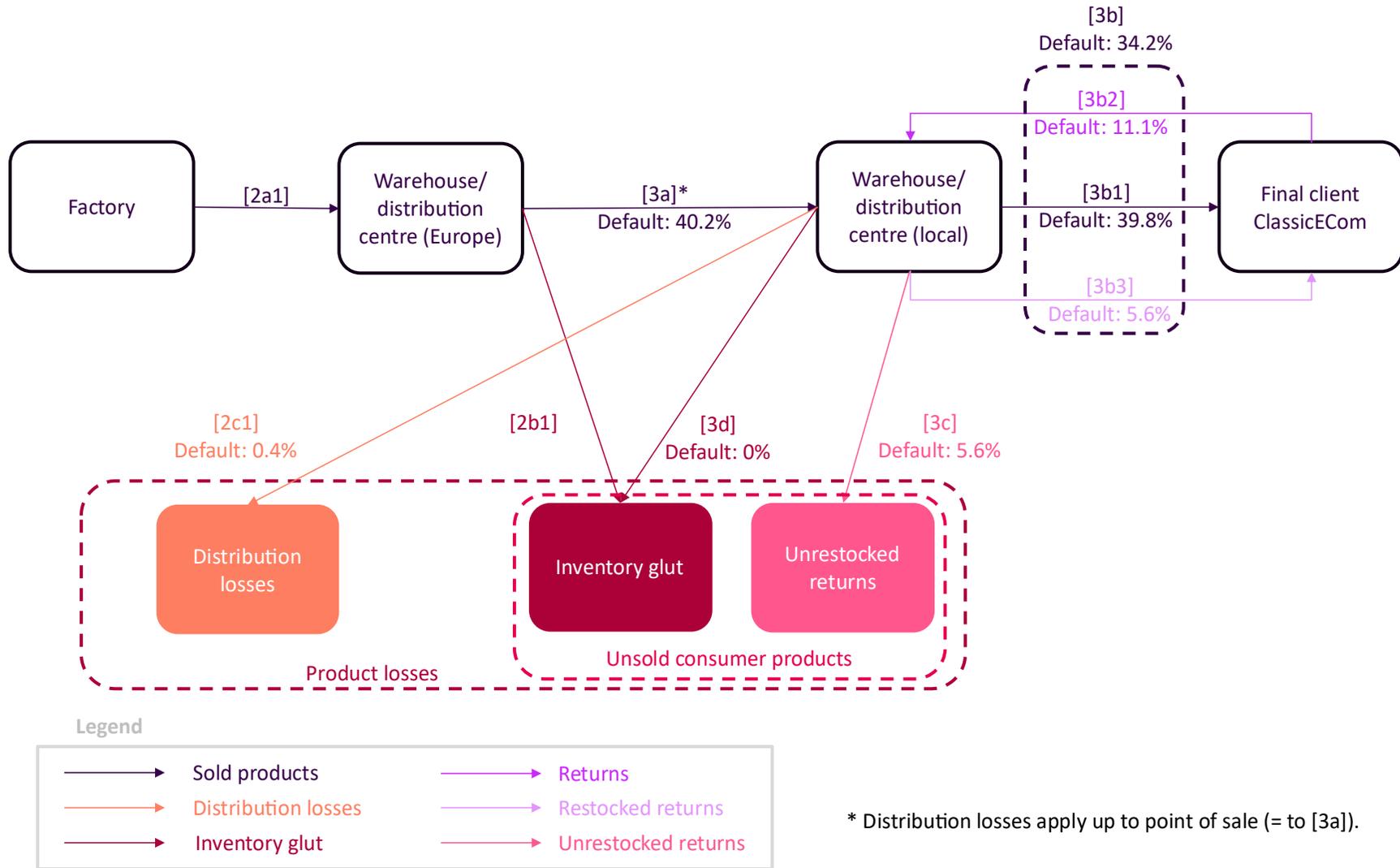


Figure 5 - Transport legs for the classic e-commerce scenario.

Percentages may not add up due to rounding

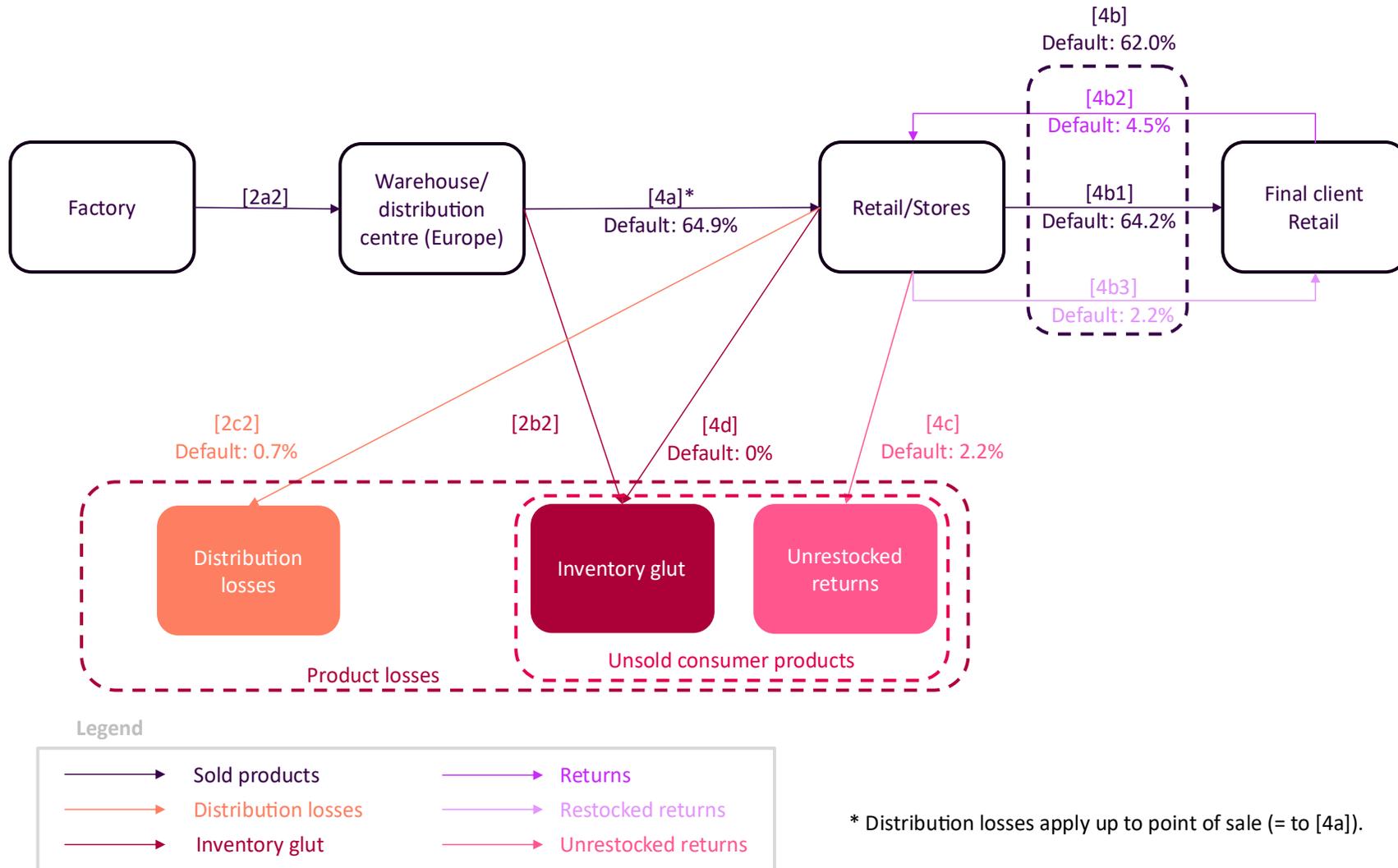


Figure 6 - Transport legs for the retail scenario.

Percentages may not add up due to rounding.

The e-commerce scenario includes the transport of the final product from outside or inside Europe (factory) to a warehouse or distribution centre (located in Europe and/or local), the storage at the warehouse or distribution centre, and further transportation from the warehouse or distribution centre to the final client (see Figure 5). F2C e-commerce is a growing part of online sales which involves a high share of international supply chains for products sold in Europe (see Figure 4).

In the retail sales scenario, the product is first transported from the factory to a warehouse or distribution centre (located in Europe), then from the warehouse or distribution centre to a retail/ store, and finally transported to the final clients' home by the consumer (see Figure 6). To have 1 final product reach the consumer, more than 1 product will need to be manufactured due to manufacturing losses, unsold consumer products, and distribution losses. Company specific data is required for the total share of unsold consumer products (UnsoldProducts, see Section 5.4.1.2), which include unrestocked returns (returned products that are not restocked for resale) and inventory glut (items that are made for a brand/retailer and sent to their distribution centre, such as surplus, excessive inventory, overstock and deadstock).

The distribution stage impacts depend mainly on supply chain specifics (e.g. local, intracontinental and international supply chains), corresponding transport modes and utilisation ratios, and distances covered, as well as product weights and volumes.

#### **5.4.3.1.1. Product returns and unsold consumer products**

Returns are taken into account by multiplying the distances from warehouse to final client by the percentage of the returns. The distribution of unsold consumer products as defined in Section 5.4.1.2 are included in this life cycle stage (see

Table 28). Unsold consumer products in this life cycle stage takes the form of unrestocked items (e.g. items that were sold, brought back by the consumer and never restocked, see Section 5.4.1.2) and inventory glut (Items that are made for a brand/retailer and sent to their distribution centre, such as surplus, excessive inventory, overstock and deadstock). It can be retained either at the point of sale (local warehouse or retail store, InventoryGlut<sub>POS</sub>) or at the European distribution centre (InventoryGlut<sub>DC</sub>). With the default values (Cascale), this leads to an unsold consumer products rate of 16.3%, which means that the weight of the final product transported will be multiplied by 1.163 per product for the transport steps up to where the unsold

consumer products remain. The end of life of unsold consumer products takes place in LCS3 and is modelled using the end-of-life scenarios described in Section 5.2.1.

Returns that are restocked and sold are considered part of the functional unit. Unrestocked returns fall under the unsold consumer products definition (see also Section 5.4.1.2).

#### 5.4.3.1.2. Distribution losses

A default loss rate  $DistribLoss$  of 1% (TS expertise) is used for the distribution stages until the point of sale for all apparel and footwear sub-categories.

The end of life of distribution losses takes place in LCS3 and is modelled using the end-of-life scenarios described in Section 5.2.1.

#### 5.4.3.1.3. Shares of transport legs

The final product will be distributed through the three distribution models with  $Share_{Retail}$  the share of products sold through retail stores,  $Share_{ClassicECom}$  the share of products sold through classic e-commerce and  $Share_{F2C}$  the share of products sold through e-commerce directly delivered to the final client (F2C). The sum of the shares of the three distribution models adds up to 100%, including returns that are sold again.

#### Shares of transport legs for the F2C scenario

The following transport legs (adapted from the PEF method) are considered for apparel and footwear, with the number in brackets matching Figure 4 above:

- From factory to the final client (F2C) [1a1];
- From final client to local warehouse/ DC for F2C returns [1a2];
- From local warehouse/ DC to final client for restocked F2C returns [1a3];

It is assumed that the non-restocked share of consumer returns to point of sale ([1c]) is directly sent to end-of-life. This transport is modelled according to Section 5.2.1.

$Share_{F2C}$  ([1a]) is the sum of the share of products sold to consumers through factory-to-consumer, minus the share of F2C products returned at a return rate of  $ReturnRate_{ClassicECom}$  ([1a2]), plus the share of returned products restocked at a rate of  $RestockRate$  and sold again through classic e-commerce ([1a3]). The share of F2C in this PEF-RP study is considered to only represent non-customised products.

## Shares of transport legs for the classic e-commerce scenario

The following transport legs (adapted from the PEF method) are considered for apparel and footwear, with the number in brackets matching Figure 5 above:

- From factory to warehouse/ distribution centre (DC) located in Europe [2a1];
- From a warehouse/ distribution centre located in Europe to a local warehouse/ distribution centre [3a];
- From local warehouse/ distribution centre to final client [3b1] and [3b3];
- From final client to local warehouse/ distribution centre for returns [3b2];

It is assumed that the non-restocked share of consumer returns to point of sale ([3c]), the inventory glut ([2b1] and [3d]) and the distribution losses ([2c1]) are directly sent to end-of-life. This transport is modelled according to Section 5.2.1.

**Share**<sub>ClassicECom</sub> ([3b]) is the sum of the share of products sold to consumers through classic e-commerce ([3b1] = [3a] as [3d] = 0), minus the share of classic e-commerce products returned at a return rate of  $\text{ReturnRate}_{\text{ClassicECom}}$  ([3b2]), plus the share of returned products restocked at a rate of  $\text{RestockRate}$  and sold again through classic e-commerce ([3b3]).

## Shares of transport legs for the retail scenario

The following transport legs (adapted from the PEF method) are considered for apparel and footwear, with the number in brackets matching Figure 6 above:

- From factory to warehouse/ distribution centre (DC) located in Europe [2a2];
- From warehouse/ distribution centre located in Europe to retail/ stores [4a];
- From retail/ stores to the final client (consumer travel) [4b1] and [4b3]; and
- From the final client to the retail/ stores for returns (consumer travel) [4b2].

It is assumed that the non-restocked share of consumer returns to point of sale ([4c]), the inventory glut ([2b2] and [4d]) and the distribution losses ([2c2]) are directly sent to end-of-life. This transport is modelled according to Section 5.2.1.

**Share<sub>Retail</sub>** ([4b]) is the sum of the share of products sold to consumers through retail ([4b1] = [4a] as [4d] = 0), minus the share of retail products returned at a return rate of **ReturnRate<sub>Retail</sub>** ([4b2]), plus the share of returned products restocked at a rate of **RestockRate** and sold again through retail ([4b3]). The default value of 50% is used for **RestockRate** (i.e. one out of every two returns are resold), the default value of 7% is used for **ReturnRate<sub>Retail</sub>**, and the default value of 28% is used for **ReturnRate<sub>ClassicECom</sub>** (Cascale 2022).

**Shares of transport legs used for the PEF RP-study**

To have 1 final product reach the consumer, more than 1 product will need to be manufactured due to losses, considering unstocked returns, inventory glut and distribution losses. **UnstockedReturns** represents the share of unstocked returns ([1c] for factory-to-consumer, 3c] for classic e-commerce and [4c] for retail). **InventoryGlut** represents the share of inventory glut ([2b1] for **InventoryGlut<sub>DC</sub>** + [3d] for **InventoryGlut<sub>POS</sub>** for the classic e-commerce scenario and [2b2] for **InventoryGlut<sub>DC</sub>** + [4d] for **InventoryGlut<sub>POS</sub>** for the retail scenario).

Due to the lack of data (Cascale, 2022) on the split of inventory glut between these locations ([2b1] vs [3d] and [2b2] vs [4d]), it was assumed that inventory glut only occurs at the European distribution centre (meaning that **InventoryGlut<sub>POS</sub>** = 0 and therefore [3d] = [4d] = 0), and a value of 7% for **InventoryGlut<sub>DC</sub>** (Cascale) was used in this study..

The default shares of a product relative to each transport leg are given in

Table 28.

Table 28 - Share of product per transport leg

Transport leg	Default share of manufactured product transported per transport leg, including distribution losses (%)
[1]	3.8%
[1a1]	4.4%
[1a2]	1.2%
[1a3]	0.6%
[1c]	0.6%

Transport leg	Default share of manufactured product transported per transport leg, including distribution losses (%)
[2a1]	43.2%
[2a2]	69.8%
[2b1]	3.0%
[2b2]	4.9%
[2c1]	0.4%
[2c2]	0.7%
[3a]	40.2%
[3b]	34.2%
[3b1]	39.8%
[3b2]	11.1%
[3b3]	5.6%
[3c]	5.6%
[4a]	64.9%
[4b]	62.0%
[4b1]	64.2%
[4b2]	4.5%
[4b3]	2.2%
[4c]	2.2%
[3d]	0%
[4d]	0%

The calculation for total unsold consumer products is shown below:

$$\begin{aligned}
 \text{UnsoldProducts} &= \text{InventoryGlut}_{DC} + \text{UnrestockedReturns} + \text{InventoryGlut}_{POS} \\
 &= [2b1] + [2b2] + [1c] + [3c] + [4c] + [3d] + [4d] = 16.3\%
 \end{aligned}$$

Including 1% distribution losses, this leads to a total share of manufactured products of (1 final product + 16.3% unsold consumer goods) multiplied by (1+1% distribution losses) = 117.4% manufactured product.

#### 5.4.3.1.4. Distribution impacts

The distribution impacts are based on:

- a) the mass or the volume of the product being transported including primary, secondary and tertiary packaging, considering the distribution losses and the unsold consumer products mass.
- b) the distance travelled and the mode of transport.

The transport of unsold consumer products for disposal includes inventory glut ([2b1], [2b2], [3d] and [4d]) and unrestocked returns ([1c] + [3c] and [4c]). The transport of distribution losses for disposal includes [2c1] and [2c2]. The end-of-life transport of unsold consumer products is modelled according to Section 5.2.1 and is accounted for in LCS3.

#### 5.4.3.1.5. Mass and volume transported

The weight transported is defined as the sum of the product weight (**Weight<sub>Product</sub>**) plus the weight of all removable accessories such as hangtags (price label, brand tags, etc.), primary (**Weight<sub>Pack1</sub>**), secondary (**Weight<sub>Pack2</sub>**) and tertiary (**Weight<sub>Pack3</sub>**) packaging, considering the distribution losses and unsold consumer products.

The product volume transported is defined as the volume of the product including primary packaging (**Volume<sub>Product</sub>**), and the default values in Table 29 is used (primary data provided by Balzac, Nov. 2020). To account for the additional volume of secondary and tertiary packaging in the relevant transport legs, the product volume is multiplied by a volume factor (**Volume<sub>Factor</sub>**) and a default volume factor of 4 (OEFSRs retail, 2018) is used unless primary data of packaging volume is used.

Table 29 - Default representative product volumes

No.	Sub-category	Default product volume (m <sup>3</sup> )
1	T-shirts	0.0018
2	Shirts and blouses	0.006
3	Sweaters and midlayers	0.0102
4	Jackets and coats	0.015
5	Pants and shorts	0.004

No.	Sub-category	Default product volume (m <sup>3</sup> )
6	Dresses, skirts and jumpsuits	0.007
7	Leggings, stockings, tights and socks	0.0006
8	Underwear	0.0006
9	Swimwear	0.0006
10	Apparel accessories	0.0012
11	Open-toed shoes	0.0048
12	Closed-toed shoes	0.018
13	Boots	0.024

The weights and volumes relative to each transport leg are given in Table 30. For packaging, the default values in Table 20 (for the retail scenario), Table 21 (for the classic e-commerce scenario), and Table 22 (for the F2C scenario) are used. The transport of unsold consumer products (inventory glut and unrestocked returns) and distribution losses disposal transport marked with (\*) is approximated by weight-limited product disposal transport (see Section 5.2.1).

Table 30 - Weights and volumes transported per transport leg

Transport leg	Packaging included	Weight transported (kg/product)	Volume transported to/by final client (m <sup>3</sup> /product)
		Weight[X]	Volume[X]
[1a1]	Primary + Secondary + Tertiary	$Weight_{product} + Weight_{pack1} + Weight_{pack2} + Weight_{pack3}$	N/A (weight-limited transport)
[1a2]	Primary + Secondary	N/A (volume-limited transport)	$Volume_{product}$
[1a3]	Primary + Secondary	N/A (volume-limited transport)	$Volume_{product}$
[1c]*	N/A	$Weight_{product}$	N/A (weight-limited transport)

Transport leg	Packaging included	Weight transported (kg/product)	Volume transported to/by final client (m <sup>3</sup> /product)
		Weight[X]	Volume[X]
[2a1] [2a2]	Primary + Secondary + Tertiary	$Weight_{Product} + Weight_{Pack1} + Weight_{Pack2} + Weight_{Pack3}$	N/A (weight-limited transport)
[2b1]* [2b2]*	N/A	$Weight_{Product}$	N/A (weight-limited transport)
[2c1]* [2c2]*	N/A	$Weight_{Product}$	N/A (weight-limited transport)
[3a]	Primary + Secondary + Tertiary	$Weight_{Product} + Weight_{Pack1} + Weight_{Pack2} + Weight_{Pack3}$	N/A (weight-limited transport)
[3b1] [3b3]	Primary + Secondary	N/A (volume-limited transport)	$Volume_{Product}$
[3b2]	Primary + Secondary	N/A (volume-limited transport)	$Volume_{Product}$
[3c]*	N/A	$Weight_{Product}$	N/A (weight-limited transport)
[3d]*	N/A	$Weight_{Product}$	N/A (weight-limited transport)
[4a]	Primary + Secondary + Tertiary	$Weight_{Product} + Weight_{Pack1} + Weight_{Pack2} + Weight_{Pack3}$	N/A (weight-limited transport)
[4b1] [4b3]	Primary	N/A (volume-limited transport)	$Volume_{Product}$
[4b2]	Primary	N/A (volume-limited transport)	$Volume_{Product}$
[4c]*	N/A	$Weight_{Product}$	N/A (weight-limited transport)
[4d]*	N/A	$Weight_{Product}$	N/A (weight-limited transport)

The default distances for each transport leg are given in Table 31. The default values for the transport processes from retail/ stores to the final client in Table 31 are given as roundtrip distances and datasets for consumer travel are per kilometre.

Table 31 - Default transport parameters per representative product

No.	Transport leg [X]	Default per functional unit				
		Supply chain location [Z]	Distance (km)	Utilisation ratio	Share of product mass transported for each origin (%)	Transport mode [Y]
1a1	Factory to final client (factory-to-consumer)	Local	1'200	64%	5%	Truck (>32t, EURO 4)
		Intracontinental	3'500	64%	15%	Truck (>32t, EURO 4)
		International (ship)	1'000	64%	0%	Truck (>32t, EURO 4)
			18'000	n/a		Ship (transoceanic container)
		International (plane)	1'000	64%	80%	Truck (>32t, EURO 4)
10'000	n/a		Cargo plane			
1a2	From final client to local warehouse/ DC (returns)	Local	250 (round trip)	20%*	100%	Van (lorry <7.5t, EURO 3)
1a3	From local warehouse/ DC to final client	Local	250 (round trip)	20%*	100%	Van (lorry <7.5t, EURO 3)
2a1	Factory to warehouse/ DC located in Europe	Local	1'200	64%	5%	Truck (>32t, EURO 4)
2a2		Intracontinental (barge)	2'500	64%	3%	Truck (>32t, EURO 4)
			800	n/a		Ship (barge)
Intracontinental (train)		800	64%	14%	Truck (>32t, EURO 4)	
		2'500	n/a		Train (average freight train)	
International (ship)		1'000	64%	66%**	Truck (>32t, EURO 4)	
		18'000	n/a		Ship (transoceanic container)	
International (plane)		1'000	64%	10%**	Truck (>32t, EURO 4)	
		10'000	n/a		Cargo plane	
International (train)		1'000	64%	2%	Truck (>32t, EURO 4)	
	10'000	n/a	Train (average freight train)			
3a	From warehouse/ DC located in Europe to local warehouse/ DC	Intracontinental (plane)	500	64%	100%	Truck (>32t, EURO 4)
			3'500	n/a		Cargo plane
		Intracontinental (train)	1000	64%	48%	Truck (>32t, EURO 4)
			3000	n/a	48%	Train (average freight train)
		Intracontinental (truck)	4000	64%	17%	Truck (>32t, EURO 4)
3b1	From local warehouse/ DC to final client	Local	250 (round trip)	20%*	100%	Van (lorry <7.5t, EURO 3)
3b3						
3b2	From final client to local warehouse/ DC (returns)	Local	250 (round trip)	20%*	100%	Van (lorry <7.5t, EURO 3)

No.	Transport leg [X]	Default per functional unit				
		Supply chain location [Z]	Distance (km)	Utilisation ratio	Share of product mass transported for each origin (%)	Transport mode [Y]
4a	From warehouse/ DC located in Europe to retail/ stores	Local	1'200	64%	100%	Truck (>32t, EURO 4)
4b1 4b3	From retail/ stores to final client (consumer travel)	Local	5	See below	62%	Passenger car (average)
			5	20%*	5%	Van (lorry <7.5t, EURO 3)
			N/A	N/A	33%	No impact modelled (walking, cycling etc)
4b2	Final client to retail/ stores (customer travel, returns)	Local	5	See below	62%	Passenger car (average)
			5	20%*	5%	Van (lorry <7.5t, EURO 3)
			N/A	N/A	33%	No impact modelled (walking, cycling etc)

\* As there was no dataset for (lorry <1.2t, EURO 3) available, a van (lorry <7.5t, EURO 3) with a 20% utilisation ratio was used

\*\* calculated with values based on McKinsey (2020b)

## Consumer travel

The impacts from consumer travel (allocation of the car impact) are based on volume with a single distance of 5 km (or 5000 m, total distance of transport, PEF method, 4.4.3.5 Default scenarios – from factory to final client). For an average car, the maximum volume that can be transported is 0.2 m<sup>3</sup>, which equals 1/3 of a 0.6 m<sup>3</sup> trunk, whereas for products bigger than 0.2 m<sup>3</sup> the full car transport impact shall be included. Considering products that are sold through in-store retail, the volume of the product (including primary packaging) is used to allocate the transport burdens, and the allocation factor is calculated as the volume of the product divided by the maximum volume of 0.2 m<sup>3</sup>.

The default value for the volume is specified in

Table 29.

### 5.4.3.1. Calculation of distribution impacts

For weight-limited transport as prescribed by Table 30, the activity quantity (in kgkm) for the distribution impact calculation per transport mode Y is calculated using Equation 7:

$$\text{Activity}W_{XY} = \text{Share}_{[X]} * \text{Weight}_{[X]} * \text{Distance}_{[XY]} * \text{ShareProductMass}_{[XYZ]}$$

Equation 7

With the following parameters:

**Share[X] (%)**: Share of product mass transported per transport leg X. See

Table 28 for detailed calculation and default values.

**Weight[X] (kg/product)**: Weight transported per transport leg X. See Table 30 for detailed calculation.

**Distance[XY] (km)**: Transport distance per transport leg X and transport mode Y. See Table 31 for default values.

**ShareProductMass[XYZ] (%)**: Share of product mass transported for each transport leg X, transport mode Y and origin Z. See Table 31 for default values.

For volume-limited transport as prescribed by Table 30, the activity quantity (in kilometers) for the distribution impact calculation per transport mode Y is calculated using Equation 8:

$$\text{Activity}_{V_{XY}} = \text{Share}_{[X]} * \frac{\text{Volume}_{[X]}}{\text{VolumeMax}_{[Y]}} * \text{Distance}_{[XY]} * \text{ShareProductMass}_{[XYZ]}$$

Equation 8

With the following parameters:

**Share[X] (%)**: Share of product mass transported per transport leg X. See Table 28 for detailed calculation and default values.

**VolumeMax[Y] (m<sup>3</sup>)**: Maximum volume transported by transport mode Y. For passenger cars, this is 0.2 m<sup>3</sup> (PEF Method, 2021).

**Volume[X] (m<sup>3</sup>/product)**: Volume transported per transport leg X. See Table 30 for detailed calculation and Table 29 for default values.

**Distance[XY] (m)**: Transport distance per transport leg X and transport mode Y. See Table 31 for default values.

**ShareProductMass[XYZ] (%)**: Share of product mass transported for each transport leg X, transport mode Y and origin Z. See Table 31 for default values.

#### 5.4.3.2. Storage at warehouse/ DC and retail/ store

Storage is modelled for the scenarios including warehouse/distribution centres and retail/ stores as defined in Figure 4 for the F2C scenario, Figure 5 for the classic e-commerce scenario and Figure 6 for the retail scenario. For the F2C e-commerce scenario, this is only applicable for the returned products. The storage characteristics (capacity, time, etc.) required for each transport leg can be found in Table 32.

The impacts generated by the storage of final products in warehouses or retail locations/stores are related to energy for heating and lighting, and waste associated with lost products and packaging.

No energy and waste differentiation are needed between apparel and footwear product sub-categories as usually a variety of products are stored and sold in the same

warehouse or retail setting (ambient storage). This gives consistency of the energy inputs per unit sold within the chosen reference flow.

The emissions and resources used by storage systems are allocated to the product stored, and the allocation is based on the space (in  $m^3$ ) and time (in weeks) occupied by the product. Time-based allocation is based on the storage capacity of the storage location (52 weeks in a year) and the time the product is stored in this location. Default storage durations in Table 32 are used.

Space-based allocation is based on the volume of the storage location, which is either a warehouse (**Volume<sub>Warehouse</sub>**) or retail store (**Volume<sub>Retail</sub>**), as well as the average storage shelf height (**ShelfHeight**) and the shelf coverage of the storage location surface (**ShelfCoverage**). The default values of 48'000  $m^3$  for **Volume<sub>Warehouse</sub>**, 2'000  $m^3$  for **Volume<sub>Retail</sub>**, 2 m for **ShelfHeight** and 50% for **ShelfCoverage** (PEF 2019, 4.4.5 Storage at distribution centre or retail) are used. The product volume stored is defined as the volume of the product including primary packaging (**Volume<sub>Product</sub>**) and the default values in Table 29 are used. Additionally, a storage volume factor (**VolumeFactor**) of 4 is used for ambient storage (OEFSRs retail, 2018) to account for the additional space the product takes in the storage facility, meaning the product volume will be multiplied by 4.

The default data (from the PEF method) for electricity consumption, 30 kWh/  $m^2$ \*year for warehouses (**Consumption<sub>ElectricityWarehouse</sub>**) and 150 kWh/ $m^2$ /year for retail stores (**Consumption<sub>ElectricityRetail</sub>**), and gas consumption, 360 MJ/ $m^2$ /year for warehouses (**Consumption<sub>GasWarehouse</sub>**) are used for all apparel and footwear sub-categories.

The energy consumption also takes into account the impacts generated by the digital infrastructure (**DigitalInfrastructure**) used for online shopping in the two e-commerce scenarios (classic e-commerce and F2C). For each product ordered, 0.030 kWh of electricity (European grid mix) are needed based on expert judgement.

The impact linked to energy consumption for storage and distribution for each transport leg [X] is calculated according to Equation 9, using the equation parameters in Table 32.

$$\begin{aligned}
& \text{ConsumptionEnergy}[X] \\
& = \frac{\text{Share}[X] * \text{Volume stored}[X] * \text{StorageTime}[X] * \text{StorageSurface}[X]}{\text{StorageCapacity}[X]} \\
& * (\text{Consumption}_{\text{Energy}}[X])
\end{aligned}$$

Equation 9

Equation 9 is repeated for the calculation of the electricity and the natural gas consumption according to Table 32. The energy consumption for the “other” column is added to the electricity consumption where relevant.

Table 32 - Default storage capacity and energy consumption for warehouse/DC and retail/stores

Transport leg	Volume stored (m <sup>3</sup> /product) VolumeStored[X]	Default storage time (weeks) StorageTime[X]	Storage capacity (m <sup>3</sup> * weeks / year) StorageCapacity[X]	Storage surface (m2) StorageSurface[X]	Storage energy consumption (kWh/m2/year or MJ/m2/year) Consumption[X]	Other (kWh / product) Other[X]
[1a1] [1a3]	N/A	N/A	N/A	N/A	N/A	DigitalInfrastructure
[1a2]	$Volume_{Product} * VolumeFactor$	7 / 2 = 3.5 weeks <sup>+</sup>	$Volume_{Warehouse} * 52 weeks / year$	$\frac{Volume_{Warehouse} * ShelfCoverage}{ShelfHeight}$	$Consumption_{ElectricityWarehouse} + Consumption_{GasWarehouse}$	N/A
[1c]	N/A	N/A	N/A	N/A	N/A	N/A
[2a1] [2a2]	$Volume_{Product} * VolumeFactor$	7 / 2 = 3.5 weeks <sup>+</sup>	$Volume_{Warehouse} * 52 weeks / year$	$\frac{Volume_{Warehouse} * ShelfCoverage}{ShelfHeight}$	$Consumption_{ElectricityWarehouse} + Consumption_{GasWarehouse}$	N/A
[2b1] [2b2]	$Volume_{Product} * VolumeFactor$	3 years = 156 weeks <sup>++</sup>	$Volume_{Warehouse} * 52 weeks / year$	$\frac{Volume_{Warehouse} * ShelfCoverage}{ShelfHeight}$	$Consumption_{ElectricityWarehouse} + Consumption_{GasWarehouse}$	N/A
[2c1] [2c2]	N/A	N/A	N/A	N/A	N/A	N/A
[3a]	$Volume_{Product} * VolumeFactor$	7 / 2 = 3.5 weeks <sup>+</sup>	$Volume_{Warehouse} * 52 weeks / year$	$\frac{Volume_{Warehouse} * ShelfCoverage}{ShelfHeight}$	$Consumption_{ElectricityWarehouse} + Consumption_{GasWarehouse}$	N/A
[3b]	N/A	N/A	N/A	N/A	N/A	N/A
[3c]	N/A	N/A	N/A	N/A	N/A	N/A
[3d]	N/A	N/A	N/A	N/A	N/A	N/A
[4a]	$Volume_{Product} * VolumeFactor$	7 / 2 = 3.5 weeks <sup>+</sup>	$Volume_{Retail} * 52 weeks / year$	$\frac{Volume_{Retail} * ShelfCoverage}{ShelfHeight}$	$Consumption_{ElectricityRetail}$	N/A
[4b]	N/A	N/A	N/A	N/A	N/A	DigitalInfrastructure
[4c]	N/A	N/A	N/A	N/A	N/A	N/A
[4d]	N/A	N/A	N/A	N/A	N/A	N/A

<sup>+</sup> Based on OEFSRs retail, 2018, and data received

<sup>++</sup> According to unsold consumer products definition from Section 5.4.1.2

#### **5.4.3.1. Secondary and tertiary packaging end-of-life**

In this study, the default CFF parameters for the recycling, incineration and landfilling of paper/cardboard, LDPE and polypropylene from Part C of Annex II of the PEF method were used for the end-of-life of secondary and tertiary packaging. The collection of the packaging at the end of life is already considered in the EF dataset used. As no wood recycling dataset was available, the end-of-life of wood pallets was estimated to consist only of incineration and landfill.

#### **5.4.3.2. Repair distribution**

In this study, a repairability multiplier of 1 has been used, leading to no repair and no repair distribution.

#### **5.4.4. Use**

The use stage for apparel considers impacts related to the following steps for most of the sub-categories:

- Washing and cleaning
- Drying
- Ironing and steaming

These processes of the apparel use stage are product dependent.

The impacts related to the following steps are also considered for footwear:

- Care

The product weight considered for the use phase only includes the weight of the product. Further details on material-specific requirements for the use stage per each representative product are described below.

For apparel products, the care label typically provides washing instructions. While the care label shows instructions such as the maximum temperature a product can withstand, this does not necessarily mean that the product is washed at that temperature, it may in fact be washed at a lower temperature. Similarly, a product may not be ironed even if the care label indicates an ironing temperature. The limitations and uncertainty around product care are addressed in Section 4.5.

For the use stage, the average EU consumption mix (EU27 + UK + EFTA) was used.

#### 5.4.4.1. Washing/cleaning

In general, genuine leather and genuine fur articles will not be washed, dried, ironed or steamed. No RP is considered to be a genuine leather and/or fur product since they do not contain more than 80% leather and/or fur and no RP is considered to be a delicate garment.

##### Washing types and temperatures

All of the RPs follow the default washing scenarios provided in Table 33 (Laitala, 2018a, Cotton Incorporated, 2020), which corresponds to the “all materials” product details of Table 39 in PEFCR v3.1. The washing temperatures also correspond to the “all materials” product details.

Table 33 - Washing types

No.	Product sub-category	% Hand-washing	% Machine washing	% Dry cleaning
1	T-shirts	6%	89%	5%
2	Shirts and blouses	8%	81%	11%
3	Sweaters and midlayers	22%	64%	14%
4	Jackets and coats	20%	60%	20%
5	Pants and shorts	6%	75%	19%
6	Dresses, skirts and jumpsuits	17%	69%	14%
7	Leggings, stockings, tights and socks	10%	85%	5%
8	Underwear	12%	86%	2%
9	Swimwear	100%	0%	0%
10	Apparel accessories	29%	47%	24%

##### Washing frequency

For the representative products, the washing datasets from the EF-compliant database are used which are built on average washing programs.

With regards to the uses prior to washing, garments worn next-to-skin are typically washed more frequently, while outerwear such as jackets and accessories are washed less frequently.

Key data on the washing frequency are provided in Table 34 per product sub-category (for a standard consumer, based on data from Laitala (2020), Sandin (2019), and Daystar (2019)). Based on the BOM of the RPs, they do not contain more than 50%

animal fibres as per Table 40 of PEFCR v3.1. Hence the average number of uses prior to washing as per Table 34 is used.

Table 34 - Product uses prior to washing

No.	Product sub-category	Average uses prior to washing
1	T-shirts	2
2	Shirts and blouses	2
3	Sweaters and midlayers	6
4	Jackets and coats	20
5	Pants and shorts	5
6	Dresses, skirts and jumpsuits	3
7	Leggings, stockings, tights and socks	2
8	Underwear	1
9	Swimwear	1
10	Apparel accessories	20

#### 5.4.4.2. Drying

The tumble dryer rates used for the RPs are shown in Table 35 (Laitala 2018a, 2020, and Gore (2016)). This table is built on average tumble-drying rates, taking into account garments that are only air dried (e.g. made of wool, delicates, etc).

Table 35 - Data for drying per product sub-category

No.	Product Sub-category	Air drying	Tumble drying
1	T-shirts	70%	30%
2	Shirts and blouses	88%	12%
3	Sweaters and midlayers	70%	30%
4	Jackets and coats	75%	25%
5	Pants and shorts	70%	30%
6	Dresses, skirts and jumpsuits	88%	12%
7	Leggings, stockings, tights and socks	88%	12%
8	Underwear	65%	35%
9	Swimwear	88%	12%
10	Apparel accessories	88%	12%

#### 5.4.4.3. Ironing/steaming

Product materials and care instructions are considered in the ironing of garments as presented in Table 36 based on data from Laitala (2018a), Daystar (2019) and Sandin (2019). Values provided in the table below are representative of ironing per cleaning cycle, taking into account garments that are not ironed (e.g. made of wool, delicates, etc).

Table 36 - Data for ironing and steaming

No.	Product sub-category	% of garments ironed use	Time spent per garment (min)
1	T-shirts	40%	2.6
2	Shirts and blouses	70%	2.6
3	Sweaters and midlayers	0%	n/a
4	Jackets and coats	5%	4
5	Pants and shorts	63%	4.3
6	Dresses, skirts and jumpsuits	18%	4.5
7	Leggings, stockings, tights and socks	5%	3.4
8	Underwear	1%	1
9	Swimwear	0%	n/a
10	Apparel accessories	25%	2.0

#### 5.4.4.4. Footwear care

Footwear care is twofold: washing and waxing. Washing concerns all footwears labelled as textiles (EU Footwear Labelling Directive), while waxing concerns closed-toed shoes and boots only.

While washing footwear in a washing machine is discouraged by footwear brands, it is assumed that consumers wash their shoes once during the shoe's lifetime (Cascale and thinkstep, 2016), using a dedicated delicate cycle. Only 50% of the footwear RPs were considered to be washed once during the shoe's lifetime, as it is assumed that 50% of each footwear RP is textile-based (therefore receiving washing care) and 50% of each footwear RP is considered to contain at least 5% genuine leather (therefore not receiving washing care). Footwear products are considered to be left to air dry, hence no tumble drying shall be modelled.

No data on the frequency of waxing being available, a conservative approach has been used and 100% of closed-toed shoes and boots are receiving care every 10 uses (expert judgement). 0.002 kg of wax/ kg of footwear are used for the modelling.

Table 37 - Data for footwear care

Type of care	Frequency	Value	Dataset
Washing (RP 11, 12 & 13)	Once per lifetime	Mass of the footwear	Washing, 30°, average washing, cold to warm water production mix, at plant service
Waxing (RP 12 & 13)	Every 10 uses	0.002 kg/ kg of footwear	Wax production technology mix production mix, at plant 100% active substance

**5.4.4.5. Repairability and use stage modelling**

Product repair and maintenance such as the addition of a lost button; replacement of a zipper; or specific footwear care such as the application of Durable Water Repellent (DWR) spray, will not be included in PEF-RP study v3.1 In this study, a repairability multiplier of 1 is used, meaning repair during the use stage has not been modelled.

**5.4.4.6. Extended lifetime and circularity**

No extended lifetime (intrinsic durability multiplier = 1) was considered in the PEF-RP study. Recycling polyester and polyamide are used in some RPs and were modelled with the CFF according to Section 5.2.1.

**5.4.5. End of life**

The end of life of an apparel or footwear product is defined as the point when the product is no longer used for its initial purpose.

The modelling of the end-of-life stage includes the collection, transport, sorting, and treatment of the product.

The modelling of the end-of-life scenario should include the transportation, collection and sorting when applicable, and follow the CFF formula, as presented in Section 5.10 of PEFCR v3.1 and Section 5.2.1 in this study.

The end-of-life fate of unsold consumer products (Section 6.2.3 of the PEFCR v3.1) is modelled using the default assumptions for the product illustrated in Figure 7 and Figure 8 of Section 5.10 of PEFCR v3.1 and Section 5.2.1 in this study.

**5.4.5.1. Collection and transport**

At the end of life, apparel and footwear representative products are either directly disposed of through municipal waste collection or they are collected prior to being sorted and treated as shown in Figure 7 for apparel and Figure 8 for footwear.

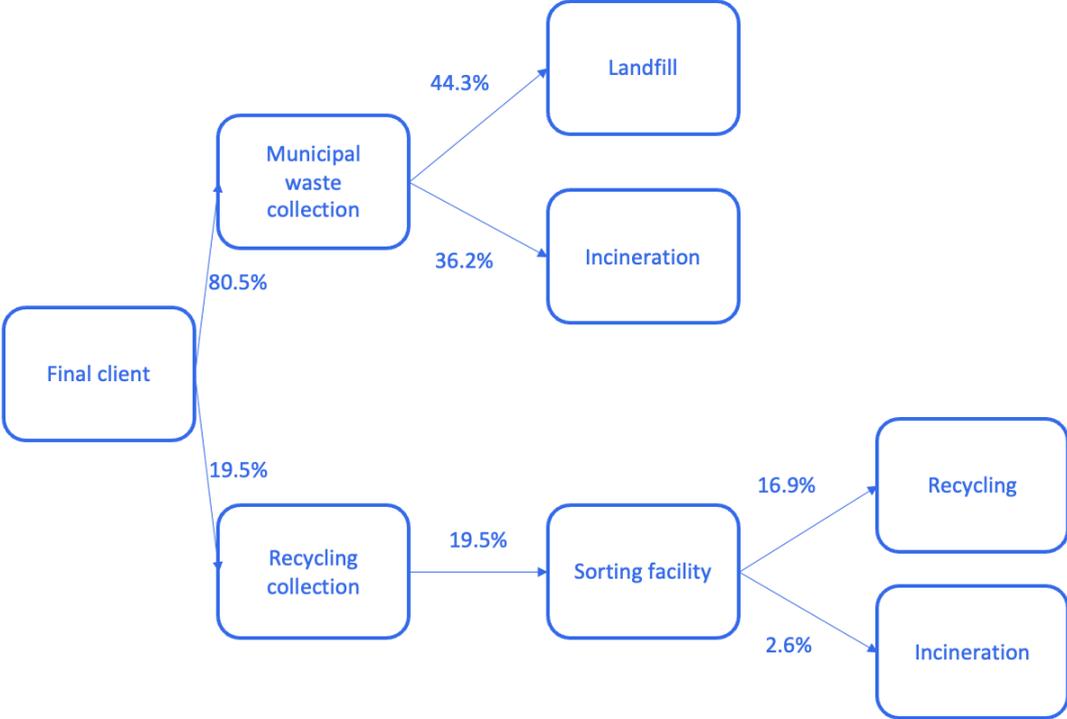


Figure 7 - End-of-life fate scenarios for apparel

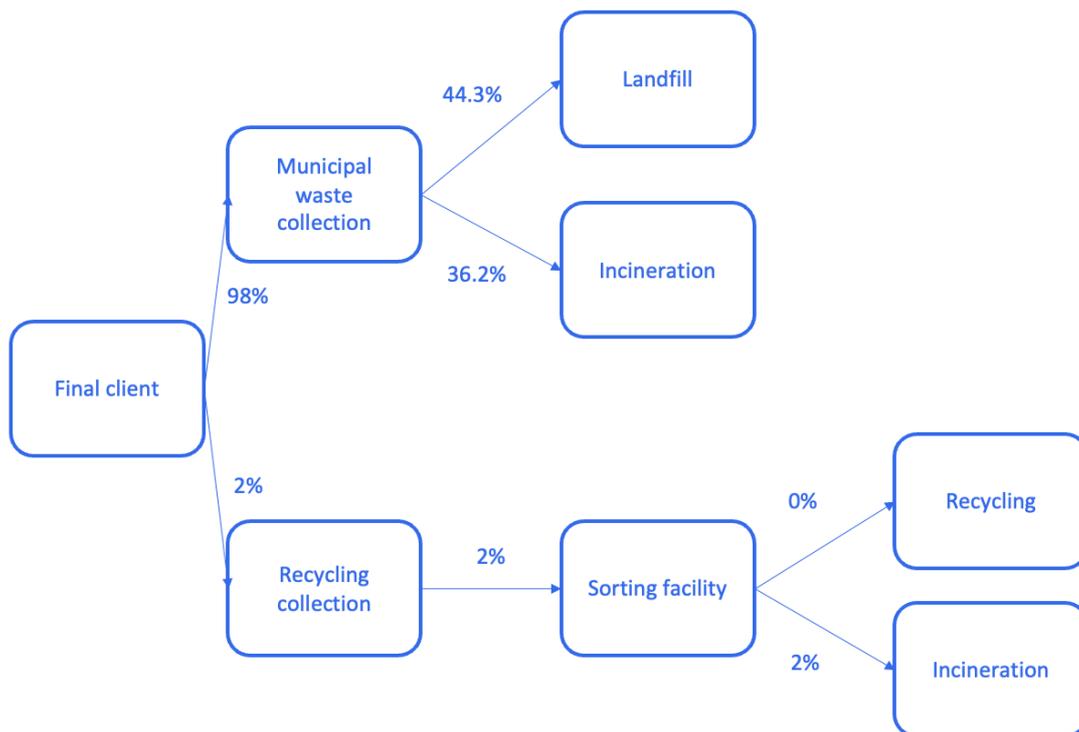


Figure 8 - End-of-life fate scenarios for footwear

For the transport from the client to the recycling collection point, the allocation factor is calculated as the volume of the product divided by the maximum volume (0.2 m<sup>3</sup> for a passenger car), as presented in Table 38.

Table 38 - Default representative product volumes

No.	Sub-category	Default product volume (m <sup>3</sup> )	Allocation
1	T-shirts	0.0018	0.009
2	Shirts and blouses	0.006	0.03
3	Sweaters and midlayers	0.0102	0.051
4	Jackets and coats	0.015	0.075
5	Pants and shorts	0.004	0.02
6	Dresses, skirts and jumpsuits	0.007	0.035
7	Leggings, stockings, tights and socks	0.0006	0.003
8	Underwear	0.0006	0.003
9	Swimwear	0.0006	0.003
10	Apparel accessories	0.0012	0.006
11	Open-toed shoes	0.0048	0.024
12	Closed-toed shoes	0.018	0.09
13	Boots	0.024	0.12

The default transport means and distances presented in Table 39 for apparel and Table 40 for footwear were used. The collection rate is based on the default values in the PEFCR and amounts to 17% for apparel and 0% for footwear.

For reused products, transport means and distances from the PEF method (supplier to factory assumptions) have been used (Reuse rate - Refashion, (2017a and b); Destination Refashion, (2019)):

- For apparel products, a 5% reuse scenario in Europe and 18% reuse scenario outside of Europe are assumed;
- For footwear products, a 2% reuse scenario in Europe and 8% reuse scenario outside of Europe are assumed.

Table 39 - Default transport parameters for apparel end of life. See Figure 7 for more details.

Supply chain	Distance (km)	Utilisation ratio	Share of product mass transported for each transport leg (%)	Transportation mode
<b>Municipal waste collection</b>				
Final client to landfill	30	64%	80.5%	Truck (>32t, EURO 4)
Final client to incineration	30	64%	80.5%	Truck (>32t, EURO 4)
<b>Recycling collection</b>				
Final client to collection point	1	n/a	19.5%	Passenger car
Collection point to sorting point	130	64%	19.5%	Truck (>32t, EURO 4)
	240	n/a		Train (average freight train)
	270	n/a		Ship (barge)
Sorting point to recycling	100	64%	16.9%	Truck (>32t, EURO 4)
Sorting point to incineration	30	64%	2.6%	Truck (>32t, EURO 4)

Table 40 - Default transport parameters for footwear end of life. See Figure 8 for more details.

Supply chain	Distance (km)	Utilisation ratio	Share of product mass transported for each transport leg (%)	Transportation mode
<b>Municipal waste collection</b>				
Final client to landfill	30	64%	98%	Truck (>32 t, EURO 4)
Final client to incineration	30	64%	98%	Truck (>32 t, EURO 4)
<b>Recycling collection</b>				
Final client to collection point	1	n/a	2%	Passenger car
Collection point to sorting point	130	64%	2%	Truck (>32 t, EURO 4)
	240	n/a		Train (average freight train)
	270	n/a		Ship (barge)
Sorting point to recycling	100	64%	0%	Truck (>32 t, EURO 4)
Sorting point to incineration	30	64%	2%	Truck (>32 t, EURO 4)

#### 5.4.5.2. Treatment and circularity

In this study, the following fates are identified for the end of life of apparel and footwear products:

- Landfill;
- Incineration; and
- Recycling.

According to Part C of Annex II of the PEF method, 45% of municipal waste collected is incinerated and 55% is landfilled.

Different incineration datasets are used based on the following types of materials being incinerated to account for the different heating values:

- Incineration of polyester and other synthetic materials including: acrylic, elastane, polyamide, polyester and other synthetics, PTFE, EVA and synthetic rubber;
- Incineration of biobased textile including: cotton, cashmere and camel hair, duck down, fur, leather, linen, silk, viscose, and wool;
- Incineration of polyurethane including: polyurethane and synthetic rubber;
- Incineration of PVC; and
- Incineration of inert waste including: metal trims.

More details on end-of-life stage modelling and allocating the associated burdens and credits using the CFF are presented in Section 5.2.1.

#### **5.4.5.1. Primary packaging end-of-life**

In this study, the default CFF parameters for the recycling, incineration and landfilling of paper/cardboard, LDPE and polypropylene from Part C of Annex II of the PEF method were used for the end-of-life of primary packaging. The collection of the packaging at the end of life is already considered in the EF dataset used. As no wood recycling dataset was available, the end-of-life of wood pallets was estimated to consist only of incineration and landfill.

## **5.5. Data quality requirements and rating**

Because the PEF-RP study is conducted on virtual products, every process is in situation 3. The DQR of the PEF-RP study can be found in ANNEX I, at the bottom of each RP tab.

## 6. Impact assessment results

### 6.1. PEF results

For each representative product, characterised results are calculated for each EF impact category. The characterised results are then normalised and weighted to identify the most relevant impact categories.

The EF normalisation and weighing factors used are available at <http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml> and can also be found in Annex I in the PEFCR for apparel and footwear.

#### 6.1.1. Characterized results

The characterised, normalised, and weighted results including the weighted results as a single score for the 13 representative products (RPs) are presented in Table 41 through Table 53 for each impact category.

The sub-categories 'climate change –fossil', 'climate change – biogenic' and 'climate change - land use and land use change', are reported separately if they show a contribution of more than 5% each to the total score of climate change.

Table 41 - Characterised, normalised and weighted results including the single score per use for t-shirts (RP1)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	1.76E-01	1.96E-01	Person-years	2.33E-05	2.59E-05	Points	4.9E-06	5.5E-06
Climate change - Fossil	kg CO <sub>2</sub> eq	1.69E-01	1.86E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	4.60E-03	4.99E-03	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	2.74E-03	4.41E-03	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	1.81E-09	2.86E-09	Person-years	3.46E-08	5.47E-08	Points	2.2E-09	3.5E-09
Human toxicity, cancer	CTUh	2.54E-10	2.80E-10	Person-years	1.47E-05	1.62E-05	Points	3.1E-07	3.5E-07
Human toxicity, non-cancer	CTUh	2.85E-09	3.09E-09	Person-years	2.22E-05	2.40E-05	Points	4.1E-07	4.4E-07
Particulate matter	disease inc.	2.99E-08	3.13E-08	Person-years	5.03E-05	5.25E-05	Points	4.5E-06	4.7E-06
Ionising radiation	kBq U-235 eq	9.10E-03	1.41E-02	Person-years	2.16E-06	3.33E-06	Points	1.1E-07	1.7E-07
Photochemical ozone formation	kg NMVOC eq	6.72E-04	7.18E-04	Person-years	1.65E-05	1.76E-05	Points	7.9E-07	8.4E-07
Acidification	mol H <sup>+</sup> eq	1.32E-03	1.40E-03	Person-years	2.38E-05	2.51E-05	Points	1.5E-06	1.6E-06
Eutrophication, terrestrial	mol N eq	3.96E-03	4.14E-03	Person-years	2.24E-05	2.34E-05	Points	8.3E-07	8.7E-07
Eutrophication, freshwater	kg P eq	4.44E-05	4.64E-05	Person-years	2.77E-05	2.88E-05	Points	7.7E-07	8.1E-07
Eutrophication, marine	kg N eq	6.33E-04	6.68E-04	Person-years	3.24E-05	3.42E-05	Points	9.6E-07	1.0E-06
Ecotoxicity, freshwater	CTUe	2.05E+00	2.27E+00	Person-years	3.62E-05	4.00E-05	Points	7.0E-07	7.7E-07
Land use	Pt	6.19E+00	6.64E+00	Person-years	7.55E-06	8.10E-06	Points	6.0E-07	6.4E-07
Water use	m <sup>3</sup> depriv.	6.96E-01	7.11E-01	Person-years	6.07E-05	6.20E-05	Points	5.2E-06	5.3E-06
Resource use, minerals and metals	kg Sb eq	1.23E-06	1.55E-06	Person-years	1.93E-05	2.44E-05	Points	1.5E-06	1.8E-06
Resource use, fossils	MJ	2.28E+00	2.57E+00	Person-years	3.51E-05	3.95E-05	Points	2.9E-06	3.3E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>2.6E-05</b>	<b>2.8E-05</b>

Table 42 - Characterised, normalised and weighted results including the single score per use for shirts and blouses (RP2)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	3.07E-01	3.34E-01	Person-years	4.07E-05	4.42E-05	Points	8.6E-06	9.3E-06
Climate change - Fossil	kg CO <sub>2</sub> eq	2.97E-01	3.20E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	6.97E-03	7.51E-03	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	3.57E-03	5.81E-03	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	2.70E-09	5.88E-09	Person-years	5.16E-08	1.12E-07	Points	3.3E-09	7.1E-09
Human toxicity, cancer	CTUh	4.09E-10	4.47E-10	Person-years	2.37E-05	2.59E-05	Points	5.0E-07	5.5E-07
Human toxicity, non-cancer	CTUh	4.15E-09	4.49E-09	Person-years	3.22E-05	3.49E-05	Points	5.9E-07	6.4E-07
Particulate matter	disease inc.	5.37E-08	5.55E-08	Person-years	9.02E-05	9.32E-05	Points	8.1E-06	8.3E-06
Ionising radiation	kBq U-235 eq	1.82E-02	2.47E-02	Person-years	4.32E-06	5.85E-06	Points	2.2E-07	2.9E-07
Photochemical ozone formation	kg NMVOC eq	1.09E-03	1.16E-03	Person-years	2.67E-05	2.83E-05	Points	1.3E-06	1.4E-06
Acidification	mol H <sup>+</sup> eq	2.17E-03	2.27E-03	Person-years	3.90E-05	4.09E-05	Points	2.4E-06	2.5E-06
Eutrophication, terrestrial	mol N eq	5.93E-03	6.20E-03	Person-years	3.35E-05	3.51E-05	Points	1.2E-06	1.3E-06
Eutrophication, freshwater	kg P eq	5.73E-05	5.97E-05	Person-years	3.57E-05	3.72E-05	Points	1.0E-06	1.0E-06
Eutrophication, marine	kg N eq	8.80E-04	9.31E-04	Person-years	4.50E-05	4.76E-05	Points	1.3E-06	1.4E-06
Ecotoxicity, freshwater	CTUe	3.05E+00	3.35E+00	Person-years	5.37E-05	5.90E-05	Points	1.0E-06	1.1E-06
Land use	Pt	8.28E+00	8.92E+00	Person-years	1.01E-05	1.09E-05	Points	8.0E-07	8.6E-07
Water use	m <sup>3</sup> depriv.	9.01E-01	9.22E-01	Person-years	7.85E-05	8.04E-05	Points	6.7E-06	6.8E-06
Resource use, minerals and metals	kg Sb eq	2.13E-06	2.47E-06	Person-years	3.34E-05	3.88E-05	Points	2.5E-06	2.9E-06
Resource use, fossils	MJ	4.07E+00	4.44E+00	Person-years	6.26E-05	6.83E-05	Points	5.2E-06	5.7E-06
Total	Pt	n/a	n/a	Person-years	n/a	n/a	Points	<b>4.1E-05</b>	<b>4.4E-05</b>

Table 43 - Characterised, normalised and weighted results including the single score per use for sweaters and midlayers (RP3)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	8.57E-01	8.75E-01	Person-years	1.13E-04	1.16E-04	Points	2.39E-05	2.44E-05
Climate change - Fossil	kg CO <sub>2</sub> eq	5.24E-01	5.40E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	2.43E-01	2.44E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	8.97E-02	9.09E-02	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	3.04E-09	5.74E-09	Person-years	5.81E-08	1.10E-07	Points	3.67E-09	6.91E-09
Human toxicity, cancer	CTUh	4.76E-10	5.08E-10	Person-years	2.76E-05	2.95E-05	Points	5.88E-07	6.27E-07
Human toxicity, non-cancer	CTUh	1.09E-08	1.12E-08	Person-years	8.47E-05	8.70E-05	Points	1.56E-06	1.60E-06
Particulate matter	disease inc.	1.53E-07	1.54E-07	Person-years	2.56E-04	2.59E-04	Points	2.30E-05	2.32E-05
Ionising radiation	kBq U-235 eq	1.77E-02	2.18E-02	Person-years	4.20E-06	5.15E-06	Points	2.11E-07	2.58E-07
Photochemical ozone formation	kg NMVOC eq	1.97E-03	2.02E-03	Person-years	4.83E-05	4.96E-05	Points	2.31E-06	2.37E-06
Acidification	mol H <sup>+</sup> eq	1.57E-02	1.58E-02	Person-years	2.83E-04	2.85E-04	Points	1.76E-05	1.77E-05
Eutrophication, terrestrial	mol N eq	6.08E-02	6.10E-02	Person-years	3.44E-04	3.45E-04	Points	1.28E-05	1.28E-05
Eutrophication, freshwater	kg P eq	1.60E-04	1.62E-04	Person-years	9.95E-05	1.01E-04	Points	2.79E-06	2.82E-06
Eutrophication, marine	kg N eq	8.72E-03	8.76E-03	Person-years	4.46E-04	4.48E-04	Points	1.32E-05	1.33E-05
Ecotoxicity, freshwater	CTUe	5.27E+01	5.30E+01	Person-years	9.29E-04	9.34E-04	Points	1.78E-05	1.79E-05
Land use	Pt	1.38E+02	1.39E+02	Person-years	1.69E-04	1.69E-04	Points	1.34E-05	1.34E-05
Water use	m <sup>3</sup> depriv.	1.72E+00	1.74E+00	Person-years	1.50E-04	1.52E-04	Points	1.28E-05	1.29E-05
Resource use, minerals and metals	kg Sb eq	2.61E-06	2.88E-06	Person-years	4.10E-05	4.53E-05	Points	3.10E-06	3.42E-06
Resource use, fossils	MJ	5.10E+00	5.37E+00	Person-years	7.84E-05	8.26E-05	Points	6.53E-06	6.87E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>1.51E-04</b>	<b>1.54E-04</b>

Table 44 - Characterised, normalised and weighted results including the single score per use for jackets and coats (RP4)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	7.40E-01	7.51E-01	Person-years	9.80E-05	9.95E-05	Points	2.06E-05	2.10E-05
Climate change - Fossil	kg CO <sub>2</sub> eq	5.66E-01	5.76E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	1.24E-01	1.24E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	5.03E-02	5.09E-02	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	4.51E-09	6.67E-09	Person-years	8.61E-08	1.27E-07	Points	5.44E-09	8.03E-09
Human toxicity, cancer	CTUh	6.37E-10	6.56E-10	Person-years	3.69E-05	3.80E-05	Points	7.86E-07	8.10E-07
Human toxicity, non-cancer	CTUh	8.54E-09	8.70E-09	Person-years	6.63E-05	6.76E-05	Points	1.22E-06	1.24E-06
Particulate matter	disease inc.	1.33E-07	1.34E-07	Person-years	2.23E-04	2.24E-04	Points	2.00E-05	2.01E-05
Ionising radiation	kBq U-235 eq	2.65E-02	2.92E-02	Person-years	6.27E-06	6.91E-06	Points	3.14E-07	3.46E-07
Photochemical ozone formation	kg NMVOC eq	2.03E-03	2.06E-03	Person-years	4.97E-05	5.04E-05	Points	2.38E-06	2.41E-06
Acidification	mol H <sup>+</sup> eq	1.06E-02	1.07E-02	Person-years	1.91E-04	1.92E-04	Points	1.19E-05	1.19E-05
Eutrophication, terrestrial	mol N eq	3.71E-02	3.72E-02	Person-years	2.10E-04	2.11E-04	Points	7.79E-06	7.82E-06
Eutrophication, freshwater	kg P eq	9.84E-05	9.94E-05	Person-years	6.12E-05	6.18E-05	Points	1.71E-06	1.73E-06
Eutrophication, marine	kg N eq	4.95E-03	4.97E-03	Person-years	2.53E-04	2.54E-04	Points	7.49E-06	7.53E-06
Ecotoxicity, freshwater	CTUe	2.94E+01	2.95E+01	Person-years	5.18E-04	5.20E-04	Points	9.94E-06	9.99E-06
Land use	Pt	6.18E+01	6.21E+01	Person-years	7.55E-05	7.58E-05	Points	5.99E-06	6.01E-06
Water use	m <sup>3</sup> depriv.	1.15E+00	1.16E+00	Person-years	1.01E-04	1.01E-04	Points	8.56E-06	8.63E-06
Resource use, minerals and metals	kg Sb eq	5.24E-06	5.38E-06	Person-years	8.24E-05	8.46E-05	Points	6.22E-06	6.39E-06
Resource use, fossils	MJ	6.94E+00	7.11E+00	Person-years	1.07E-04	1.09E-04	Points	8.89E-06	9.10E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>1.14E-04</b>	<b>1.15E-04</b>

Table 45 - Characterised, normalised and weighted results including the single score per use for pants and shorts (RP5)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	3.01E-01	3.25E-01	Person-years	3.98E-05	4.30E-05	Points	8.38E-06	9.07E-06
Climate change - Fossil	kg CO <sub>2</sub> eq	2.88E-01	3.11E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	8.73E-03	9.12E-03	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	3.65E-03	5.15E-03	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	3.27E-09	7.14E-09	Person-years	6.25E-08	1.36E-07	Points	3.94E-09	8.61E-09
Human toxicity, cancer	CTUh	4.07E-10	4.42E-10	Person-years	2.36E-05	2.56E-05	Points	5.02E-07	5.46E-07
Human toxicity, non-cancer	CTUh	4.07E-09	4.37E-09	Person-years	3.16E-05	3.40E-05	Points	5.82E-07	6.25E-07
Particulate matter	disease inc.	5.23E-08	5.38E-08	Person-years	8.78E-05	9.04E-05	Points	7.86E-06	8.10E-06
Ionising radiation	kBq U-235 eq	1.64E-02	2.30E-02	Person-years	3.89E-06	5.46E-06	Points	1.95E-07	2.73E-07
Photochemical ozone formation	kg NMVOC eq	1.09E-03	1.15E-03	Person-years	2.66E-05	2.81E-05	Points	1.27E-06	1.34E-06
Acidification	mol H <sup>+</sup> eq	2.25E-03	2.34E-03	Person-years	4.04E-05	4.22E-05	Points	2.51E-06	2.61E-06
Eutrophication, terrestrial	mol N eq	6.26E-03	6.50E-03	Person-years	3.54E-05	3.68E-05	Points	1.31E-06	1.36E-06
Eutrophication, freshwater	kg P eq	5.28E-05	5.47E-05	Person-years	3.29E-05	3.41E-05	Points	9.21E-07	9.54E-07
Eutrophication, marine	kg N eq	8.77E-04	9.18E-04	Person-years	4.49E-05	4.70E-05	Points	1.33E-06	1.39E-06
Ecotoxicity, freshwater	CTUe	3.39E+00	3.65E+00	Person-years	5.98E-05	6.44E-05	Points	1.15E-06	1.24E-06
Land use	Pt	7.86E+00	8.33E+00	Person-years	9.60E-06	1.02E-05	Points	7.62E-07	8.07E-07
Water use	m <sup>3</sup> depriv.	8.13E-01	8.30E-01	Person-years	7.09E-05	7.24E-05	Points	6.03E-06	6.16E-06
Resource use, minerals and metals	kg Sb eq	2.76E-06	3.07E-06	Person-years	4.33E-05	4.83E-05	Points	3.27E-06	3.65E-06
Resource use, fossils	MJ	4.02E+00	4.39E+00	Person-years	6.18E-05	6.75E-05	Points	5.14E-06	5.62E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>4.12E-05</b>	<b>4.38E-05</b>

Table 46 - Characterised, normalised and weighted results including the single score per use for dresses, skirts and jumpsuits (RP6)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	2.29E-01	2.49E-01	Person-years	3.03E-05	3.30E-05	Points	6.38E-06	6.95E-06
Climate change - Fossil	kg CO <sub>2</sub> eq	2.10E-01	2.28E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	1.22E-02	1.26E-02	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	6.46E-03	8.00E-03	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	1.91E-09	5.13E-09	Person-years	3.66E-08	9.80E-08	Points	2.31E-09	6.18E-09
Human toxicity, cancer	CTUh	2.81E-10	3.14E-10	Person-years	1.63E-05	1.82E-05	Points	3.47E-07	3.88E-07
Human toxicity, non-cancer	CTUh	3.15E-09	3.44E-09	Person-years	2.44E-05	2.67E-05	Points	4.50E-07	4.92E-07
Particulate matter	disease inc.	4.09E-08	4.24E-08	Person-years	6.87E-05	7.12E-05	Points	6.16E-06	6.38E-06
Ionising radiation	kBq U-235 eq	1.22E-02	1.69E-02	Person-years	2.88E-06	4.01E-06	Points	1.44E-07	2.01E-07
Photochemical ozone formation	kg NMVOC eq	7.79E-04	8.33E-04	Person-years	1.91E-05	2.04E-05	Points	9.11E-07	9.75E-07
Acidification	mol H <sup>+</sup> eq	2.09E-03	2.18E-03	Person-years	3.76E-05	3.92E-05	Points	2.33E-06	2.43E-06
Eutrophication, terrestrial	mol N eq	6.40E-03	6.63E-03	Person-years	3.62E-05	3.75E-05	Points	1.34E-06	1.39E-06
Eutrophication, freshwater	kg P eq	4.36E-05	4.56E-05	Person-years	2.72E-05	2.84E-05	Points	7.61E-07	7.94E-07
Eutrophication, marine	kg N eq	9.13E-04	9.58E-04	Person-years	4.67E-05	4.90E-05	Points	1.38E-06	1.45E-06
Ecotoxicity, freshwater	CTUe	3.89E+00	4.14E+00	Person-years	6.85E-05	7.30E-05	Points	1.32E-06	1.40E-06
Land use	Pt	7.94E+00	8.44E+00	Person-years	9.68E-06	1.03E-05	Points	7.69E-07	8.18E-07
Water use	m <sup>3</sup> depriv.	6.61E-01	6.79E-01	Person-years	5.76E-05	5.92E-05	Points	4.90E-06	5.04E-06
Resource use, minerals and metals	kg Sb eq	1.48E-06	1.74E-06	Person-years	2.33E-05	2.73E-05	Points	1.76E-06	2.06E-06
Resource use, fossils	MJ	2.82E+00	3.10E+00	Person-years	4.33E-05	4.77E-05	Points	3.60E-06	3.97E-06
Total	Pt	n/a	n/a	Person-years	n/a	n/a	Points	<b>3.26E-05</b>	<b>3.47E-05</b>

Table 47 - Characterised, normalised and weighted results including the single score per use for leggings, stockings, tights and socks (RP7)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	1.21E-01	1.33E-01	Person-years	1.61E-05	1.76E-05	Points	3.38E-06	3.71E-06
Climate change - Fossil	kg CO <sub>2</sub> eq	1.11E-01	1.21E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	7.26E-03	7.54E-03	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	3.03E-03	4.25E-03	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	1.07E-09	1.87E-09	Person-years	2.04E-08	3.58E-08	Points	1.29E-09	2.26E-09
Human toxicity, cancer	CTUh	1.55E-10	1.72E-10	Person-years	8.97E-06	9.98E-06	Points	1.91E-07	2.12E-07
Human toxicity, non-cancer	CTUh	1.29E-09	1.45E-09	Person-years	9.99E-06	1.13E-05	Points	1.84E-07	2.07E-07
Particulate matter	disease inc.	2.00E-08	2.08E-08	Person-years	3.35E-05	3.49E-05	Points	3.00E-06	3.13E-06
Ionising radiation	kBq U-235 eq	5.60E-03	8.20E-03	Person-years	1.33E-06	1.94E-06	Points	6.65E-08	9.74E-08
Photochemical ozone formation	kg NMVOC eq	4.35E-04	4.65E-04	Person-years	1.07E-05	1.14E-05	Points	5.09E-07	5.43E-07
Acidification	mol H <sup>+</sup> eq	1.11E-03	1.16E-03	Person-years	1.99E-05	2.08E-05	Points	1.24E-06	1.29E-06
Eutrophication, terrestrial	mol N eq	3.26E-03	3.38E-03	Person-years	1.84E-05	1.91E-05	Points	6.84E-07	7.10E-07
Eutrophication, freshwater	kg P eq	1.43E-05	1.56E-05	Person-years	8.88E-06	9.69E-06	Points	2.49E-07	2.71E-07
Eutrophication, marine	kg N eq	4.31E-04	4.57E-04	Person-years	2.20E-05	2.34E-05	Points	6.52E-07	6.91E-07
Ecotoxicity, freshwater	CTUe	2.13E+00	2.27E+00	Person-years	3.75E-05	4.01E-05	Points	7.20E-07	7.69E-07
Land use	Pt	3.08E+00	3.42E+00	Person-years	3.76E-06	4.17E-06	Points	2.98E-07	3.31E-07
Water use	m <sup>3</sup> depriv.	2.06E-01	2.17E-01	Person-years	1.80E-05	1.89E-05	Points	1.53E-06	1.61E-06
Resource use, minerals and metals	kg Sb eq	7.15E-07	8.99E-07	Person-years	1.12E-05	1.41E-05	Points	8.48E-07	1.07E-06
Resource use, fossils	MJ	1.57E+00	1.73E+00	Person-years	2.42E-05	2.66E-05	Points	2.01E-06	2.21E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>1.56E-05</b>	<b>1.69E-05</b>

Table 48 - Characterised, normalised and weighted results including the single score per use for underwear (RP8)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	7.21E-02	9.29E-02	Person-years	9.55E-06	1.23E-05	Points	2.01E-06	2.59E-06
Climate change - Fossil	kg CO <sub>2</sub> eq	6.94E-02	8.82E-02	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	1.74E-03	2.12E-03	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	9.83E-04	2.51E-03	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	6.99E-10	1.17E-09	Person-years	1.33E-08	2.24E-08	Points	8.42E-10	1.41E-09
Human toxicity, cancer	CTUh	1.02E-10	1.27E-10	Person-years	5.92E-06	7.34E-06	Points	1.26E-07	1.56E-07
Human toxicity, non-cancer	CTUh	1.07E-09	1.31E-09	Person-years	8.31E-06	1.02E-05	Points	1.53E-07	1.87E-07
Particulate matter	disease inc.	1.22E-08	1.36E-08	Person-years	2.05E-05	2.28E-05	Points	1.84E-06	2.04E-06
Ionising radiation	kBq U-235 eq	3.67E-03	9.15E-03	Person-years	8.69E-07	2.17E-06	Points	4.35E-08	1.09E-07
Photochemical ozone formation	kg NMVOC eq	2.84E-04	3.32E-04	Person-years	6.95E-06	8.12E-06	Points	3.32E-07	3.88E-07
Acidification	mol H <sup>+</sup> eq	5.41E-04	6.22E-04	Person-years	9.73E-06	1.12E-05	Points	6.04E-07	6.94E-07
Eutrophication, terrestrial	mol N eq	1.57E-03	1.77E-03	Person-years	8.86E-06	9.99E-06	Points	3.29E-07	3.71E-07
Eutrophication, freshwater	kg P eq	1.57E-05	1.75E-05	Person-years	9.74E-06	1.09E-05	Points	2.73E-07	3.06E-07
Eutrophication, marine	kg N eq	2.42E-04	2.78E-04	Person-years	1.24E-05	1.42E-05	Points	3.67E-07	4.22E-07
Ecotoxicity, freshwater	CTUe	8.34E-01	1.06E+00	Person-years	1.47E-05	1.86E-05	Points	2.82E-07	3.58E-07
Land use	Pt	2.26E+00	2.71E+00	Person-years	2.76E-06	3.30E-06	Points	2.19E-07	2.62E-07
Water use	m <sup>3</sup> depriv.	2.45E-01	2.60E-01	Person-years	2.14E-05	2.27E-05	Points	1.82E-06	1.93E-06
Resource use, minerals and metals	kg Sb eq	2.96E-07	6.11E-07	Person-years	4.65E-06	9.61E-06	Points	3.51E-07	7.26E-07
Resource use, fossils	MJ	9.54E-01	1.27E+00	Person-years	1.47E-05	1.95E-05	Points	1.22E-06	1.62E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>9.97E-06</b>	<b>1.22E-05</b>

Table 49 - Characterised, normalised and weighted results including the single score per use for swimwear (RP9)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	1.76E-01	2.00E-01	Person-years	2.34E-05	2.64E-05	Points	4.92E-06	5.56E-06
Climate change - Fossil	kg CO <sub>2</sub> eq	1.72E-01	1.94E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	4.32E-03	4.79E-03	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	2.36E-04	3.14E-04	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	8.08E-10	1.11E-09	Person-years	1.54E-08	2.13E-08	Points	9.74E-10	1.34E-09
Human toxicity, cancer	CTUh	2.48E-10	2.91E-10	Person-years	1.44E-05	1.69E-05	Points	3.07E-07	3.60E-07
Human toxicity, non-cancer	CTUh	1.15E-09	1.62E-09	Person-years	8.90E-06	1.26E-05	Points	1.64E-07	2.32E-07
Particulate matter	disease inc.	2.62E-08	2.86E-08	Person-years	4.40E-05	4.81E-05	Points	3.94E-06	4.31E-06
Ionising radiation	kBq U-235 eq	9.58E-03	1.39E-02	Person-years	2.27E-06	3.30E-06	Points	1.14E-07	1.66E-07
Photochemical ozone formation	kg NMVOC eq	6.33E-04	7.24E-04	Person-years	1.55E-05	1.77E-05	Points	7.40E-07	8.47E-07
Acidification	mol H <sup>+</sup> eq	1.15E-03	1.31E-03	Person-years	2.06E-05	2.36E-05	Points	1.28E-06	1.46E-06
Eutrophication, terrestrial	mol N eq	2.48E-03	2.97E-03	Person-years	1.41E-05	1.68E-05	Points	5.22E-07	6.24E-07
Eutrophication, freshwater	kg P eq	5.44E-06	8.14E-06	Person-years	3.38E-06	5.07E-06	Points	9.47E-08	1.42E-07
Eutrophication, marine	kg N eq	2.87E-04	3.85E-04	Person-years	1.47E-05	1.97E-05	Points	4.34E-07	5.83E-07
Ecotoxicity, freshwater	CTUe	1.59E+00	2.03E+00	Person-years	2.80E-05	3.59E-05	Points	5.37E-07	6.89E-07
Land use	Pt	5.69E-01	1.25E+00	Person-years	6.94E-07	1.53E-06	Points	5.51E-08	1.22E-07
Water use	m <sup>3</sup> depriv.	9.32E-02	1.27E-01	Person-years	8.13E-06	1.11E-05	Points	6.92E-07	9.44E-07
Resource use, minerals and metals	kg Sb eq	1.72E-06	1.85E-06	Person-years	2.70E-05	2.91E-05	Points	2.04E-06	2.20E-06
Resource use, fossils	MJ	2.70E+00	3.08E+00	Person-years	4.16E-05	4.73E-05	Points	3.46E-06	3.94E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>1.93E-05</b>	<b>2.22E-05</b>

Table 50 - Characterised, normalised and weighted results including the single score per use for apparel accessories (RP10)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	1.31E-01	1.32E-01	Person-years	1.73E-05	1.75E-05	Points	3.65E-06	3.68E-06
Climate change - Fossil	kg CO <sub>2</sub> eq	9.07E-02	9.20E-02	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	2.64E-02	2.64E-02	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	1.37E-02	1.38E-02	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	1.36E-09	1.66E-09	Person-years	2.60E-08	3.17E-08	Points	1.64E-09	2.00E-09
Human toxicity, cancer	CTUh	1.11E-10	1.13E-10	Person-years	6.43E-06	6.58E-06	Points	1.37E-07	1.40E-07
Human toxicity, non-cancer	CTUh	2.15E-09	2.17E-09	Person-years	1.67E-05	1.69E-05	Points	3.08E-07	3.11E-07
Particulate matter	disease inc.	2.53E-08	2.54E-08	Person-years	4.24E-05	4.26E-05	Points	3.80E-06	3.82E-06
Ionising radiation	kBq U-235 eq	3.18E-03	3.50E-03	Person-years	7.53E-07	8.30E-07	Points	3.77E-08	4.16E-08
Photochemical ozone formation	kg NMVOC eq	3.82E-04	3.86E-04	Person-years	9.35E-06	9.45E-06	Points	4.47E-07	4.51E-07
Acidification	mol H <sup>+</sup> eq	2.51E-03	2.51E-03	Person-years	4.51E-05	4.52E-05	Points	2.80E-06	2.80E-06
Eutrophication, terrestrial	mol N eq	9.36E-03	9.38E-03	Person-years	5.30E-05	5.31E-05	Points	1.97E-06	1.97E-06
Eutrophication, freshwater	kg P eq	2.18E-05	2.19E-05	Person-years	1.35E-05	1.36E-05	Points	3.79E-07	3.81E-07
Eutrophication, marine	kg N eq	1.17E-03	1.18E-03	Person-years	6.00E-05	6.02E-05	Points	1.78E-06	1.78E-06
Ecotoxicity, freshwater	CTUe	6.88E+00	6.90E+00	Person-years	1.21E-04	1.22E-04	Points	2.33E-06	2.34E-06
Land use	Pt	9.96E+00	9.99E+00	Person-years	1.22E-05	1.22E-05	Points	9.65E-07	9.68E-07
Water use	m <sup>3</sup> depriv.	2.44E-01	2.45E-01	Person-years	2.13E-05	2.14E-05	Points	1.81E-06	1.82E-06
Resource use, minerals and metals	kg Sb eq	4.73E-07	4.89E-07	Person-years	7.44E-06	7.69E-06	Points	5.62E-07	5.81E-07
Resource use, fossils	MJ	9.89E-01	1.01E+00	Person-years	1.52E-05	1.55E-05	Points	1.27E-06	1.29E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>2.22E-05</b>	<b>2.24E-05</b>

Table 51 - Characterised, normalised and weighted results including the single score per use for open-toed shoes (RP11)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	3.06E-01	3.06E-01	Person-years	4.05E-05	4.05E-05	Points	8.53E-06	8.54E-06
Climate change - Fossil	kg CO <sub>2</sub> eq	2.60E-01	2.61E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	3.46E-02	3.46E-02	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	1.10E-02	1.11E-02	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	8.98E-09	8.98E-09	Person-years	1.71E-07	1.72E-07	Points	1.08E-08	1.08E-08
Human toxicity, cancer	CTUh	6.15E-10	6.16E-10	Person-years	3.57E-05	3.57E-05	Points	7.60E-07	7.61E-07
Human toxicity, non-cancer	CTUh	1.35E-08	1.35E-08	Person-years	1.05E-04	1.05E-04	Points	1.93E-06	1.93E-06
Particulate matter	disease inc.	4.70E-08	4.70E-08	Person-years	7.89E-05	7.90E-05	Points	7.07E-06	7.08E-06
Ionising radiation	kBq U-235 eq	9.85E-03	9.90E-03	Person-years	2.33E-06	2.35E-06	Points	1.17E-07	1.18E-07
Photochemical ozone formation	kg NMVOC eq	1.50E-03	1.51E-03	Person-years	3.68E-05	3.68E-05	Points	1.76E-06	1.76E-06
Acidification	mol H <sup>+</sup> eq	3.82E-03	3.83E-03	Person-years	6.88E-05	6.89E-05	Points	4.27E-06	4.27E-06
Eutrophication, terrestrial	mol N eq	1.40E-02	1.40E-02	Person-years	7.94E-05	7.94E-05	Points	2.94E-06	2.95E-06
Eutrophication, freshwater	kg P eq	2.10E-05	2.11E-05	Person-years	1.31E-05	1.31E-05	Points	3.67E-07	3.68E-07
Eutrophication, marine	kg N eq	1.40E-03	1.40E-03	Person-years	7.15E-05	7.16E-05	Points	2.12E-06	2.12E-06
Ecotoxicity, freshwater	CTUe	1.04E+01	1.04E+01	Person-years	1.83E-04	1.83E-04	Points	3.50E-06	3.51E-06
Land use	Pt	1.52E+01	1.52E+01	Person-years	1.86E-05	1.86E-05	Points	1.47E-06	1.48E-06
Water use	m <sup>3</sup> depriv.	1.70E-01	1.71E-01	Person-years	1.48E-05	1.49E-05	Points	1.26E-06	1.27E-06
Resource use, minerals and metals	kg Sb eq	1.99E-06	2.00E-06	Person-years	3.13E-05	3.15E-05	Points	2.37E-06	2.38E-06
Resource use, fossils	MJ	3.70E+00	3.71E+00	Person-years	5.70E-05	5.70E-05	Points	4.74E-06	4.75E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>4.32E-05</b>	<b>4.33E-05</b>

Table 52 - Characterised, normalised and weighted results including the single score per use for closed-toed shoes (RP12)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	5.41E-01	5.42E-01	Person-years	7.17E-05	7.18E-05	Points	1.51E-05	1.51E-05
Climate change - Fossil	kg CO <sub>2</sub> eq	4.41E-01	4.42E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	6.92E-02	6.93E-02	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	3.10E-02	3.11E-02	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	8.99E-09	9.00E-09	Person-years	1.72E-07	1.72E-07	Points	1.08E-08	1.08E-08
Human toxicity, cancer	CTUh	8.55E-10	8.56E-10	Person-years	4.96E-05	4.96E-05	Points	1.06E-06	1.06E-06
Human toxicity, non-cancer	CTUh	1.42E-08	1.42E-08	Person-years	1.10E-04	1.10E-04	Points	2.02E-06	2.03E-06
Particulate matter	disease inc.	9.15E-08	9.15E-08	Person-years	1.54E-04	1.54E-04	Points	1.38E-05	1.38E-05
Ionising radiation	kBq U-235 eq	1.92E-02	1.92E-02	Person-years	4.54E-06	4.55E-06	Points	2.27E-07	2.28E-07
Photochemical ozone formation	kg NMVOC eq	2.06E-03	2.06E-03	Person-years	5.03E-05	5.04E-05	Points	2.40E-06	2.41E-06
Acidification	mol H <sup>+</sup> eq	7.40E-03	7.40E-03	Person-years	1.33E-04	1.33E-04	Points	8.25E-06	8.25E-06
Eutrophication, terrestrial	mol N eq	2.62E-02	2.63E-02	Person-years	1.48E-04	1.49E-04	Points	5.51E-06	5.51E-06
Eutrophication, freshwater	kg P eq	5.28E-05	5.29E-05	Person-years	3.28E-05	3.29E-05	Points	9.19E-07	9.21E-07
Eutrophication, marine	kg N eq	3.10E-03	3.10E-03	Person-years	1.58E-04	1.59E-04	Points	4.69E-06	4.69E-06
Ecotoxicity, freshwater	CTUe	2.20E+01	2.21E+01	Person-years	3.89E-04	3.89E-04	Points	7.46E-06	7.47E-06
Land use	Pt	2.80E+01	2.80E+01	Person-years	3.42E-05	3.42E-05	Points	2.71E-06	2.72E-06
Water use	m <sup>3</sup> depriv.	5.82E-01	5.82E-01	Person-years	5.07E-05	5.08E-05	Points	4.32E-06	4.32E-06
Resource use, minerals and metals	kg Sb eq	3.93E-06	3.95E-06	Person-years	6.18E-05	6.20E-05	Points	4.67E-06	4.68E-06
Resource use, fossils	MJ	5.85E+00	5.87E+00	Person-years	9.00E-05	9.03E-05	Points	7.49E-06	7.51E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>8.06E-05</b>	<b>8.07E-05</b>

Table 53 - Characterised, normalised and weighted results including the single score per use for boots (RP13)

Impact category	Characterised results			Normalised results			Weighted results		
	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts	Units	Excluding use	Total impacts
Climate change	kg CO <sub>2</sub> eq	5.46E-01	5.47E-01	Person-years	7.23E-05	7.24E-05	Points	1.52E-05	1.53E-05
Climate change - Fossil	kg CO <sub>2</sub> eq	4.60E-01	4.61E-01	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Biogenic	kg CO <sub>2</sub> eq	6.50E-02	6.51E-02	Person-years	n/a	n/a	Points	n/a	n/a
Climate change - Land use and land use change	kg CO <sub>2</sub> eq	2.07E-02	2.08E-02	Person-years	n/a	n/a	Points	n/a	n/a
Ozone depletion	kg CFC-11 eq	1.98E-08	1.98E-08	Person-years	3.78E-07	3.78E-07	Points	2.38E-08	2.39E-08
Human toxicity, cancer	CTUh	1.28E-09	1.28E-09	Person-years	7.39E-05	7.40E-05	Points	1.57E-06	1.58E-06
Human toxicity, non-cancer	CTUh	2.43E-08	2.43E-08	Person-years	1.89E-04	1.89E-04	Points	3.47E-06	3.48E-06
Particulate matter	disease inc.	8.77E-08	8.78E-08	Person-years	1.47E-04	1.47E-04	Points	1.32E-05	1.32E-05
Ionising radiation	kBq U-235 eq	1.96E-02	1.97E-02	Person-years	4.64E-06	4.66E-06	Points	2.33E-07	2.34E-07
Photochemical ozone formation	kg NMVOC eq	2.52E-03	2.52E-03	Person-years	6.16E-05	6.17E-05	Points	2.95E-06	2.95E-06
Acidification	mol H <sup>+</sup> eq	7.16E-03	7.16E-03	Person-years	1.29E-04	1.29E-04	Points	7.99E-06	7.99E-06
Eutrophication, terrestrial	mol N eq	2.62E-02	2.62E-02	Person-years	1.48E-04	1.48E-04	Points	5.50E-06	5.50E-06
Eutrophication, freshwater	kg P eq	4.17E-05	4.18E-05	Person-years	2.59E-05	2.60E-05	Points	7.26E-07	7.29E-07
Eutrophication, marine	kg N eq	2.60E-03	2.60E-03	Person-years	1.33E-04	1.33E-04	Points	3.93E-06	3.94E-06
Ecotoxicity, freshwater	CTUe	1.95E+01	1.95E+01	Person-years	3.44E-04	3.44E-04	Points	6.61E-06	6.61E-06
Land use	Pt	2.52E+01	2.52E+01	Person-years	3.07E-05	3.07E-05	Points	2.44E-06	2.44E-06
Water use	m <sup>3</sup> depriv.	3.57E-01	3.58E-01	Person-years	3.12E-05	3.12E-05	Points	2.65E-06	2.66E-06
Resource use, minerals and metals	kg Sb eq	4.93E-06	4.95E-06	Person-years	7.75E-05	7.77E-05	Points	5.85E-06	5.87E-06
Resource use, fossils	MJ	6.30E+00	6.32E+00	Person-years	9.69E-05	9.72E-05	Points	8.07E-06	8.09E-06
Total	Pt	<b>n/a</b>	<b>n/a</b>	Person-years	<b>n/a</b>	<b>n/a</b>	Points	<b>8.04E-05</b>	<b>8.05E-05</b>

### **6.1.2. Normalized results**

The normalized results for the 13 representative products are presented in Table 41 through Table 53.

Normalisation is the step in which the life cycle impact assessment results are multiplied by normalisation factors to calculate and compare the magnitude of their contributions to the EF impact categories relative to a reference unit. As a result, dimensionless, normalised results are obtained. These reflect the burdens attributable to a product relative to the reference unit.

In the PEF method the normalisation factors are expressed per capita based on a global value.

Normalised environmental footprint results do not indicate the severity or relevance of the respective impacts. Normalised results shall not be aggregated as this implicitly applies weighting.

### **6.1.3. Weighted results**

The weighted results for the 13 representative products are presented in Table 41 through Table 53.

Weighting is a mandatory step in the PEF-RP study and it supports the interpretation and communication of the results of the analysis. In this step, normalised results are multiplied by a set of weighting factors (in percentages) which reflect the perceived relative importance of the life cycle impact categories considered. Weighted results of different impact categories may then be compared to assess their relative importance.

To develop weighting factors, value judgments are required as to the respective importance of the life cycle impact categories considered.

### **6.1.4. Weighted results as a single score**

The weighted results as a single score for the 13 representative products are presented in Table 41 through Table 53.

The weighted results are aggregated across life cycle impact categories to obtain a single overall score.

## 6.2. Additional information

### Note

Due to the novelty of the fibre fragment assessment approach proposed in the PEFCR v3.1, the methodology has only been applied to one representative product (RP1) to avoid significant delays to the publication of the PEFCR. It is however sufficient to confirm that the approach is applicable.

### Fibre fragment impact of RP1

The fibre fragment impact of RP1 was calculated following Section 4.4.1. The description of the emission and characterisation factors can be found in Table 54 and the fibre fragment inventory is obtained using Equation 10 (AvgFFLoss provided are from the TMC Data Portal available at the time of publication).

Table 54 - Chosen emission and characterisation factors for fibre fragment impact calculation

Material	Chosen fibre fragment emission factor	Chosen characterisation factor
Cotton	Weft knit, from staple fibre	Cotton, 10 µm
Polyester and other synthetics	Weft knit, from staple fibre	PET, 10 µm
Polyester recycled	Weft knit, from staple fibre	PET, 10 µm
Viscose/Modal	Weft knit, from staple fibre	Viscose, 10 µm

$$\begin{aligned}
 FF_{Loss_{Cotton}} &= \frac{0.17 \text{ kg}}{2 \text{ uses/wash}} * (70\% \text{ share cotton} * AvgFF_{Loss_{CottonWeftKnit}}) \\
 &= \frac{0.17 \text{ kg}}{2 \text{ uses/wash}} \\
 &\quad * (0.7 * 0.749 \text{ g fibre fragment emitted/kg of product/wash}) \\
 &= 0.045 \text{ g cotton fibre fragment emitted/use}
 \end{aligned}$$

$$FFLOSS_{Polyester}$$

$$= \frac{0.17 \text{ kg}}{2 \text{ uses/wash}}$$

$$* (21\% \text{ share polyester and other synthetics})$$

$$* AvgFFLOSS_{PolyesterWftKnit}$$

$$= \frac{0.17 \text{ kg}}{2 \text{ uses/wash}}$$

$$* (0.21 * 0.749 \text{ g fibre fragment emitted/kg of product/wash})$$

$$= 0.013 \text{ g polyester fibre fragment emitted/use}$$

$$FFLOSS_{RecycledPolyester} = \frac{0.17 \text{ kg}}{2 \text{ uses/wash}} * (0.02 * AvgFFLOSS_{PolyesterWftKnit})$$

$$= \frac{0.17 \text{ kg}}{2 \text{ uses/wash}}$$

$$* (2\% \text{ share recycled polyester})$$

$$* 0.749 \text{ g fibre fragment emitted/kg of product/wash})$$

$$= 0.001 \text{ g recycled polyester fibre fragment emitted/use}$$

$$FFLOSS_{Viscose/Modal}$$

$$= \frac{0.17 \text{ kg}}{2 \text{ uses/wash}} * (6\% \text{ share viscose/modal} * AvgFFLOSS_{MMCFWftKnit})$$

$$= \frac{0.17 \text{ kg}}{2 \text{ uses/wash}}$$

$$* (0.06 * 0.749 \text{ g fibre fragment emitted/kg of product/wash})$$

$$= 0.004 \text{ g viscose/modal fibre fragment emitted/use}$$

Equation 10

The fibre fragment inventory of each material is then multiplied by the characterisation factor of each material (directly available in this case) as per Equation 11 for the midpoint impact and Equation 12 for the endpoint impact..

$$\begin{aligned}
 \text{MidpointImpact}_{\text{Cotton}} &= \frac{FFLOSS_{\text{Cotton}}}{1000 \text{ g/kg}} * \text{MidpointCF}_{\text{Cotton},10\mu\text{m}} \\
 &= \frac{0.045 \text{ g fibre fragment emitted/use}}{1000 \text{ g/kg}} * 1.04 * 10^5 \text{ PAF} * \text{m}^3 \\
 &\quad * \text{day/ kg fibre fragment emitted} = 4.64 \text{ PAF} * \text{m}^3 * \frac{\text{day}}{\text{use}}
 \end{aligned}$$

$$\begin{aligned}
 \text{MidpointImpact}_{\text{Polyester}} &= \frac{FFLOSS_{\text{Polyester}}}{1000 \text{ g/kg}} * \text{MidpointCF}_{\text{PET},10\mu\text{m}} \\
 &= \frac{0.013 \text{ g fibre fragment emitted/use}}{1000 \text{ g/kg}} * 1.40 * 10^7 \text{ PAF} * \text{m}^3 \\
 &\quad * \text{day/ kg fibre fragment emitted} = 186.59 \text{ PAF} * \text{m}^3 * \frac{\text{day}}{\text{use}}
 \end{aligned}$$

$$\begin{aligned}
 \text{MidpointImpact}_{\text{RecycledPolyester}} &= \frac{FFLOSS_{\text{RecycledPolyester}}}{1000 \text{ g/kg}} * \text{MidpointCF}_{\text{PET},10\mu\text{m}} \\
 &= \frac{0.001 \text{ g fibre fragment emitted/use}}{1000 \text{ g/kg}} * 1.40 * 10^7 \text{ PAF} * \text{m}^3 \\
 &\quad * \text{day/ kg fibre fragment emitted} = 17.77 \text{ PAF} * \text{m}^3 * \frac{\text{day}}{\text{use}}
 \end{aligned}$$

$$\begin{aligned}
 \text{MidpointImpact}_{\text{Viscose/Modal}} &= \frac{FFLOSS_{\text{Viscose/Modal}}}{1000 \text{ g/kg}} * \text{MidpointCF}_{\text{Viscose},10\mu\text{m}} \\
 &= \frac{0.004 \text{ g fibre fragment emitted/use}}{1000 \text{ g/kg}} * 6.96 * 10^4 \text{ PAF} * \text{m}^3 \\
 &\quad * \text{day/ kg fibre fragment emitted} = 0.266 \text{ PAF} * \text{m}^3 * \frac{\text{day}}{\text{use}}
 \end{aligned}$$

Equation 11

$$\begin{aligned}
 \text{EndpointImpact}_{\text{Cotton}} &= \frac{FFLOSS_{\text{Cotton}}}{1000 \text{ g/kg}} * \text{EndpointCF}_{\text{Cotton},10\mu\text{m}} \\
 &= \frac{0.045 \text{ g fibre fragment emitted/use}}{1000 \text{ g/kg}} * 2.86 \text{ PDF} * \text{m}^2 \\
 &\quad * \text{year/ kg fibre fragment emitted} = 1.28 * 10^{-4} \text{ PDF} * \text{m}^2 * \frac{\text{year}}{\text{use}}
 \end{aligned}$$

$$\begin{aligned}
 \text{EndpointImpact}_{\text{Polyester}} &= \frac{FFLOSS_{\text{Polyester}}}{1000 \text{ g/kg}} * \text{EndpointCF}_{\text{PET},10\mu\text{m}} \\
 &= \frac{0.013 \text{ g fibre fragment emitted}}{1000 \frac{\text{g}}{\text{kg}}} * 383.80 \text{ PDF} * \text{m}^2 \\
 &* \text{year/ kg fibre fragment emitted} = 5.13 * 10^{-3} \text{ PDF} * \text{m}^2 * \frac{\text{year}}{\text{use}} \\
 \\
 \text{EndpointImpact}_{\text{RecycledPolyester}} &= \frac{FFLOSS_{\text{RecycledPolyester}}}{1000 \text{ g/kg}} * \text{EndpointCF}_{\text{PET},10\mu\text{m}} \\
 &= \frac{0.001 \text{ g fibre fragment emitted/use}}{1000 \text{ g/kg}} * 383.80 \text{ PDF} * \text{m}^2 \\
 &* \text{year/ kg fibre fragment emitted} = 4.89 * 10^{-4} \text{ PDF} * \text{m}^2 * \frac{\text{year}}{\text{use}} \\
 \\
 \text{EndpointImpact}_{\text{Viscose/Modal}} &= \frac{FFLOSS_{\text{Viscose/Modal}}}{1000 \text{ g/kg}} * \text{EndpointCF}_{\text{Viscose},10\mu\text{m}} \\
 &= \frac{0.004 \text{ g fibre fragment emitted/use}}{1000 \text{ g/kg}} * 1.92 \text{ PDF} * \text{m}^2 \\
 &* \text{year/ kg fibre fragment emitted} = 7.31 * 10^{-6} \text{ PDF} * \text{m}^2 * \frac{\text{year}}{\text{use}}
 \end{aligned}$$

Equation 12

The midpoint and endpoint impacts of each material are then summed to obtain the total fibre fragment impact as per Equation 13 for the midpoint impact and Equation 14 for the endpoint impact.

$$\begin{aligned}
 \text{MidpointImpact} &= \text{MidpointImpact}_{\text{Cotton}} + \text{MidpointImpact}_{\text{Polyester}} \\
 &+ \text{MidpointImpact}_{\text{RecycledPolyester}} + \text{MidpointImpact}_{\text{Viscose/Modal}} \\
 &= 4.64 + 186.59 + 17.77 + 0.266 = 209.27 \text{ PAF} * \text{m}^3 * \text{day/use}
 \end{aligned}$$

Equation 13

*EndpointImpact*

$$\begin{aligned} &= \textit{EndpointImpact}_{\textit{Cotton}} + \textit{EndpointImpact}_{\textit{Polyester}} \\ &+ \textit{EndpointImpact}_{\textit{RecycledPolyester}} + \textit{EndpointImpact}_{\textit{Viscose/Modal}} \\ &= 1.28 * 10^{-4} + 5.13 * 10^{-3} + 4.89 * 10^{-4} + 7.31 * 10^{-6} \\ &= 5.75 * 10^{-3} \text{ PDF * m}^2 * \text{year/ use} \end{aligned}$$

Equation 14

This leads to a fibre fragment impact of 0.53 PAF\*m<sup>3</sup>\*day/use for midpoint impacts and 1.45E-05 PDF\*m<sup>2</sup>\*year/ use for endpoint impacts.

This fibre fragment impact embeds a high uncertainty due to the developing nature of the underlying scientific assessment methodology.

## 7. Interpreting PEF results

### 7.1. Assessment of the robustness of the PEF study

The PEF method requires an assessment of the robustness of the PEF model consisting of completeness checks, sensitivity checks, and consistency checks.

#### 7.1.1. Completeness and consistency checks

A technical control was conducted by two Quantis experts not involved on the project on a daily basis. Their comments were all taken into account, and they've confirmed that all materials, transport, and processing steps were connected to the corresponding secondary datasets with the correct assumptions.

The review panel is also conducting a similar completeness and consistency checks.

#### 7.1.2. Sensitivity checks

The hotspot analysis methodology is described in Section 6.3 of the PEF method, and uses an 80% of cumulated impacts threshold to identify the most relevant impact categories, life cycle stages (LCS), processes and elementary flows.

The aim of the sensitivity analysis is to identify if the most relevant impact categories and the relevant life cycle stages may change according to the modification of the model completeness, modelling assumptions, the impact assessment method or the database used in the PEF-RP studies.

The sensitivity analysis has been performed by analysing the differences between version 1.2 (v1.2) and version 1.3 (v1.3) of the PEF-RP study, as well as between version v1.3, version 2.0 (v2.0) and version 2.1 (v2.1) of the PEF-RP study, as the versions changed several modelling parameters including the inventory, the database used and the impact assessment method.

Overall, considering the numerous modifications made between the different versions of the RP studies:

- Between v1.2 and v1.3, for all RPs, the most relevant impact categories remained mostly the same, with the exception of eutrophication and ecotoxicity (see Section 7.1.2.1), while they mostly remained the same for all RPs between

v1.3 and v2.0 as well as between v2.0 and v2.1 (see Sections 7.1.2.2 & 7.1.2.3). The identification of the most relevant categories can thus be considered as robust, but they are subject to change in case of significant changes in the EF database and/or impact assessment method in the future.

- The most relevant LCS are relatively stable across the four versions of the RP studies, as well as across the RPs. LCS5 is never identified as most relevant while LCS1 and LCS2 are almost always identified as such. LCS3 and LCS4 are rarely considered as most relevant. It is worth noting that in the three comparisons, the identification of the most relevant LCS is similar, and thus robust, for RP1, RP3, RP4, RP5, RP6, RP8, RP10. However, the identification of the most relevant LCS for RP1 for RP2, RP7, RP9, RP12 and RP13 were always influenced by the modifications except for the last comparison (v2.0 vs. v2.1) for which RP7 only was affected (addition of LCS 4 as a most relevant stages). Thus, considering the completeness of the model reached in v2.1, the identification of the most relevant LCS can be considered as robust, unless the EF database or of the EF impact assessment method significantly change in the future.

#### 7.1.2.1. Comparing v1.2 and v1.3 of the PEF-RP study

The modifications made between v1.2 and v1.3 of the PEF-RP studies were:

- The switch from the Quantis selection of datasets (WALDB and ecoinvent) and EF 2.0 to the EF 3.1 database; including the use of a representative dataset for the modelling of fur instead of a leather proxy;
- The use of a new version of the EF impact assessment method (v3.1 instead of v3.0).

#### **Most relevant impact categories**

Between v1.2 and v1.3, the most relevant impact categories didn't significantly change (see Table 55). Climate change, particulate matter, water use, resource use, minerals and metals as well as resource use, fossils, remain among the most relevant categories for almost all RPs. The removal or addition of impact categories concerns mainly the least contributing categories to reach the 80% of impact threshold for each RP. Since these categories were such small contributors, even a small variation in the contribution resulted in their removal or addition to the list of most relevant impact

categories. In particular, eutrophication, terrestrial and eutrophication, marine were likely to be added, while eutrophication, freshwater, ecotoxicity, freshwater and land use were mostly removed.

Table 55 - Most relevant impact categories removed or added between v1.2 and v1.3 of the PEF-RP study

Impact category	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Climate change	Same												
Ozone depletion													
Human toxicity, cancer													
Human toxicity, non-cancer											Add.		Add.
Particulate matter	Same												
Ionising radiation													
Photochemical ozone formation													
Acidification	Same												
Eutrophication, terrestrial			Add.	Add.						Add.	Same	Same	Same
Eutrophication, freshwater	Rem.	Rem.				Rem.	Rem.	Rem.					
Eutrophication, marine	Add.		Add.			Add.		Add.		Same	Add.	Add.	Add.
Ecotoxicity, freshwater	Rem.	Rem.	Add.	Add.	Rem.	Rem.	Same	Rem.	Rem.	Same	Same	Same	Rem.
Land use			Same	Rem.						Rem.		Rem.	
Water use	Same		Same										
Resource use, minerals and metals	Add.	Add.		Same	Same	Same	Same	Add.	Same			Same	Same
Resource use, fossils	Same	Same	Rem.	Same	Same	Same	Same	Same	Same	Rem.	Same	Same	Same

**Most relevant life cycle stages**

The most relevant LCS have remained mostly consistent between v1.2 and v1.3 (Table 56): LCS1 and LCS2 are almost always considered as most relevant for all RPs, while LCS5 is never most relevant. LCS3 got newly identified as most relevant between v1.2 and v1.3, but, like LCS4, it is only most relevant for a few RPs.

Table 56 - Occurrence of the most relevant LCS between v1.2 and v1.3 of the PEF-RP study

	LCS1	LCS2	LCS3	LCS4	LCS5
Occurrence among all RPs v1.2	100%	100%	0%	38%	0%
Occurrence among all RPs v1.3	100%	85%	15%	15%	0%

Table 57 details which LCS were removed or added. It is worth noticing that more LCS were removed (2 times LCS2 and 3 times LCS4) than added (2 times LCS3). These variations involved 6 RPs (RP2, RP5, RP7, RP9, RP12 and RP13).

Table 57 - Most relevant LCS in v1.2 and v1.3 of the PEF-RP study

	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
LCS In v1.2	1,2,4	1,2	1,2	1,2	1,2,4	1,2	1,2,4	1,2,4	1,2,4	1,2	1,2	1,2	1,2
LCS In v1.3	1,2,4	1,2,3	1,2	1,2	1,2	1,2	1,2	1,2,4	1,2	1,2	1,2	1	1,3
LCS Removed	-	-	-	-	4	-	4	-	4	-	-	2	2
LCS Added	-	3	-	-	-	-	-	-	-	-	-	-	3

### 7.1.2.2. Comparing v1.3 and v2.0 of the PEF-RP study

Based on the review of the supporting studies, several changes have been implemented in PEF-RP study v2.0 compared to PEF-RP study v1.3. The main changes and their influence on the results are as follows.

#### LCS1

- Addition of hangtags: no significant influence on the conclusions
- Increased granularity of animal sources for leather: increases the impact of LCS1 as goat leather is more impactful than Leather, cattle which was the only dataset considered in PEF-RP study v1.3.
- Added cellulose paper for footwear packaging: no significant influence on the conclusions
- Change of Nylon dataset: the replacement of Nylon 6.6 with the less impactful Nylon 6 dataset decreases the relative impact of the process, which leads to the emergence of new relevant processes across every life cycle stage.

#### LCS2

- Addition of intermediate product packaging: no significant influence on the conclusions
- Addition of end-of-life of manufacturing losses (processing, assembly and leftovers): increases the relative impact of LCS2 for all RPs, and landfilling of textiles becomes a relevant process for RP1.
- Addition of screen printing for fabrics for all RPs: no significant influence on the conclusions
- Addition of footwear processes (lasting, lamination, coating and waterproofing): increases the relative impact of LCS2, and lamination and coating replace assembly, insole and vulcanizing as relevant processes for footwear RPs.
- Change of synthetic fibre spinning dataset: the replacement of Extrusion and staple fibre spinning with the less impactful continuous filament spinning dataset decreases the relative impact of the process, which leads to the emergence of new relevant processes.

#### LCS3

- Remodelled LCS3 to include the new transport legs, distribution channel-specific return rates, and unsold consumer products storage, increasing the relative impact of LCS3 and leading to thermal energy being a relevant process.

#### LCS4

- Decreased washing frequency for t-shirts (RP1), sweaters (RP3) and pants and shorts (RP 5): decreases the relative impact of LCS4 for those RPs.
- Update of DoS of RP1, RP5 and RP7 (alignment which was forgotten in PEF-RP study v1.3): no significant influence on the conclusions

#### Changes across several life cycle stages:

- Refinement of unsold consumer products production and addition of unsold consumer products' end-of-life: increases the impacts of LCS1, LCS2, LCS3 and LCS5, thereby decreasing the relative impact of LCS4 for all RPs. Unsold consumer products were only partially included previously (only inventory glut production).
- Alignment with CFF parameters for packaging end-of-life at LCS2, LCS3 and LCS5: no significant influence on the conclusions
- Addition of pallet reuse factor and transport: no significant influence on the conclusions

#### **Most relevant impact categories**

Between v1.3 and v2.0, the most relevant impact categories didn't significantly change (see Table 58). Climate change, particulate matter, water use, resource use, minerals and metals as well as resource use, fossils, remain among the most relevant categories for almost all RPs. Ozone depletion, human toxicity, cancer and non-cancer, eutrophication, freshwater, and land use are never or very seldomly identified as most relevant. Eutrophication, terrestrial and eutrophication, marine as well as ecotoxicity, freshwater appears in around half of the RPs in both versions of the study. The few changes concern mainly the least contributing categories to reach the 80% of impact threshold for each RP. Since these categories were such small contributors, even a small variation in the contribution resulted in their removal or addition to the list of most relevant impact categories.

Table 58 - Most relevant impact categories removed or added between v1.3 and v2.0 of the PEF-RP study

Impact category	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Climate change	Same												
Ozone depletion													
Human toxicity, cancer													
Human toxicity, non-cancer											Same		Rem.
Particulate matter	Same												
Ionising radiation													
Photochemical ozone formation													
Acidification	Same												
Eutrophication, terrestrial			Rem.	Same						Same	Same	Same	Same
Eutrophication, freshwater													
Eutrophication, marine	Same		Same	Add.		Same		Same		Same	Same	Same	Same
Ecotoxicity, freshwater			Same	Same			Same			Same	Same	Same	Add.
Land use			Same										
Water use	Same	Add.	Same		Add.								
Resource use, minerals and metals	Same	Same		Rem.	Same	Same	Same	Same	Same			Rem.	Same
Resource use, fossils	Same	Same		Same	Same	Same	Same	Same	Same		Same	Same	Same

**Most relevant life cycle stages**

The most relevant LCS have remained mostly consistent between v1.3 and v2.0 (Table 59):

LCS1 and LCS2 are almost always considered as most relevant for all RPs, while LCS5 is never most relevant. LCS3 disappeared as a most relevant LCS between v1.2 and v1.3 for some RPs (RP2 and RP13), and LCS4 has come back as most relevant for a few RPs (RP7 and RP9).

Table 59 - Occurrence of the most relevant LCS between v1.3 and v2.0 of the PEF-RP study

	LCS1	LCS2	LCS3	LCS4	LCS5
Occurrence among all RPs v1.3	100%	85%	15%	15%	0%
Occurrence among all RPs v2.0	100%	100%	0%	23%	0%

Table 60 details which LCS were removed or added.

Table 60 – Most relevant LCS in v1.3 and v2.0 of the PEF-RP study

	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
LCS In v1.3	1,2,4	1,2,3	1,2	1,2	1,2	1,2	1,2	1,2,4	1,2	1,2	1,2	1	1,3
LCS In v2.0	1,2	1,2	1,2	1,2	1,2	1,2	1,2,4	1,2,4	1,2,4	1,2	1,2	1,2	1,2
LCS Removed	4	3	-	-	-	-	-	-	-	-	-	-	3
LCS Added	-	-	-	-	-	-	4	-	4	-	-	2	2

### 7.1.2.3. Comparing v2.0 and v2.1 of the PEF-RP study

Based on the comments of the second public consultation, several changes have been implemented in PEF-RP study v2.1 compared to PEF-RP study v2.0. The main changes and their influence on the results are as follows.

#### LCS1

- Updated relevant trims for each RP:
  - Apparel: replacement of zipper tape & puller, metal by zipper tape & puller, plastic (as a proxy for other trims) for the RPs that would most likely not have a metal zipper (RP1, RP2, RP3, RP6, RP7, RP8, RP9). As zipper tape & puller has a high environmental impact, its replacement leads to the emergence of other relevant processes.
  - Footwear: the relevant trims for each RP were updated to:
    - RP11: shoe eyelet metal. Resource use, minerals & metals becomes a relevant indicator, which leads to the emergence of new relevant processes such as polyester. Shoe eyelet metal becomes a relevant process and replaces other relevant processes.
    - RP12: shoe eyelet metal, shoe eyelet plastic, shoe lace. The addition of shoe eyelet leads to the replacement of the water use indicator with resource use, minerals & metals, which affects some relevant processes.
    - RP13: zipper tape & puller metal, shoe eyelet metal, shoe eyelet plastic, shoe lace. Shoe eyelet metal becomes a relevant process and replaces other relevant processes.
- Addition of paper bag for primary packaging: no significant influence on the conclusions
- Addition of virgin input for CFF-compliant recycled polyester and recycled polyamide: no significant influence on the conclusions

#### LCS2

- Addition of delasting for footwear RPs: no significant influence on the conclusions

- Addition of pre-dye treatment: this becomes a relevant process
- Increased granularity of dyeing processes: addition of dyeing, reactive and dyeing, disperse to the initial dyeing process (dyeing, acid). This decreases the impact of dyeing overall as reactive and disperse dyeing are less impactful than acid dyeing and the impacts are split across several dyeing processes. This leads to the emergence of other relevant processes.
- Increased granularity of sole production process: addition of injection molding. Injection molding becomes a relevant process.

### LCS3

- Addition of truck transport and train transport for 3a: this decreases the impact of distribution as the share of cargo plane decreases, which leads to the emergence of new relevant processes.
- Addition of F2C returns: this leads to an increase in unsold consumer goods, increasing the raw materials & manufacturing impacts compared to others such as packaging and leads to the emergence and disappearance of several relevant processes.
- Addition of conversion from medium to low voltage for storage: no significant influence on the conclusions
- Replacement of residual mix with European consumption mix for storage: no significant influence on the conclusions
- Adapted the utilization ratios for van transport (lorry <7.5t EURO 3) from the default one (64%) to the utilization ratio from the PEF method (20%) using a linear correlation between impact and utilization ratio: no significant influence on the conclusions

### LCS4

- Removed washing as footwear care for RP12 and RP13, as they are considered to contain more than 5% genuine leather

### Changes across several life cycle stages:

- Addition of F2C returns: this leads to an increase in unsold consumer goods, increasing the impacts of LCS1, LCS2 and LCS3 and LCS5, thereby decreasing the relative impact of LCS4 and LCS5 for all RPs and leads to the emergence and disappearance of several relevant processes.

## **Most relevant impact categories**

Between v2.0 and v2.1, the most relevant impact categories didn't significantly change (see Table 64). Climate change, particulate matter, water use, resource use, minerals and metals as well as resource use, fossils, remain among the most relevant categories for almost all RPs. Ozone depletion, human toxicity, cancer and non-cancer, eutrophication, freshwater, and land use are never or very seldomly identified as most relevant. Eutrophication, terrestrial and eutrophication, marine as well as ecotoxicity, freshwater appear in around half of the RPs in both versions of the study. The few changes concern mainly the least contributing categories to reach the 80% of impact threshold for each RP. Since these categories were such small contributors, even a small variation in the contribution resulted in their removal or addition to the list of most relevant impact categories.

Table 61 - Most relevant impact categories removed or added between v2.0 and v2.1 of the PEF-RP study

Impact category	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Climate change	Same												
Ozone depletion													
Human toxicity, cancer													
Human toxicity, non-cancer											Rem.		
Particulate matter	Same												
Ionising radiation													
Photochemical ozone formation													
Acidification	Same												
Eutrophication, terrestrial			Add.	Same						Same	Same	Same	Same
Eutrophication, freshwater													
Eutrophication, marine	Same		Same	Same		Same		Same		Same	Same	Same	Same
Ecotoxicity, freshwater			Same	Same			Same			Same	Same	Same	Same
Land use			Same										
Water use	Same		Rem.										
Resource use, minerals and metals	Same	Same			Same	Same	Same	Same	Same		Add.	Add.	Same
Resource use, fossils	Same	Same		Same	Same	Same	Same	Same	Same		Same	Same	Same

**Most relevant life cycle stages**

The most relevant LCS have remained mostly consistent between v2.0 and v2.1 (Table 65).

LCS1 and LCS2 are always considered as most relevant for all RPs, while LCS3 and LCS 5 are never most relevant. In addition to RP8 and RP9, LCS4 is most relevant in RP7 as well in v2.1.

Table 62 - Occurrence of the most relevant LCS between v2.0 and v2.1 of the PEF-RP study

	LCS1	LCS2	LCS3	LCS4	LCS5
Occurrence among all RPs v2.0	100%	100%	0%	15%	0%
Occurrence among all RPs v2.1	100%	100%	0%	23%	0%

Table 66 details which LCS were removed or added.

Table 63 – Most relevant LCS in v2.0 and v2.1 of the PEF-RP study

	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
LCS In v2.0	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2,4	1,2,4	1,2	1,2	1,2	1,2
LCS In v2.1	1,2	1,2	1,2	1,2	1,2	1,2	1,2,4	1,2,4	1,2,4	1,2	1,2	1,2	1,2
LCS Removed	-	-	-	-	-	-	4	-	-	-	-	-	-
LCS Added	-	-	-	-	-	-	-	-	-	-	-	-	-

#### 7.1.2.4. Comparing v2.1 and v3.0 of the PEF-RP study

One correction has been implemented in PEF-RP study v3.0 compared to PEF-RP study v2.1. The main changes and their influence on the results are as follows.

LCS4

- Corrected shares of washing temperatures per RP to correspond to the “all materials” category in Table 39 of PEFCR v3.0. This leads to the following changes:
  - RP1: Disperse dyeing, pre-treatment and plane transport for raw materials are no longer relevant processes
  - RP6: Washing 40°C replaces Washing 30°C as a relevant process
  - RP7: Disperse dyeing is no longer a relevant process
  - RP8: Washing 40°C is no longer a relevant process

For all RPs, this correction does not lead to a change in the most relevant impact categories and life cycle stages compared to PEF-RP study v2.1.

#### 7.1.2.5. Comparing v3.0 and v3.1 of the PEF-RP study

Two minor corrections have been implemented in PEF-RP study v3.1 compared to PEF-RP study v3.0. The main changes and their influence on the results are as follows.

LCS1

- Cardboard was not accounted for in PEF-RP study v3.0 due to a change in names, this has been corrected.

Changes across several life cycle stages:

- Corrected the distribution losses applied in the model. The total manufactured products decrease from 119.9% to 117.4%.

For all RPs, this correction does not lead to a change in the most relevant impact categories and life cycle stages compared to PEF-RP study v3.0.

## 7.2. Most relevant impact categories

The contribution of different impact categories based on normalised and weighted results for all 13 representative products are shown in Table 64. For each representative product, the most relevant impact categories were identified as the ones that cumulatively contribute to at least 80% to the total environmental impact. The most relevant impact categories for each representative product are highlighted in bold and grey underlined in the table and the total cumulative contribution of the most relevant impact categories are reported in the final row of the table.

Table 64 - Most relevant impact categories including the relative contributions per RP

Impact category	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Climate change	<b>19%</b>	<b>21%</b>	<b>16%</b>	<b>18%</b>	<b>21%</b>	<b>20%</b>	<b>22%</b>	<b>21%</b>	<b>25%</b>	<b>16%</b>	<b>20%</b>	<b>19%</b>	<b>19%</b>
Ozone depletion	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Human toxicity, cancer	1%	1%	0%	1%	1%	1%	1%	1%	2%	1%	2%	1%	2%
Human toxicity, non-cancer	2%	1%	1%	1%	1%	1%	1%	2%	1%	1%	4%	3%	4%
Particulate matter	<b>17%</b>	<b>19%</b>	<b>15%</b>	<b>17%</b>	<b>19%</b>	<b>18%</b>	<b>19%</b>	<b>17%</b>	<b>19%</b>	<b>17%</b>	<b>16%</b>	<b>17%</b>	<b>16%</b>
Ionising radiation	1%	1%	0%	0%	1%	1%	1%	1%	1%	0%	0%	0%	0%
Photochemical ozone formation	3%	3%	2%	2%	3%	3%	3%	3%	4%	2%	4%	3%	4%
Acidification	<b>6%</b>	<b>6%</b>	<b>11%</b>	<b>10%</b>	<b>6%</b>	<b>7%</b>	<b>8%</b>	<b>6%</b>	<b>7%</b>	<b>13%</b>	<b>10%</b>	<b>10%</b>	<b>10%</b>
Eutrophication, terrestrial	3%	3%	<b>8%</b>	<b>7%</b>	3%	4%	4%	3%	3%	<b>9%</b>	<b>7%</b>	<b>7%</b>	<b>7%</b>
Eutrophication, freshwater	3%	2%	2%	2%	2%	2%	2%	3%	1%	2%	1%	1%	1%
Eutrophication, marine	<b>4%</b>	3%	<b>9%</b>	<b>7%</b>	3%	<b>4%</b>	4%	<b>3%</b>	3%	<b>8%</b>	<b>5%</b>	<b>6%</b>	<b>5%</b>
Ecotoxicity, freshwater	3%	3%	<b>12%</b>	<b>9%</b>	3%	4%	<b>5%</b>	3%	3%	<b>10%</b>	<b>8%</b>	<b>9%</b>	<b>8%</b>
Land use	2%	2%	<b>9%</b>	5%	2%	2%	2%	2%	1%	4%	3%	3%	3%
Water use	<b>19%</b>	<b>15%</b>	<b>8%</b>	<b>8%</b>	<b>14%</b>	<b>14%</b>	<b>10%</b>	<b>16%</b>	<b>4%</b>	<b>8%</b>	3%	5%	3%
Resource use, minerals and metals	<b>7%</b>	<b>7%</b>	2%	6%	<b>8%</b>	<b>6%</b>	<b>6%</b>	<b>6%</b>	<b>10%</b>	3%	<b>5%</b>	<b>6%</b>	<b>7%</b>
Resource use, fossils	<b>12%</b>	<b>13%</b>	4%	<b>8%</b>	<b>13%</b>	<b>11%</b>	<b>13%</b>	<b>13%</b>	<b>18%</b>	6%	<b>11%</b>	<b>9%</b>	<b>10%</b>
Total most relevant contribution (%)	<b>83%</b>	<b>81%</b>	<b>88%</b>	<b>84%</b>	<b>80%</b>	<b>81%</b>	<b>82%</b>	<b>82%</b>	<b>83%</b>	<b>81%</b>	<b>82%</b>	<b>83%</b>	<b>83%</b>

Note: RP1. T-shirts, RP2. Shirts and blouses, RP3. Sweaters and midlayers, RP4. Jackets and coats, RP5. Pants and shorts, RP6. Dresses, skirts and jumpsuits, RP7. Leggings, stockings, tights and socks, RP8. Underwear, RP9. Swimwear, RP10. Apparel accessories, RP11. Open-toed shoes, RP12. Closed-toed shoes, RP13. Boots.

## 7.3. Most relevant life cycle stages

The most relevant life cycle stages per RP and impact category are summarized in Table 65 where

1 = LCS1 = Raw material acquisition and pre-processing;

2 = LCS2 = Manufacturing;

3 = LCS3 = Distribution (product distribution and storage);

4 = LCS4 = Use stage; and

5 = LCS5 = End of life.

Table 65 - Most relevant life cycle stages per RP and impact category

Impact category	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Climate change	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2, 4	1, 2, 4	1, 2	1, 2	1, 2	1, 2
Ozone depletion	--	--	--	--	--	--	--	--	--	--	--	--	--
Human toxicity, cancer	--	--	--	--	--	--	--	--	--	--	--	--	--
Human toxicity, non-cancer	--	--	--	--	--	--	--	--	--	--	--	--	--
Particulate matter	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1	1, 2
Ionising radiation	--	--	--	--	--	--	--	--	--	--	--	--	--
Photochemical ozone formation	--	--	--	--	--	--	--	--	--	--	--	--	--
Acidification	1, 2	1, 2	1	1	1, 2	1, 2	1, 2	1, 2, 4	1, 2, 4	1	1	1	1
Eutrophication, terrestrial	--	--	1	1	--	--	--	--	--	1	1	1	1
Eutrophication, freshwater	--	--	--	--	--	--	--	--	--	--	--	--	--
Eutrophication, marine	1, 2	--	1	1	--	1, 2	--	1, 2	--	1	1	1	1
Ecotoxicity, freshwater	--	--	1	1	--	--	1, 2	--	--	1	1	1	1
Land use	--	--	1	--	--	--	--	--	--	--	--	--	--
Water use	1, 2	1	1	1	1	1	1, 2	1	2, 4	1	--	--	--
Resource use, minerals and metals	1, 2	1, 2	--	--	1, 2	1, 2	1, 2	1, 2, 4	1, 2	--	1	1	1
Resource use, fossils	1, 2	1, 2	--	1, 2	1, 2	1, 2	1, 2	1, 2, 4	1, 2	--	1, 2	1, 2	1, 2

Note: RP1. T-shirts, RP2. Shirts and blouses, RP3. Sweaters and midlayers, RP4. Jackets and coats, RP5. Pants and shorts, RP6. Dresses, skirts and jumpsuits, RP7. Leggings, stockings, tights and socks, RP8. Underwear, RP9. Swimwear, RP10. Apparel accessories, RP11. Open-toed shoes, RP12. Closed-toed shoes, RP13. Boots.

1: LCS1. Raw materials extraction and pre-processing, 2: LCS2. Manufacturing, 3: LCS3. Distribution, 4: LCS4. Use, 5: LCS5. End of life.

The contribution of each life cycle stage based on characterised results for each representative product (RP) for the most relevant impact categories identified per RP (in Table 64) are shown in Table 66 through Table 78. The most relevant life cycle stages were identified as the ones that cumulatively contribute to at least 80%. The most relevant impact categories are highlighted in each table below and the total cumulative contributions are reported in the last column of each table. The numbers in parenthesis in Table 66 to Table 78 represent absolute values for negative impact scores coming from the CFF credits. Differences due to rounding between the sums of the LCS contributions and the total can occur in these tables.

Table 66 - Relative contribution of each life cycle stage for the most relevant impact categories for t-shirts (RP1)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	27%	55%	8%	10%	0%	82%
<b>Particulate matter</b>	30%	63%	2%	4%	0%	94%
<b>Acidification</b>	41%	48%	6%	5%	0%	89%
<b>Eutrophication, marine</b>	73%	17%	5%	5%	0%	90%
<b>Water use</b>	89%	10%	0%	2%	0%	89%
<b>Resource use, minerals and metals</b>	55%	26%	0%	21%	(1%)	80%
<b>Resource use, fossils</b>	24%	59%	8%	11%	(2%)	82%

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 67 - Relative contribution of each life cycle stage for the most relevant impact categories for shirts and blouses (RP2)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	22%	62%	8%	8%	1%	83%
<b>Particulate matter</b>	23%	72%	2%	3%	0%	95%
<b>Acidification</b>	33%	57%	6%	5%	0%	90%
<b>Water use</b>	85%	13%	0%	2%	(1%)	85%
<b>Resource use, minerals and metals</b>	59%	28%	0%	14%	(1%)	87%
<b>Resource use, fossils</b>	20%	65%	9%	8%	(1%)	84%

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 68 - Relative contribution of each life cycle stage for the most relevant impact categories for sweaters and midlayers (RP3)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>76%</b>	<b>19%</b>	2%	2%	0%	<b>95%</b>
<b>Particulate matter</b>	<b>78%</b>	<b>20%</b>	1%	1%	0%	<b>99%</b>
<b>Acidification</b>	<b>92%</b>	7%	1%	1%	0%	<b>92%</b>
<b>Eutrophication, terrestrial</b>	<b>96%</b>	3%	1%	0%	0%	<b>96%</b>
<b>Eutrophication, marine</b>	<b>97%</b>	2%	0%	0%	0%	<b>97%</b>
<b>Ecotoxicity, freshwater</b>	<b>97%</b>	2%	0%	0%	0%	<b>97%</b>
<b>Land use</b>	<b>100%</b>	0%	0%	0%	0%	<b>100%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 69 - Relative contribution of each life cycle stage for the most relevant impact categories for jackets and coats (RP4)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>55%</b>	<b>39%</b>	4%	1%	0%	<b>94%</b>
<b>Particulate matter</b>	<b>58%</b>	<b>41%</b>	1%	1%	0%	<b>99%</b>
<b>Acidification</b>	<b>82%</b>	17%	1%	0%	0%	<b>82%</b>
<b>Eutrophication, terrestrial</b>	<b>89%</b>	9%	1%	0%	0%	<b>89%</b>
<b>Eutrophication, marine</b>	<b>93%</b>	6%	1%	0%	0%	<b>93%</b>
<b>Ecotoxicity, freshwater</b>	<b>93%</b>	6%	1%	0%	0%	<b>93%</b>
<b>Water use</b>	<b>84%</b>	15%	0%	1%	(1%)	<b>84%</b>
<b>Resource use, fossils</b>	<b>35%</b>	<b>58%</b>	5%	2%	(1%)	<b>93%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 70 - Relative contribution of each life cycle stage for the most relevant impact categories for pants and shorts (RP5)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>25%</b>	<b>61%</b>	6%	8%	1%	<b>86%</b>
<b>Particulate matter</b>	<b>26%</b>	<b>69%</b>	2%	3%	0%	<b>96%</b>
<b>Acidification</b>	<b>40%</b>	<b>52%</b>	4%	4%	0%	<b>92%</b>
<b>Water use</b>	<b>84%</b>	15%	0%	2%	(1%)	<b>84%</b>
<b>Resource use, minerals and metals</b>	<b>70%</b>	<b>20%</b>	0%	10%	(1%)	<b>90%</b>
<b>Resource use, fossils</b>	<b>24%</b>	<b>63%</b>	6%	8%	(1%)	<b>87%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 71 - Relative contribution of each life cycle stage for the most relevant impact categories for dresses, skirts and jumpsuits (RP6)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>29%</b>	<b>56%</b>	7%	8%	0%	<b>84%</b>
<b>Particulate matter</b>	<b>32%</b>	<b>63%</b>	2%	3%	0%	<b>95%</b>
<b>Acidification</b>	<b>52%</b>	<b>40%</b>	4%	4%	0%	<b>92%</b>
<b>Eutrophication, marine</b>	<b>77%</b>	<b>15%</b>	3%	5%	0%	<b>92%</b>
<b>Water use</b>	<b>85%</b>	12%	0%	3%	(1%)	<b>85%</b>
<b>Resource use, minerals and metals</b>	<b>60%</b>	<b>26%</b>	0%	15%	(1%)	<b>86%</b>
<b>Resource use, fossils</b>	<b>21%</b>	<b>63%</b>	8%	9%	(1%)	<b>84%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 72 - Relative contribution of each life cycle stage for the most relevant impact categories for leggings, stockings, tights and socks (RP7)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>33%</b>	<b>50%</b>	8%	9%	1%	<b>83%</b>
<b>Particulate matter</b>	<b>37%</b>	<b>57%</b>	3%	4%	(1%)	<b>94%</b>
<b>Acidification</b>	<b>56%</b>	<b>35%</b>	5%	4%	0%	<b>91%</b>
<b>Ecotoxicity, freshwater</b>	<b>69%</b>	<b>20%</b>	5%	6%	0%	<b>89%</b>
<b>Water use</b>	<b>75%</b>	<b>20%</b>	0%	5%	(1%)	<b>96%</b>
<b>Resource use, minerals and metals</b>	<b>55%</b>	<b>25%</b>	0%	20%	(1%)	<b>81%</b>
<b>Resource use, fossils</b>	<b>29%</b>	<b>56%</b>	8%	9%	(1%)	<b>85%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 73 - Relative contribution of each life cycle stage for the most relevant impact categories for underwear (RP8)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>23%</b>	<b>46%</b>	8%	<b>22%</b>	0%	<b>91%</b>
<b>Particulate matter</b>	<b>28%</b>	<b>60%</b>	3%	10%	(1%)	<b>88%</b>
<b>Acidification</b>	<b>36%</b>	<b>44%</b>	8%	<b>13%</b>	0%	<b>93%</b>
<b>Eutrophication, marine</b>	<b>64%</b>	<b>17%</b>	6%	13%	0%	<b>81%</b>
<b>Water use</b>	<b>84%</b>	10%	0%	6%	0%	<b>84%</b>
<b>Resource use, minerals and metals</b>	<b>23%</b>	<b>26%</b>	0%	<b>52%</b>	(1%)	<b>101%</b>
<b>Resource use, fossils</b>	<b>20%</b>	<b>49%</b>	8%	<b>25%</b>	(2%)	<b>94%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 74 - Relative contribution of each life cycle stage for the most relevant impact categories for Swimwear (RP9)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>20%</b>	<b>58%</b>	9%	<b>12%</b>	2%	<b>89%</b>
<b>Particulate matter</b>	<b>18%</b>	<b>71%</b>	3%	8%	(1%)	<b>89%</b>
<b>Acidification</b>	<b>27%</b>	<b>53%</b>	8%	<b>12%</b>	(1%)	<b>92%</b>
<b>Water use</b>	14%	<b>62%</b>	0%	<b>27%</b>	(2%)	<b>89%</b>
<b>Resource use, minerals and metals</b>	<b>74%</b>	<b>19%</b>	0%	7%	(1%)	<b>93%</b>
<b>Resource use, fossils</b>	<b>26%</b>	<b>56%</b>	8%	12%	(2%)	<b>82%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 75 - Relative contribution of each life cycle stage for the most relevant impact categories for apparel accessories (RP10)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>71%</b>	<b>23%</b>	4%	1%	0%	<b>94%</b>
<b>Particulate matter</b>	<b>76%</b>	<b>22%</b>	1%	0%	0%	<b>99%</b>
<b>Acidification</b>	<b>91%</b>	7%	1%	0%	0%	<b>91%</b>
<b>Eutrophication, terrestrial</b>	<b>95%</b>	4%	1%	0%	0%	<b>95%</b>
<b>Eutrophication, marine</b>	<b>96%</b>	3%	1%	0%	0%	<b>96%</b>
<b>Ecotoxicity, freshwater</b>	<b>96%</b>	3%	1%	0%	0%	<b>96%</b>
<b>Water use</b>	<b>92%</b>	8%	0%	1%	0%	<b>92%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 76 - Relative contribution of each life cycle stage for the most relevant impact categories for open-toed shoes (RP11)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>62%</b>	<b>25%</b>	11%	0%	2%	<b>87%</b>
<b>Particulate matter</b>	<b>66%</b>	<b>31%</b>	4%	0%	0%	<b>96%</b>
<b>Acidification</b>	<b>81%</b>	14%	5%	0%	0%	<b>81%</b>
<b>Eutrophication, terrestrial</b>	<b>86%</b>	8%	5%	0%	0%	<b>86%</b>
<b>Eutrophication, marine</b>	<b>87%</b>	8%	5%	0%	0%	<b>87%</b>
<b>Ecotoxicity, freshwater</b>	<b>82%</b>	15%	3%	0%	0%	<b>82%</b>
<b>Resource use, minerals and metals</b>	<b>87%</b>	12%	0%	0%	0%	<b>87%</b>
<b>Resource use, fossils</b>	<b>58%</b>	<b>31%</b>	12%	0%	(1%)	<b>89%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 77 - Relative contribution of each life cycle stage for the most relevant impact categories for closed-toed shoes (RP12)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>78%</b>	<b>14%</b>	6%	0%	2%	<b>92%</b>
<b>Particulate matter</b>	<b>83%</b>	15%	2%	0%	0%	<b>83%</b>
<b>Acidification</b>	<b>91%</b>	7%	2%	0%	0%	<b>91%</b>
<b>Eutrophication, terrestrial</b>	<b>93%</b>	4%	3%	0%	0%	<b>93%</b>
<b>Eutrophication, marine</b>	<b>94%</b>	4%	2%	0%	0%	<b>94%</b>
<b>Ecotoxicity, freshwater</b>	<b>91%</b>	7%	1%	0%	0%	<b>91%</b>
<b>Resource use, minerals and metals</b>	<b>96%</b>	4%	0%	0%	0%	<b>96%</b>
<b>Resource use, fossils</b>	<b>75%</b>	<b>17%</b>	8%	0%	(1%)	<b>92%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

Table 78 - Relative contribution of each life cycle stage for the most relevant impact categories for boots (RP13)

Impact category	LCS1	LCS2	LCS3	LCS4	LCS5	Total most relevant (%)
<b>Climate change</b>	<b>75%</b>	<b>16%</b>	8%	0%	2%	<b>90%</b>
<b>Particulate matter</b>	<b>80%</b>	<b>18%</b>	2%	0%	0%	<b>98%</b>
<b>Acidification</b>	<b>89%</b>	8%	3%	0%	0%	<b>89%</b>
<b>Eutrophication, terrestrial</b>	<b>92%</b>	5%	3%	0%	0%	<b>92%</b>
<b>Eutrophication, marine</b>	<b>92%</b>	5%	3%	0%	0%	<b>92%</b>
<b>Ecotoxicity, freshwater</b>	<b>88%</b>	10%	2%	0%	0%	<b>88%</b>
<b>Resource use, minerals and metals</b>	<b>96%</b>	4%	0%	0%	0%	<b>96%</b>
<b>Resource use, fossils</b>	<b>73%</b>	<b>19%</b>	9%	0%	(1%)	<b>91%</b>

Note: LC1. Raw materials extraction and pre-processing, LCS2. Manufacturing, LCS3. Distribution, LCS4. Use, LCS5. End of life.

## 7.4. Most relevant processes

Note

According to the PEF method, processes that should be reported for the hotspot analysis include processes such as electricity, heat and irrigation. With this information, it is impossible to know if the electricity usage is due to spinning or finishing. Thus, in order to provide more meaningful results to the TS members at this stage, the a following additional analysis was prepared in which the most relevant processes are separated by LCS (Table 79) and separated by manufacturing processes like spinning etc. (Figure 9 to Figure 21). The full list of most relevant processes is provided in Annex I. All the results tables and figures included in this Section have been updated.

The most impacting processes across all impact categories per RP are shown in Table 79.

Table 79 - Most impacting processes per RP

Process per life cycle stage (LCS)	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
<b>LCS1: Raw material acquisition and pre-processing</b>													
Cashmere fiber {GLO}   raw   production mix   LCI result	--	--	X	X	--	--	--	--	--	--	--	--	--
Cotton fibre {GLO}   technology mix   production mix, at farm   "as is" delinted product   LCI result	X	X	X	X	X	X	X	X	--	X	--	--	--
Leather, cattle, chrome tanned (wet-blue) {GLO}   technology mix   production mix, at tannery   m2   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Leather, veal/calf, chrome tanned (wet-blue) {GLO}   technology mix   production mix, at tannery   m2   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Leather, ovine (sheep), chrome tanned (wet- blue) {GLO}   technology mix   production mix, at tannery   m2   LCI result	--	--	--	--	X	--	--	--	--	X	X	--	X
Leather, caprine (goat), chrome tanned (wet- blue) {GLO}   technology mix   production mix, at tannery   m2   LCI result	--	--	--	--	X	--	--	--	--	X	X	X	X
Leather, swine, chrome tanned (wet-blue) {GLO}   technology mix   production mix, at tannery   m2   LCI result	--	--	--	--	--	--	--	--	--	X	--	--	--
Nylon 6, fossil fuel-based {GLO}   hydrolytic polymerisation of caprolactam   production mix, at plant   petrochemical based   LCI result	--	--	--	X	X	--	X	X	X	--	--	--	--
PET granulates, bottle grade {EU+EFTA+UK}   via purified terephthalic acid (PTA) and ethylene glycol   production mix, at plant   192.17 g/mol per repeating unit   LCI result	X	X	--	X	X	X	X	X	X	--	X	X	X
Silk {GLO}   drying, immersion, brushing, reeling   production mix, at plant   1 kg   LCI result	--	--	--	--	--	--	--	--	--	X	--	--	--
Wool {GLO}   sheep   production mix, at farm   1 kg wool   LCI result	--	--	X	X	--	X	X	--	--	X	--	X	--

Process per life cycle stage (LCS)	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Dressed mink fur, farmed, global origin except china {GLO}   technology mix   production mix, at plant   1kg   LCI result	--	--	--	X	--	--	--	--	--	--	--	--	--
Acrylic fiber {GLO}   polymerisation of acrylonitrile with the ethyl acetate, spinning, post-spinning treatment   production mix, at plant   petrochemical based   LCI result	--	--	--	X	--	--	X	--	--	X	--	--	--
Styrene-butadiene rubber (SBR) fiber {EU+EFTA+UK}   Emulsion polymerization of styrene and butadiene   production mix, at plant   23.5 % styrene   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Ethylene vinyl acetate copolymer {GLO}   Technology mix   Production mix, at plant   LCI result	--	--	--	--	--	--	--	--	--	--	X	--	--
Thermoplastic polyurethane (TPU) {GLO}   reaction of diisocyanates (hard segment) with diols (soft segment)   production mix, at plant   petrochemical based   LCI result	--	--	--	--	--	--	--	--	--	--	--	--	X
Viscose fibre {GLO}   virgin production from hardwood sulphite pulp   production mix, at plant   1kg of product   LCI result	--	--	--	X	--	--	X	--	--	--	--	--	--
Elastane fibre / spandex {GLO}   dry spinning, extrusion, texturising   production mix, at plant   1kg of product   LCI result	--	--	--	--	--	--	X	--	X	--	X	X	X
Latex production {GLO}   technology mix   production mix, at plant   100% active substance   LCI result	--	--	--	--	--	--	--	--	--	--	X	--	--
Zipper tape and puller, metal {GLO}   production, at plant   1kg of product, brass zipper   LCI result	--	--	--	--	X	--	--	--	--	--	--	--	X
Stainless steel hot rolled {RoW}   hot rolling   production mix, at plant   stainless steel   LCI result	--	--	--	--	--	--	--	--	--	--	--	--	X
Shoe eyelet, metal {GLO}   production, at plant   1kg of product, brass based   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Plastic bag, LDPE {EU+EFTA+UK}   raw material production, plastic extrusion   production mix, at plant   thickness: 0.03 mm, grammage: 0.0275 kg/m2   LCI result	X	--	--	--	--	--	X	X	--	--	--	--	--
Cardboard, production mix, at plant {GLO}   Kraft Pulping Process   production mix, at plant   180- 300 kg/m3   LCI result	--	--	--	--	--	--	--	X	--	--	X	--	--
Cargo plane {GLO}   technology mix, kerosene driven, cargo   consumption mix, to consumer   65 t payload   LCI result	X	X	--	--	X	--	--	--	--	--	--	--	--

Process per life cycle stage (LCS)	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Transoceanic ship, containers {GLO}   heavy fuel oil driven, cargo   consumption mix, to consumer   27.500 dwt payload capacity, ocean going   LCI result	--	X	--	--	X	--	--	--	--	--	--	--	--
LCS2: Manufacturing													
Spinning, for knit, ring-spun {GLO}   spinning process   production mix   service of spinning 1kg of yarn (raw material excluded)   LCI result	X	X	X	--	X	X	X	X	--	--	--	--	--
Spinning, for woven, ring-spun {GLO}   spinning process   production mix   service of spinning 1kg of yarn (raw material excluded)   LCI result	--	X	--	X	X	X	--	X	--	X	--	X	--
Spinning, continuous filament (dry) {GLO}   spinning process   production mix   service of spinning 1kg of yarn (raw material excluded)   LCI result	--	--	--	X	X	--	X	--	X	--	--	X	--
Knitting, circular {GLO}   knitting process   production, at plant   service of knitting fabric   LCI result	X	X	X	X	X	X	X	X	X	X	--	--	--
Knitting, flat {GLO}   knitting process   production, at plant   service of knitting fabric   LCI result	--	--	X	--	--	--	--	--	--	X	--	--	--
Weaving (different fabric counts) {GLO}   service, Fabric, Weaved, Mix of different counts   production mix, at plant   service, Fabric, Weaved, Mix of different counts   LCI result	--	X	--	X	X	X	--	X	X	X	X	X	X
Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO}   Pre-treatment   production mix, at plant   textile service   LCI result	X	X	--	X	X	X	X	X	X	--	--	--	--
Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO}   Dyeing   production mix, at plant   textile service for 1 kg of fabric   LCI result	--	--	--	X	X	--	X	X	X	X	--	X	--
Dyeing, batch (incl. piece, jet, jig, kier [fiber], paddle, pad-batch, yarn), direct, sulfur, vat or reactive dyes {GLO}   Dyeing   production mix, at plant   textile service for 1 kg of fabric   LCI result	X	X	--	--	X	X	X	X	--	--	--	--	--
Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO}   Dyeing   production mix, at plant   textile service for 1 kg of fabric   LCI result	X	X	--	X	X	X	X	--	X	--	--	X	--
Printing, screen {GLO}   printing service   production, at plant   service of printing, Screen on 1m2 of fabric   LCI result	--	--	--	--	--	--	--	X	--	--	--	--	--
Finishing, stain resistant/stain release {GLO}   pad dry-cure method   production mix, at plant   service   LCI result	X	X	--	X	X	X	X	X	X	X	--	X	X

Process per life cycle stage (LCS)	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Injection molding, for foam {GLO}   injection process   production mix, at plant   item(s) = pair   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Lamination, water based glue {GLO}   lamination process   average service, at plant   1 kg of water based glue laminated fabric   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Coating, water based emulsion {GLO}   Finishing   technology mix   textile service for 1 kg of fabric   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	X
Cementing/gluing {GLO}   cementing process   production mix, at plant   service of glueing 1 pair of shoes   LCI result	--	--	--	--	--	--	--	--	--	--	X	X	--
Vulcanizing {GLO}   vulcanizing, press vulcanisation- injection molding   production mix, at plant   service for 1 pair   LCI result	--	--	--	--	--	--	--	--	--	--	--	X	--
Transoceanic ship, containers {GLO}   heavy fuel oil driven, cargo   consumption mix, to consumer   27.500 dwt payload capacity, ocean going   LCI result	--	--	--	--	X	--	--	--	--	--	--	--	--
<b>LCS3: Distribution</b>													
Cargo plane {GLO}   technology mix, kerosene driven, cargo   consumption mix, to consumer   65 t payload   LCI result	X	X	--	X	X	X	X	X	X	X	X	X	X
Transoceanic ship, containers {GLO}   heavy fuel oil driven, cargo   consumption mix, to consumer   27.500 dwt payload capacity, ocean going   LCI result	X	X	--	--	X	--	--	X	X	--	X	--	--
Electricity grid mix 1kV-60kV {EU+EFTA+UK}   technology mix   consumption mix, to consumer   1kV - 60kV   LCI result	--	X	--	--	--	X	--	--	--	--	--	X	X
Thermal energy from natural gas {EU+EFTA+UK}   technology mix regarding firing and flue gas cleaning   production mix, at heat plant   MJ, 100% efficiency   LCI result	--	X	--	--	--	X	--	--	--	--	--	X	X
<b>LCS4: Use stage</b>													
Handwashing {EU+EFTA+UK}   handwashing process   production mix, at plant   service   LCI result	--	--	--	--	--	--	--	X	X	--	--	--	--
Washing, 40 degrees C, average {EU+EFTA+UK}   washing, warm water   production mix, at plant   service   LCI result	X	X	--	--	X	X	X	--	--	--	--	--	--

Process per life cycle stage (LCS)	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11	RP12	RP13
Washing, 60 degrees C, average {EU+EFTA+UK}   washing, warm water   production mix, at plant   service   LCI result	--	--	--	--	--	--	--	X	--	--	--	--	--
Washing, dry cleaning {EU+EFTA+UK}   washing process   production mix, at plant   service   LCI result	--	--	--	--	X	X	--	--	--	--	--	--	--
Tumble drying {EU+EFTA+UK}   drying, condenser tumble dryer   production mix, at plant   service   LCI result	X	--	--	--	X	X	X	X	X	--	--	--	--

Note: RP1. T-shirts, RP2. Shirts and blouses, RP 3. Sweaters and midlayers, RP4. Jackets and coats, RP5. Pants and shorts, RP6. Dresses, skirts and jumpsuits, RP7. Leggings, stockings, tights and socks, RP8. Underwear, RP9. Swimwear, RP10. Apparel accessories, RP11. Open-toed shoes, RP12. Closed-toed shoes, RP13. Boots.

The most impacting processes for the most relevant impact categories for each representative product (RP) are shown in Figure 9 through Figure 21. The results shown are based on the characterized results shown as percentages and include the processes that contribute to at least 80% of the total impacts. The remaining processes that contribute to the overall impact are grouped together in the category called “rest” to ease the readability of the figures. The full list of most relevant processes can be found in Annex I.

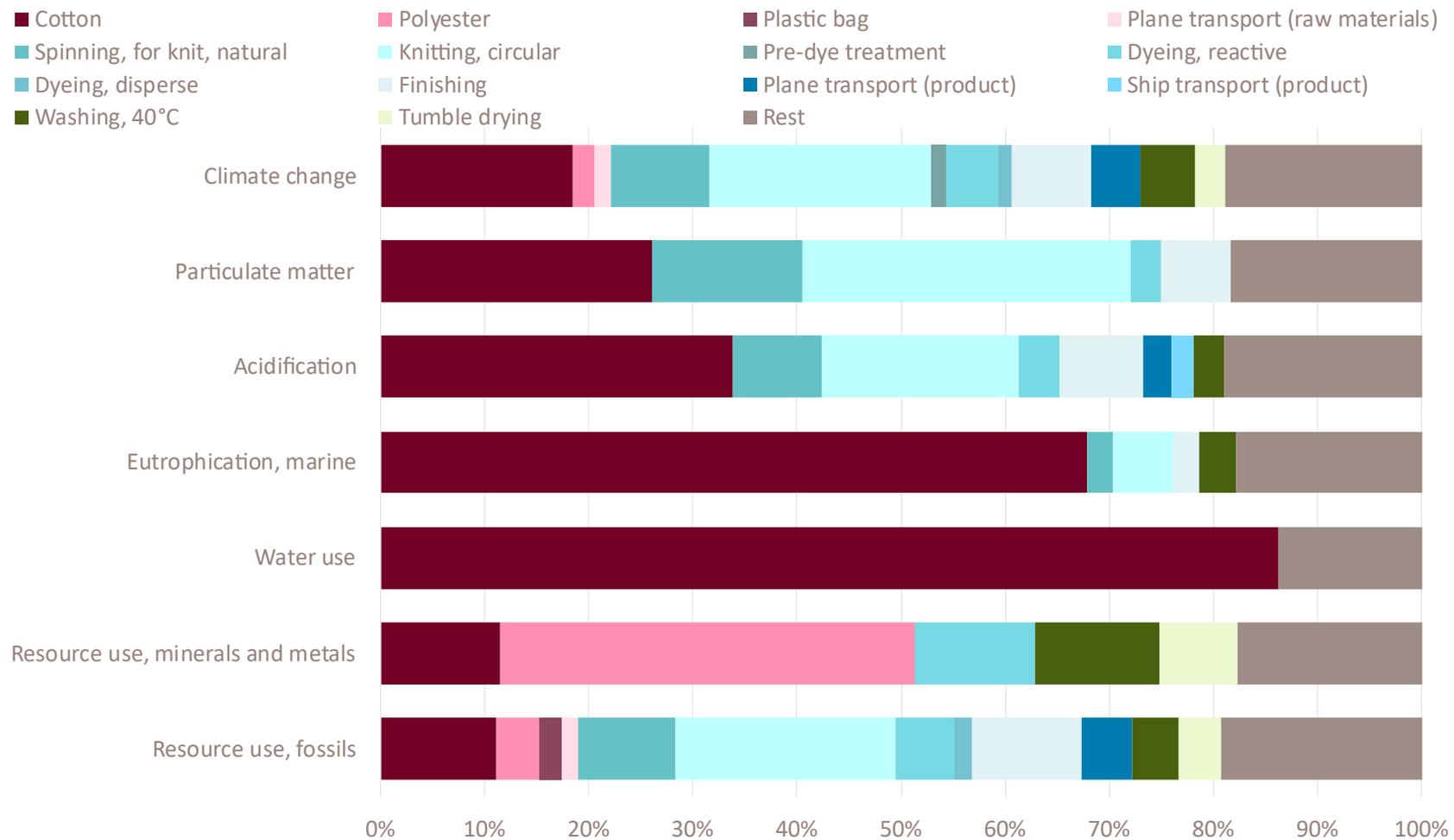


Figure 9 - Most relevant processes per most relevant impact category for t-shirts (RP1)

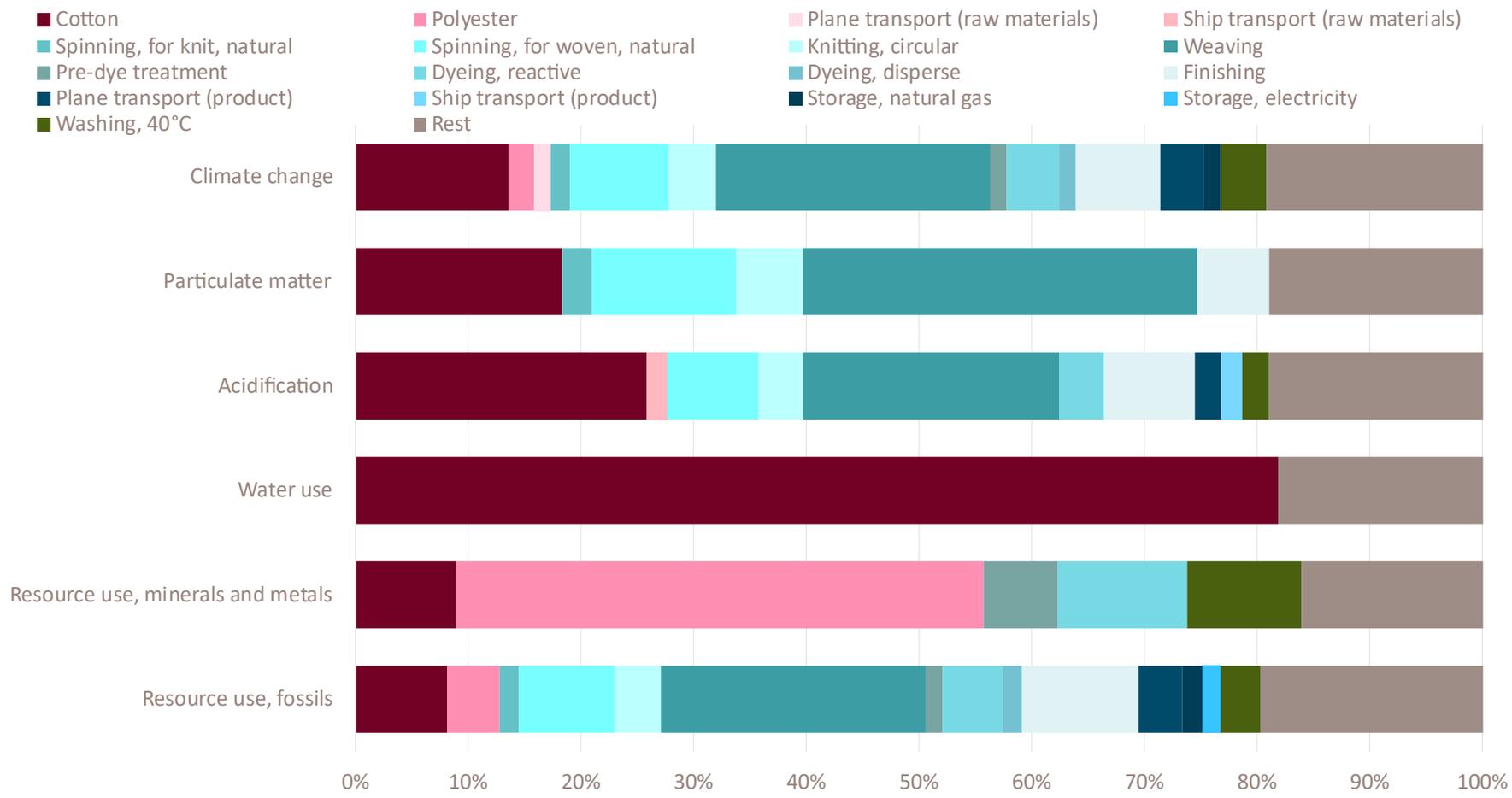


Figure 10 - Most relevant processes per most relevant impact category for shirts and blouses (RP2)

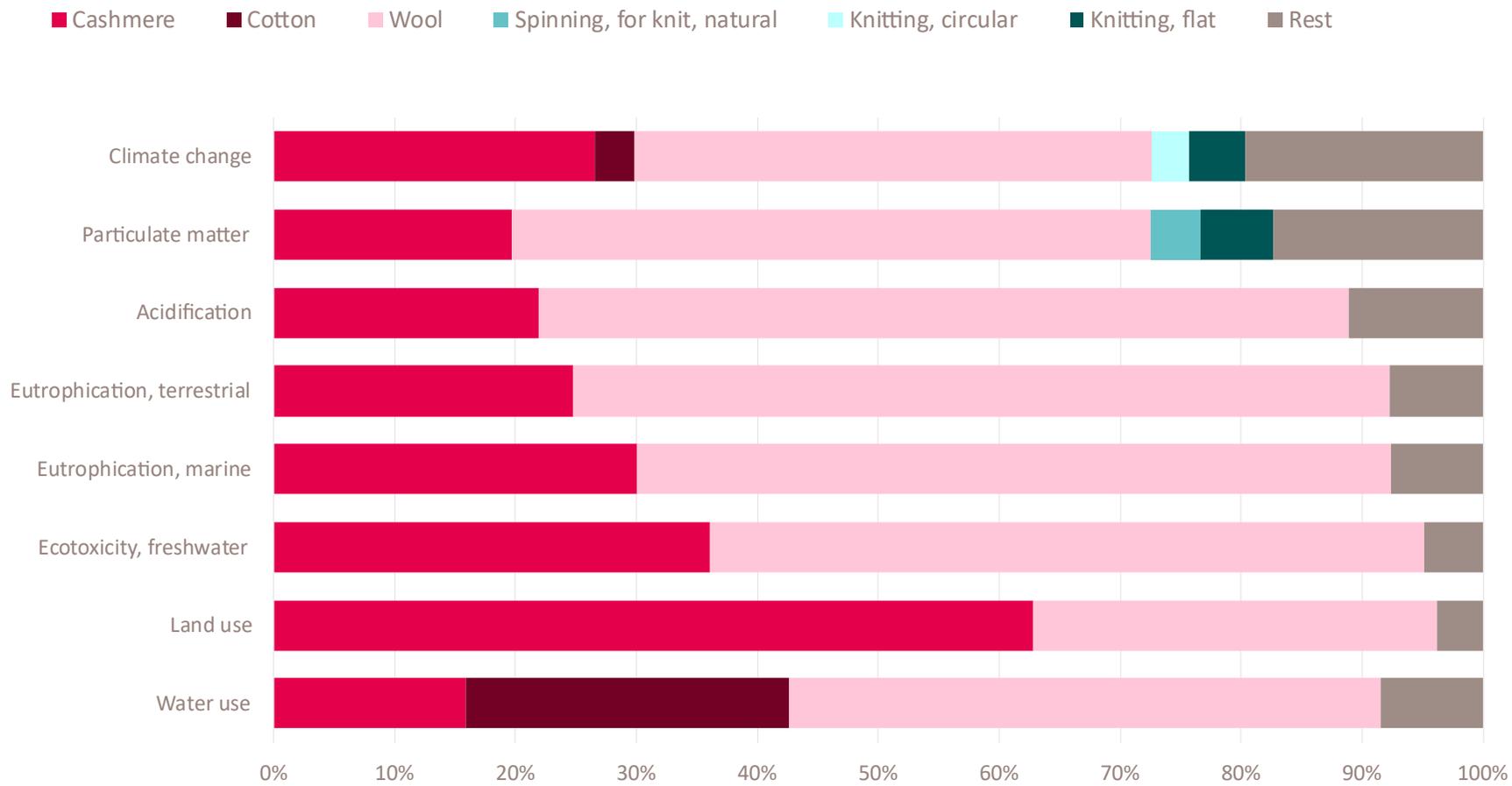


Figure 11 - Most relevant processes per most relevant impact category for sweaters and midlayers (RP3)

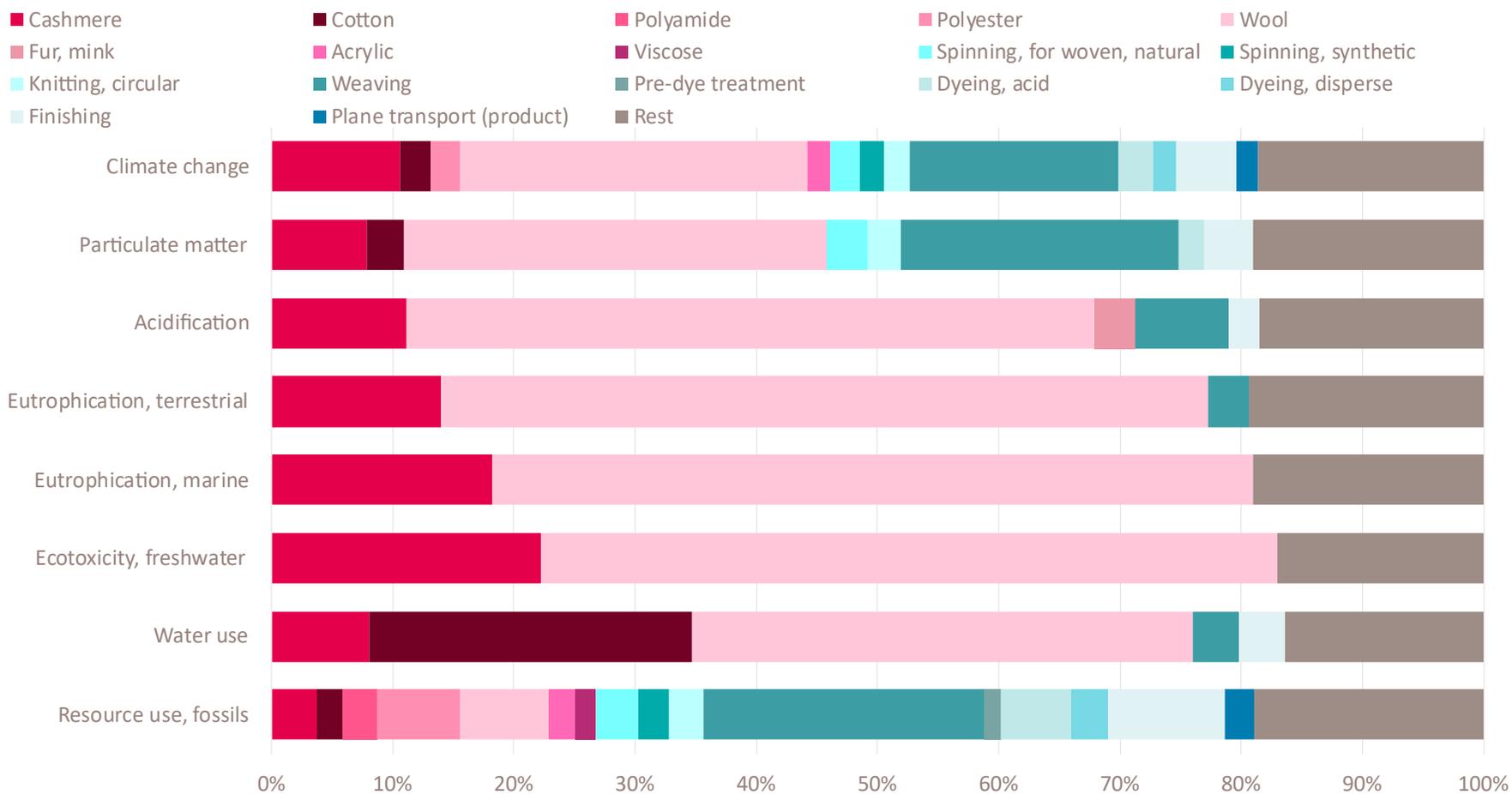


Figure 12 - Most relevant processes per most relevant impact category for jackets and coats (RP4)

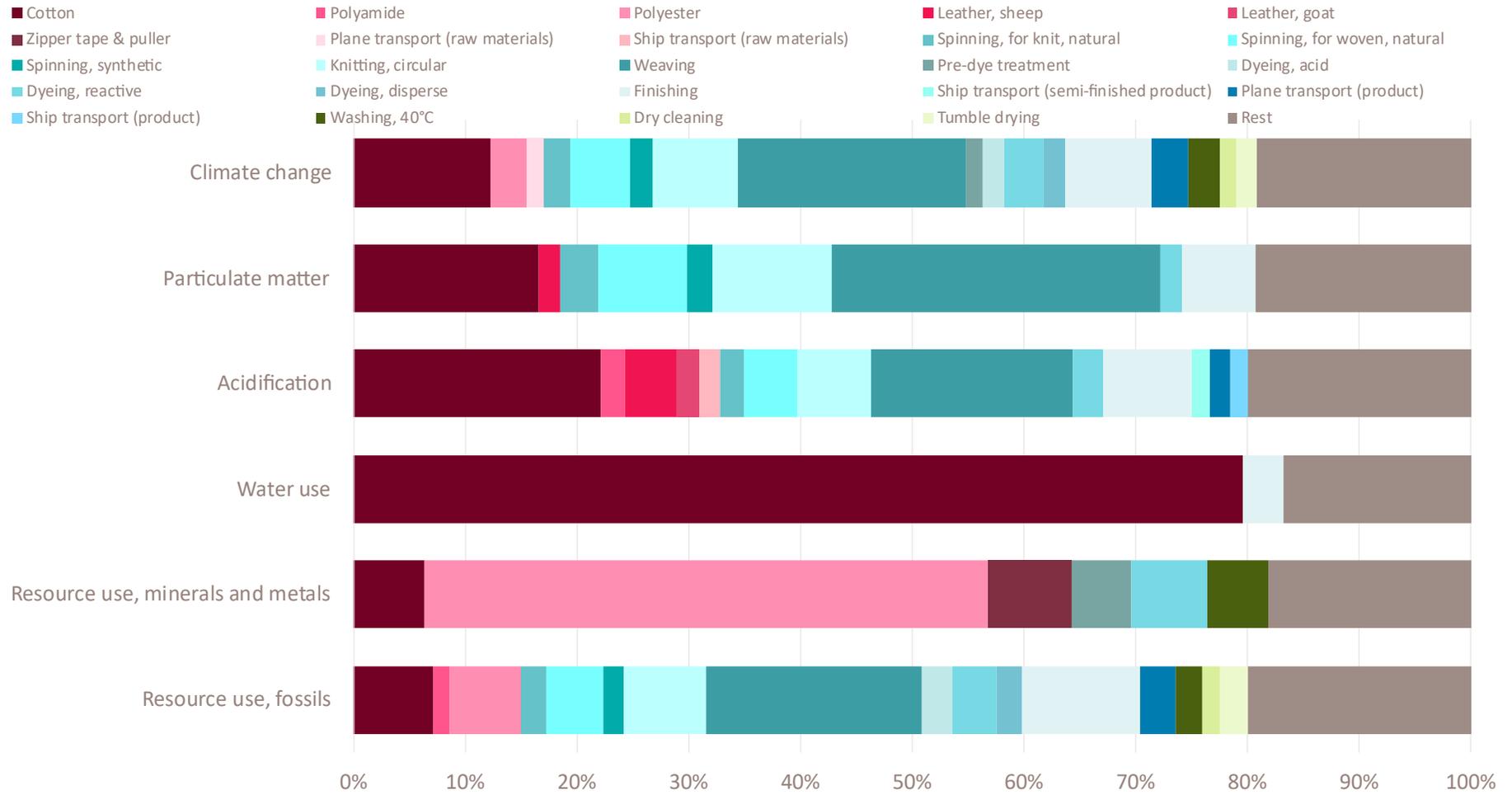


Figure 13 - Most relevant processes per most relevant impact category for pants and shorts (RP5)

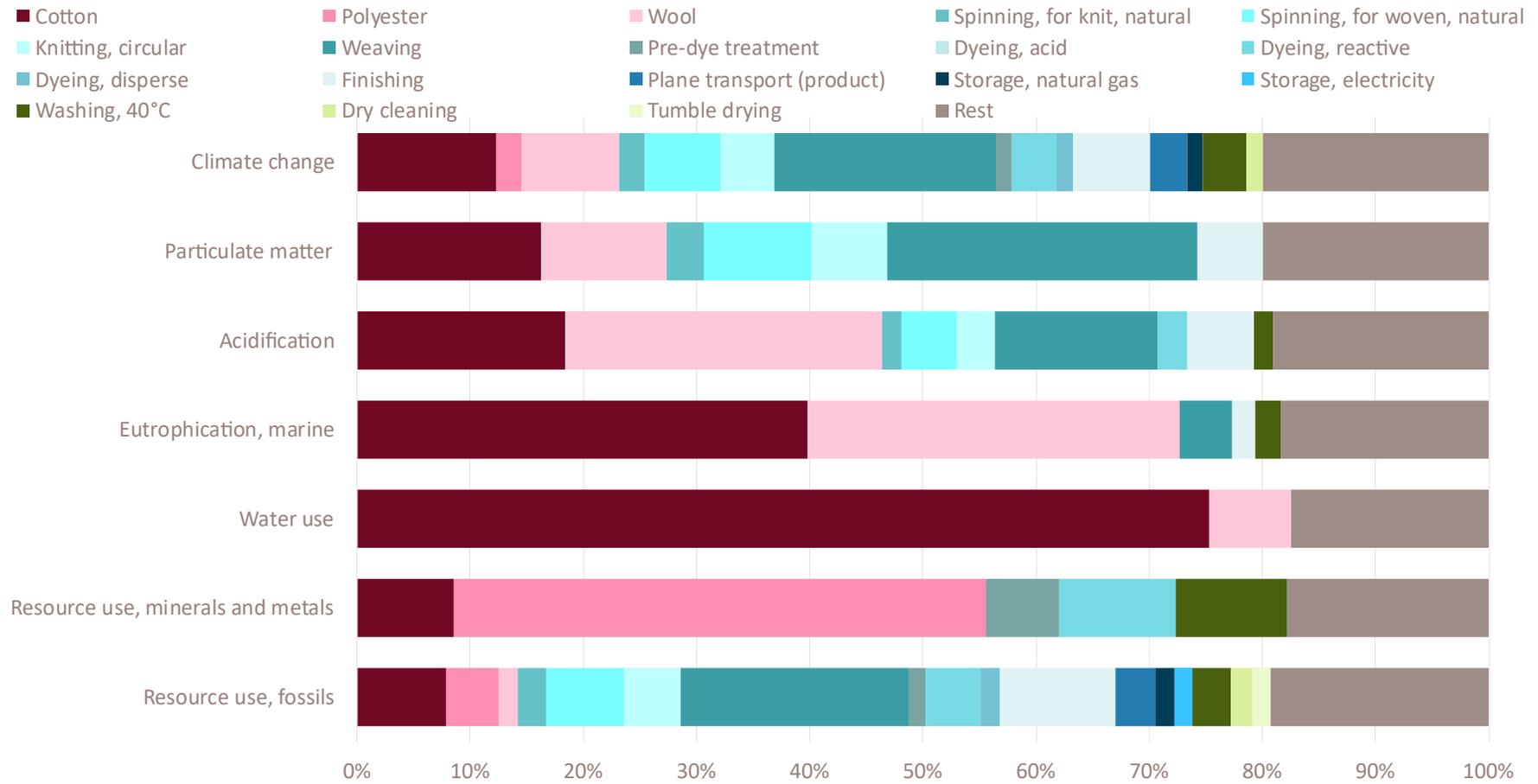


Figure 14 - Most relevant processes per most relevant impact category for dresses, skirts and jumpsuits (RP6)

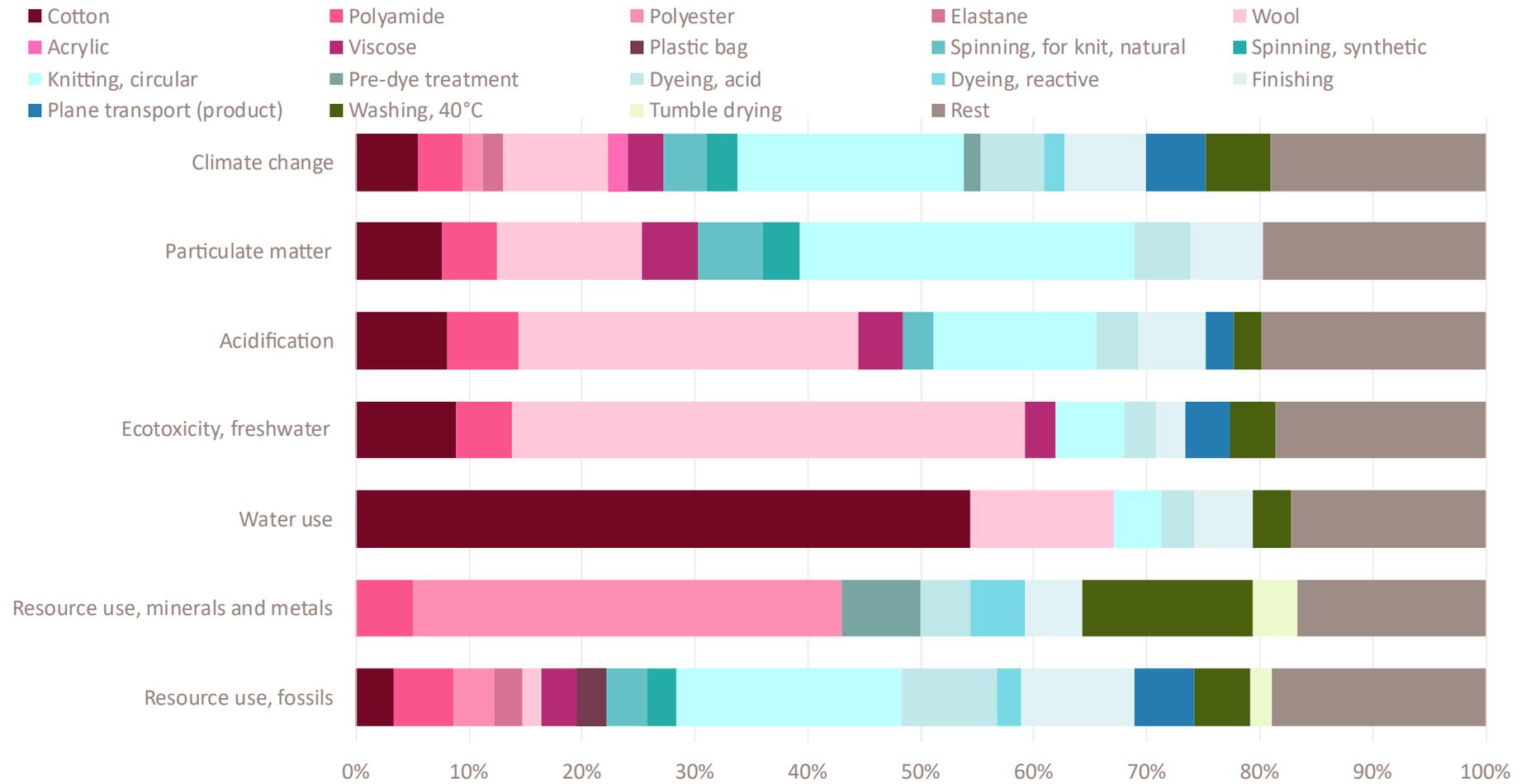


Figure 15 - Most relevant processes per most relevant impact category for leggings, stockings, tights and socks (RP7)

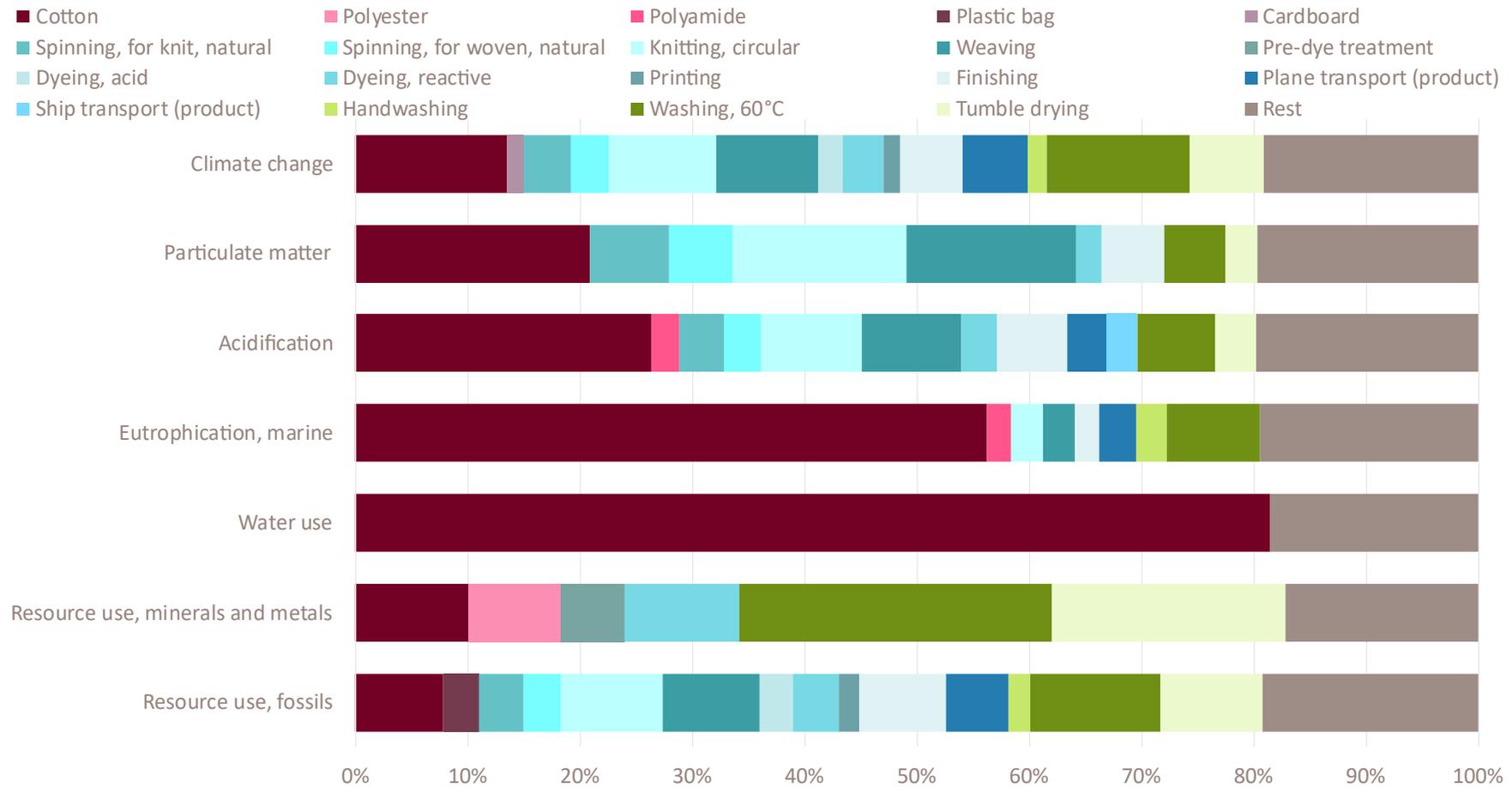


Figure 16 - Most relevant processes per most relevant impact category for underwear (RP8)

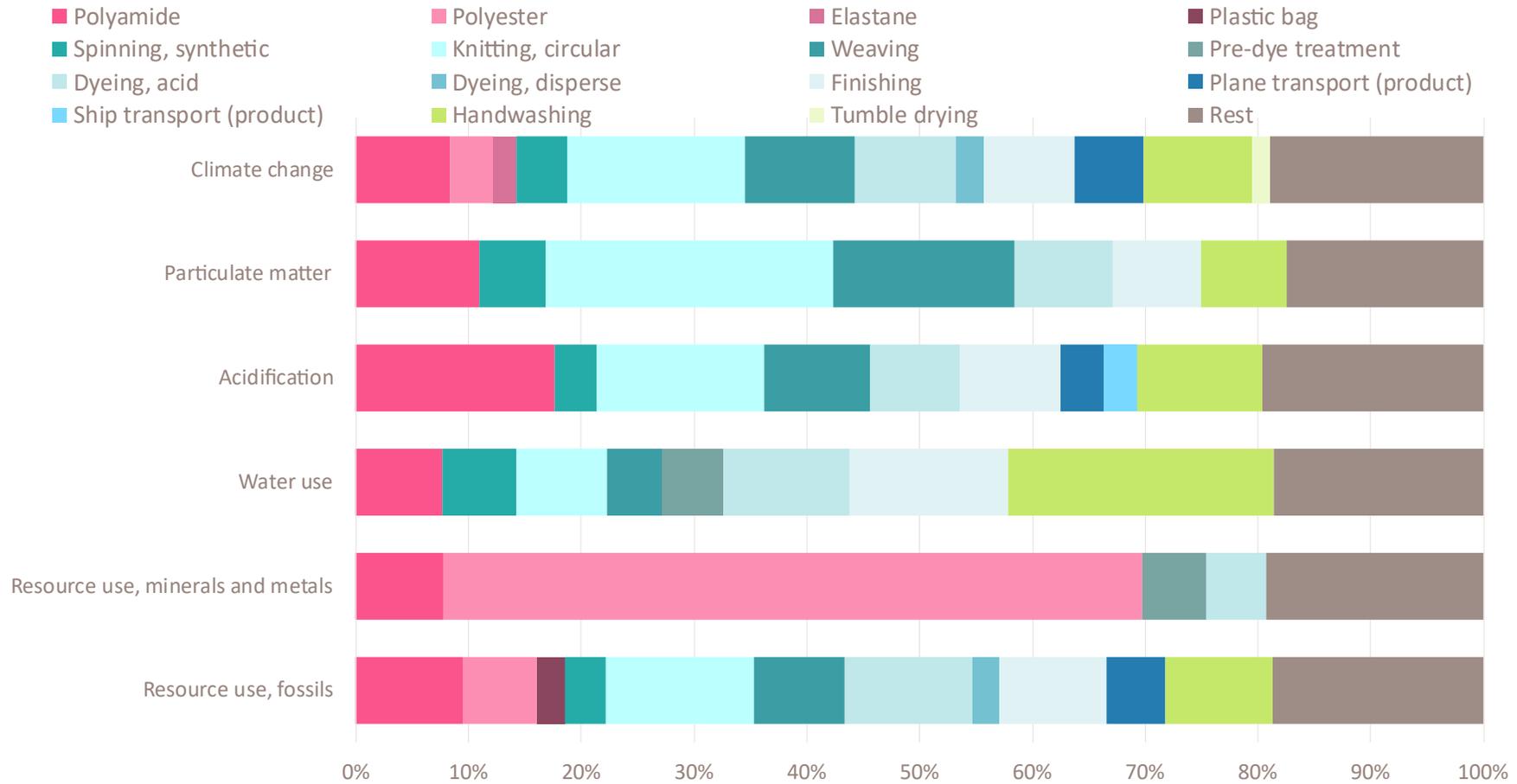


Figure 17 - Most relevant processes per most relevant impact category for Swimwear (RP9)

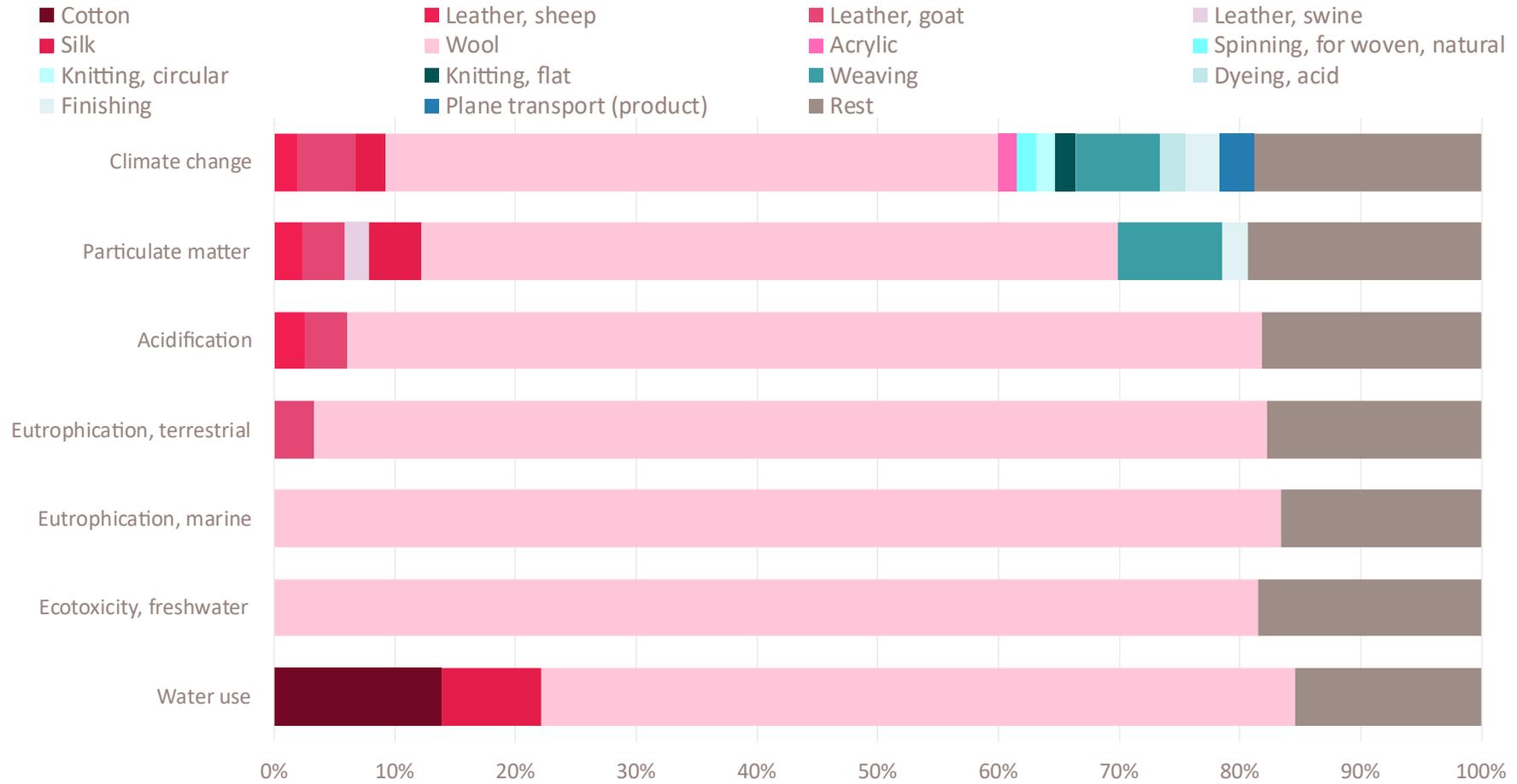


Figure 18 - Most relevant processes per most relevant impact category for apparel accessories (RP10)

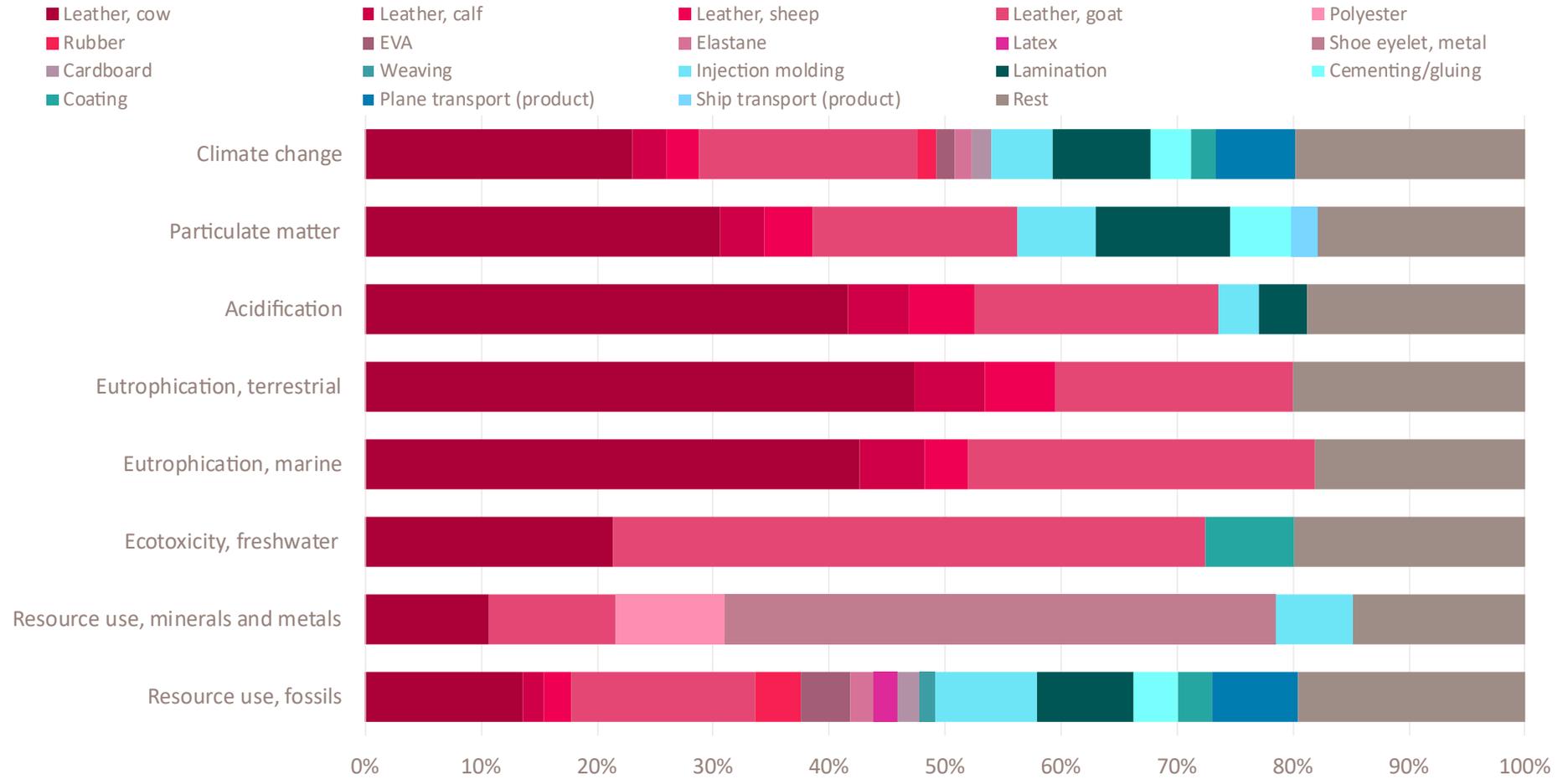


Figure 19 - Most relevant processes per most relevant impact category for open-toed shoes (RP11)

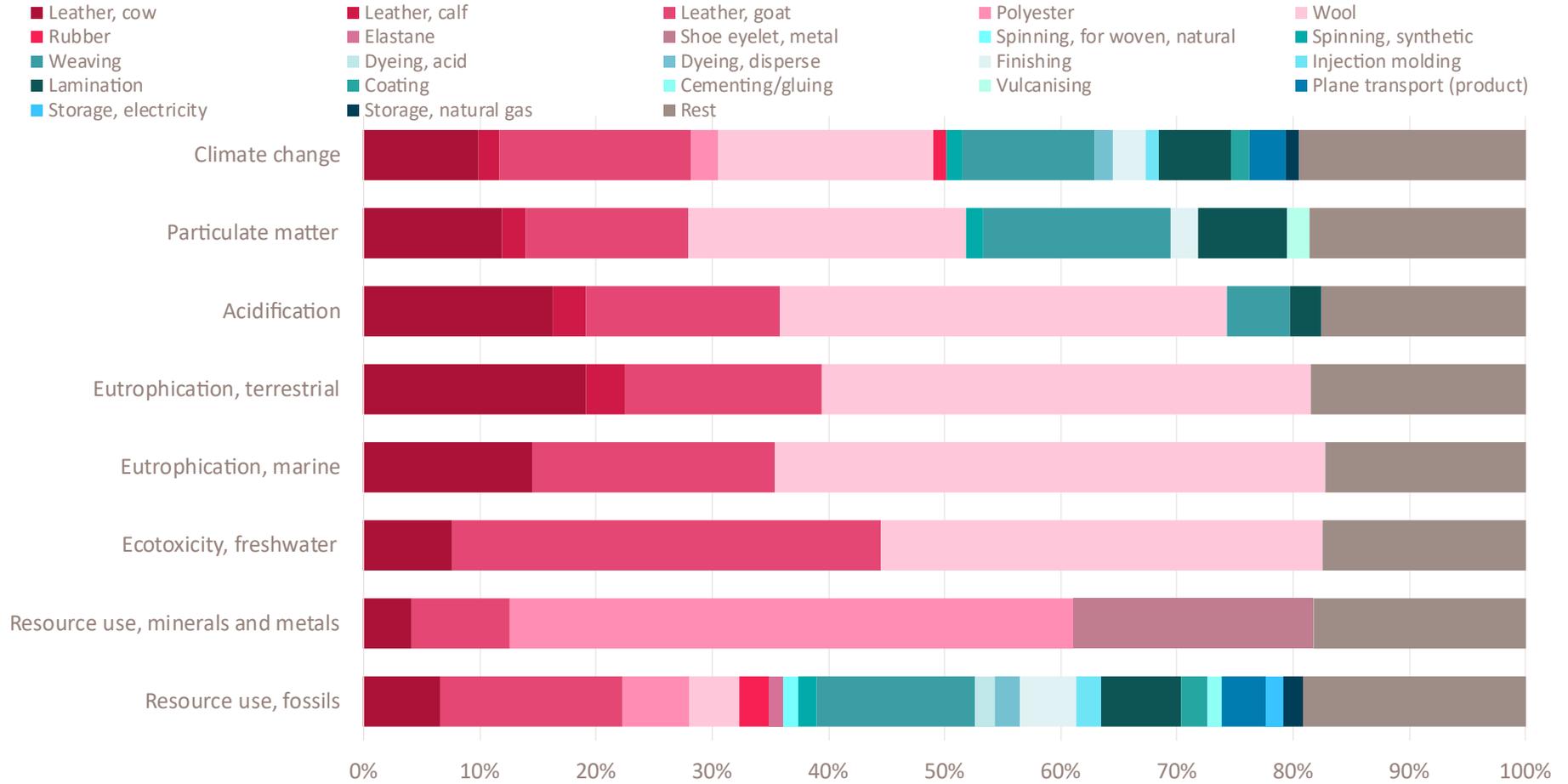


Figure 20 - Most relevant processes per most relevant impact category for closed-toed shoes (RP12)

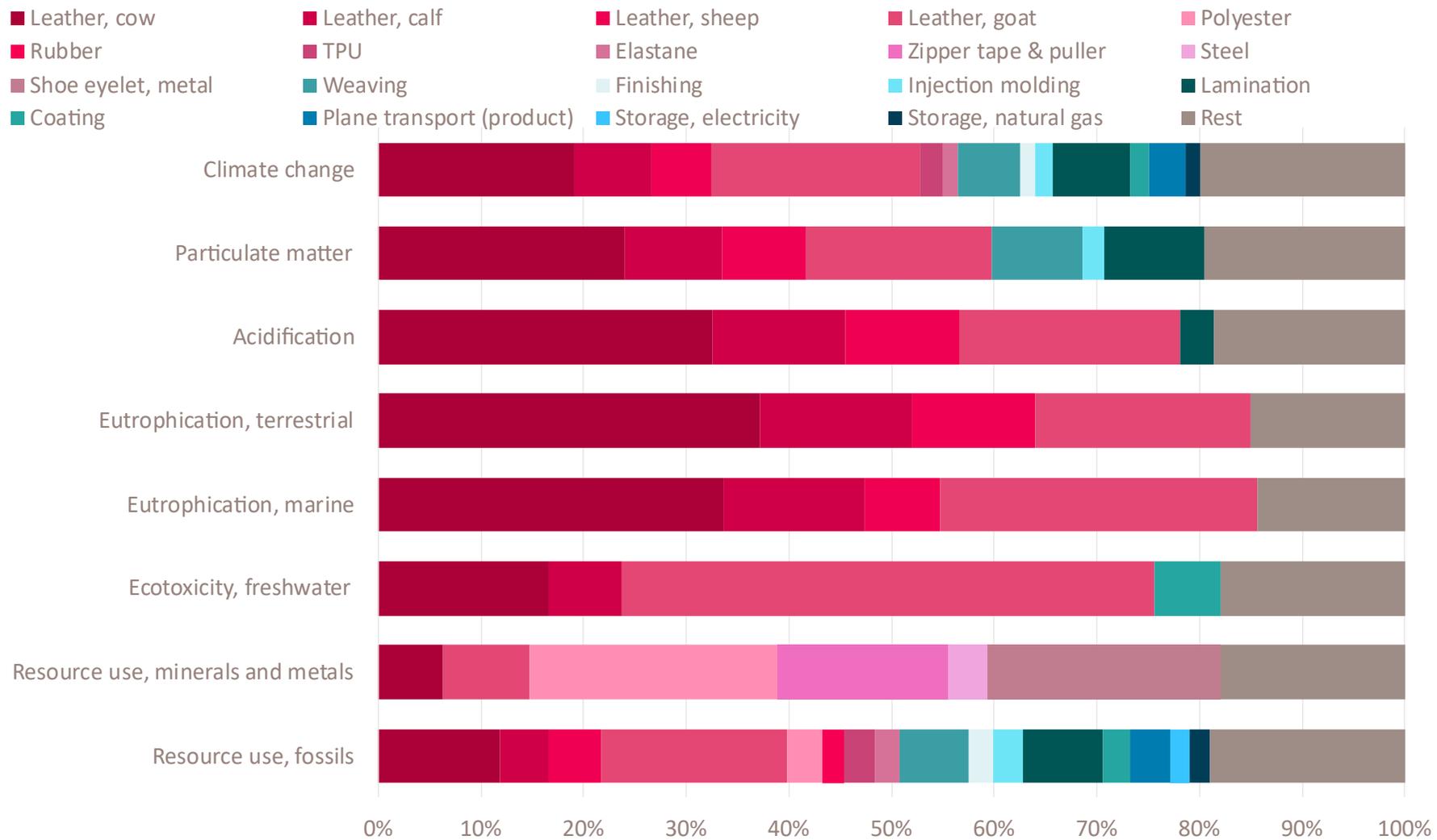


Figure 21 - Most relevant processes per most relevant impact category for boots (RP13)

In summary, the most relevant processes with the highest contributions to the most relevant indicators for each representative product are listed below:

### 1. T-shirts (RP1):

- a. Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- b. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- c. Plastic bag, LDPE {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | thickness: 0.03 mm, grammage: 0.0275 kg/m<sup>2</sup> | LCI result
- d. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for raw materials)
- e. Spinning, for knit, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- f. Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- g. Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO} | Pre-treatment | production mix, at plant | textile service | LCI result
- h. Dyeing, batch (incl. piece, jet, jig, kier [fiber], paddle, pad-batch, yarn), direct, sulfur, vat or reactive dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- i. Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- j. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- k. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)
- l. Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (for product)

- m. Washing, 40 degrees C, average {EU+EFTA+UK} | washing, warm water | production mix, at plant | service | LCI result
- n. Tumble drying {EU+EFTA+UK} | drying, condenser tumble dryer | production mix, at plant | service | LCI result

## 2. Shirts and blouses (RP2):

- a. Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- b. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- c. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for raw materials)
- d. Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (for raw materials)
- e. Spinning, for knit, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- f. Spinning, for woven, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- g. Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- h. Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- i. Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO} | Pre-treatment | production mix, at plant | textile service | LCI result
- j. Dyeing, batch (incl. piece, jet, jig, kier [fiber], paddle, pad-batch, yarn), direct, sulfur, vat or reactive dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- k. Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result

- l. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- m. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)
- n. Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (for product)
- o. Electricity grid mix 1kV-60kV {EU+EFTA+UK} | technology mix | consumption mix, to consumer | 1kV - 60kV | LCI result
- p. Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result
- q. Washing, 40 degrees C, average {EU+EFTA+UK} | washing, warm water | production mix, at plant | service | LCI result

**3. Sweaters and midlayers (RP3):**

- a. Cashmere fiber {GLO} | raw | production mix | LCI result
- b. Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- c. Wool {GLO} | sheep | production mix, at farm | 1 kg wool | LCI result
- d. Spinning, for knit, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- e. Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- f. Knitting, flat {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result

**4. Jackets and coats (RP4):**

- a. Cashmere fiber {GLO} | raw | production mix | LCI result
- b. Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- c. Nylon 6, fossil fuel-based {GLO} | hydrolytic polymerisation of caprolactam | production mix, at plant | petrochemical based | LCI result
- d. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result

- e. Wool {GLO} | sheep | production mix, at farm | 1 kg wool | LCI result
- f. Dressed mink fur, farmed, global origin except china {GLO} | technology mix | production mix, at plant | 1kg | LCI result
- g. Acrylic fiber {GLO} | polymerisation of acrylonitrile with the ethyl acetate, spinning, post-spinning treatment | production mix, at plant | petrochemical based | LCI result
- h. Viscose fibre {GLO} | virgin production from hardwood sulphite pulp | production mix, at plant | 1kg of product | LCI result
- i. Spinning, for woven, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- j. Spinning, continuous filament (dry) {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- k. Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- l. Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- m. Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO} | Pre-treatment | production mix, at plant | textile service | LCI result
- n. Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- o. Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- p. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- q. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)

**5. Pants and shorts (RP5):**

- a. Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- b. Leather, ovine (sheep), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result

- c. Leather, caprine (goat), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- d. Nylon 6, fossil fuel-based {GLO} | hydrolytic polymerisation of caprolactam | production mix, at plant | petrochemical based | LCI result
- e. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- f. Zipper tape and puller, metal {GLO} | production, at plant | 1kg of product, brass zipper | LCI result
- g. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for raw materials)
- h. Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (for raw materials)
- i. Spinning, for knit, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- j. Spinning, for woven, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- k. Spinning, continuous filament (dry) {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- l. Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- m. Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- n. Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO} | Pre-treatment | production mix, at plant | textile service | LCI result
- o. Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- p. Dyeing, batch (incl. piece, jet, jig, kier [fiber], paddle, pad-batch, yarn), direct, sulfur, vat or reactive dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result

- q. Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- r. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- s. Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (for semi-finished products)
- t. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)
- u. Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (for product)
- v. Washing, 40 degrees C, average {EU+EFTA+UK} | washing, warm water | production mix, at plant | service | LCI result
- w. Washing, dry cleaning {EU+EFTA+UK} | washing process | production mix, at plant | service | LCI result
- x. Tumble drying {EU+EFTA+UK} | drying, condenser tumble dryer | production mix, at plant | service | LCI result

**6. Dresses, skirts and jumpsuits (RP6):**

- a. Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- b. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- c. Wool {GLO} | sheep | production mix, at farm | 1 kg wool | LCI result
- d. Spinning, for knit, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- e. Spinning, for woven, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- f. Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result

- g. Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- h. Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO} | Pre-treatment | production mix, at plant | textile service | LCI result
- i. Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- j. Dyeing, batch (incl. piece, jet, jig, kier [fiber], paddle, pad-batch, yarn), direct, sulfur, vat or reactive dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- k. Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- l. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- m. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)
- n. Injection molding, for foam {GLO} | injection process | production mix, at plant | item(s) = pair | LCI result
- o. Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result
- p. Washing, 40 degrees C, average {EU+EFTA+UK} | washing, warm water | production mix, at plant | service | LCI result
- q. Washing, dry cleaning {EU+EFTA+UK} | washing process | production mix, at plant | service | LCI result

**7. Leggings, stockings, tights and socks (RP7):**

- a. Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- b. Nylon 6, fossil fuel-based {GLO} | hydrolytic polymerisation of caprolactam | production mix, at plant | petrochemical based | LCI result
- c. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result

- d. Wool {GLO} | sheep | production mix, at farm | 1 kg wool | LCI result
- e. Acrylic fiber {GLO} | polymerisation of acrylonitrile with the ethyl acetate, spinning, post-spinning treatment | production mix, at plant | petrochemical based | LCI result
- f. Viscose fibre {GLO} | virgin production from hardwood sulphite pulp | production mix, at plant | 1kg of product | LCI result
- g. Elastane fibre / spandex {GLO} | dry spinning, extrusion, texturising | production mix, at plant | 1kg of product | LCI result
- h. Plastic bag, LDPE {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | thickness: 0.03 mm, grammage: 0.0275 kg/m<sup>2</sup> | LCI result
- i. Spinning, for knit, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- j. Spinning, continuous filament (dry) {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- k. Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- l. Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO} | Pre-treatment | production mix, at plant | textile service | LCI result
- m. Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- n. Dyeing, batch (incl. piece, jet, jig, kier [fiber], paddle, pad-batch, yarn), direct, sulfur, vat or reactive dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- o. Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- p. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- q. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)
- r. Washing, 40 degrees C, average {EU+EFTA+UK} | washing, warm water | production mix, at plant | service | LCI result

- s. Tumble drying {EU+EFTA+UK} | drying, condenser tumble dryer | production mix, at plant | service | LCI result

**8. Underwear (RP8):**

- a. Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- b. Nylon 6, fossil fuel-based {GLO} | hydrolytic polymerisation of caprolactam | production mix, at plant | petrochemical based | LCI result
- c. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- d. Plastic bag, LDPE {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | thickness: 0.03 mm, grammage: 0.0275 kg/m<sup>2</sup> | LCI result
- e. Cardboard, production mix, at plant {GLO} | Kraft Pulping Process | production mix, at plant | 180- 300 kg/m<sup>3</sup> | LCI result
- f. Spinning, for knit, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- g. Spinning, for woven, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- h. Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- i. Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- j. Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO} | Pre-treatment | production mix, at plant | textile service | LCI result
- k. Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- l. Dyeing, batch (incl. piece, jet, jig, kier [fiber], paddle, pad-batch, yarn), direct, sulfur, vat or reactive dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- m. Printing, screen {GLO} | printing service | production, at plant | service of printing, Screen on 1m<sup>2</sup> of fabric | LCI result

- n. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- o. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)
- p. Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (for product)
- q. Handwashing {EU+EFTA+UK} | handwashing process | production mix, at plant | service | LCI result
- r. Washing, 60 degrees C, average {EU+EFTA+UK} | washing, warm water | production mix, at plant | service | LCI result
- s. Tumble drying {EU+EFTA+UK} | drying, condenser tumble dryer | production mix, at plant | service | LCI result

#### 9. Swimwear (RP9):

- a. Nylon 6, fossil fuel-based {GLO} | hydrolytic polymerisation of caprolactam | production mix, at plant | petrochemical based | LCI result
- b. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- c. Elastane fibre / spandex {GLO} | dry spinning, extrusion, texturising | production mix, at plant | 1kg of product | LCI result
- d. Plastic bag, LDPE {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | thickness: 0.03 mm, grammage: 0.0275 kg/m<sup>2</sup> | LCI result
- e. Spinning, continuous filament (dry) {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- f. Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- g. Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- h. Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO} | Pre-treatment | production mix, at plant | textile service | LCI result

- i. Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- j. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- k. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)
- l. Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (for product)
- m. Handwashing {EU+EFTA+UK} | handwashing process | production mix, at plant | service | LCI result
- n. Tumble drying {EU+EFTA+UK} | drying, condenser tumble dryer | production mix, at plant | service | LCI result

#### 10. Apparel accessories (RP10):

- a. Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- b. Leather, ovine (sheep), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- c. Leather, caprine (goat), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- d. Leather, swine, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- e. Silk {GLO} | drying, immersion, brushing, reeling | production mix, at plant | 1 kg | LCI result
- f. Wool {GLO} | sheep | production mix, at farm | 1 kg wool | LCI result
- g. Acrylic fiber {GLO} | polymerisation of acrylonitrile with the ethyl acetate, spinning, post-spinning treatment | production mix, at plant | petrochemical based | LCI result
- h. Spinning, for woven, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- i. Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
- j. Knitting, flat {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result

- k. Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- l. Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- m. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- n. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)

#### 11. Open-toed shoes (RP11):

- a. Leather, cattle, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- b. Leather, veal/calf, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- c. Leather, ovine (sheep), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- d. Leather, caprine (goat), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- e. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- f. Styrene-butadiene rubber (SBR) fiber {EU+EFTA+UK} | Emulsion polymerization of styrene and butadiene | production mix, at plant | 23.5 % styrene | LCI result
- g. Ethylene vinyl acetate copolymer {GLO} | Technology mix | Production mix, at plant | LCI result
- h. Elastane fibre / spandex {GLO} | dry spinning, extrusion, texturising | production mix, at plant | 1kg of product | LCI result
- i. Latex production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
- j. Shoe eyelet, metal {GLO} | production, at plant | 1kg of product, brass based | LCI result
- k. Cardboard, production mix, at plant {GLO} | Kraft Pulping Process | production mix, at plant | 180- 300 kg/m3 | LCI result

- l. Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- m. Injection molding, for foam {GLO} | injection process | production mix, at plant | item(s) = pair | LCI result
- n. Lamination, water based glue {GLO} | lamination process | average service, at plant | 1 kg of water based glue laminated fabric | LCI result
- o. Coating, water based emulsion {GLO} | Finishing | technology mix | textile service for 1 kg of fabric | LCI result
- p. Cementing/gluing {GLO} | cementing process | production mix, at plant | service of glueing 1 pair of shoes | LCI result
- q. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)
- r. Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (for product)

#### 12. Closed-toed shoes (RP12):

- a. Leather, cattle, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- b. Leather, veal/calf, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- c. Leather, caprine (goat), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- d. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- e. Wool {GLO} | sheep | production mix, at farm | 1 kg wool | LCI result
- f. Styrene-butadiene rubber (SBR) fiber {EU+EFTA+UK} | Emulsion polymerization of styrene and butadiene | production mix, at plant | 23.5 % styrene | LCI result
- g. Elastane fibre / spandex {GLO} | dry spinning, extrusion, texturising | production mix, at plant | 1kg of product | LCI result
- h. Shoe eyelet, metal {GLO} | production, at plant | 1kg of product, brass based | LCI result

- i. Spinning, for woven, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- j. Spinning, continuous filament (dry) {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
- k. Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- l. Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- m. Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- n. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- o. Injection molding, for foam {GLO} | injection process | production mix, at plant | item(s) = pair | LCI result
- p. Lamination, water based glue {GLO} | lamination process | average service, at plant | 1 kg of water based glue laminated fabric | LCI result
- q. Coating, water based emulsion {GLO} | Finishing | technology mix | textile service for 1 kg of fabric | LCI result
- r. Cementing/gluing {GLO} | cementing process | production mix, at plant | service of glueing 1 pair of shoes | LCI result
- s. Vulcanizing {GLO} | vulcanizing, press vulcanisation- injection molding | production mix, at plant | service for 1 pair | LCI result
- t. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)
- u. Electricity grid mix 1kV-60kV {EU+EFTA+UK} | technology mix | consumption mix, to consumer | 1kV - 60kV | LCI result
- v. Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result

**13. Boots (RP13):**

- a. Leather, cattle, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result

- b. Leather, veal/calf, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- c. Leather, ovine (sheep), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- d. Leather, caprine (goat), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- e. PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- f. Styrene-butadiene rubber (SBR) fiber {EU+EFTA+UK} | Emulsion polymerization of styrene and butadiene | production mix, at plant | 23.5 % styrene | LCI result
- g. Thermoplastic polyurethane (TPU) {GLO} | reaction of diisocyanates (hard segment) with diols (soft segment) | production mix, at plant | petrochemical based | LCI result
- h. Elastane fibre / spandex {GLO} | dry spinning, extrusion, texturising | production mix, at plant | 1kg of product | LCI result
- i. Zipper tape and puller, metal {GLO} | production, at plant | 1kg of product, brass zipper | LCI result
- j. Stainless steel hot rolled {RoW} | hot rolling | production mix, at plant | stainless steel | LCI result
- k. Shoe eyelet, metal {GLO} | production, at plant | 1kg of product, brass based | LCI result
- l. Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- m. Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- n. Injection molding, for foam {GLO} | injection process | production mix, at plant | item(s) = pair | LCI result
- o. Lamination, water based glue {GLO} | lamination process | average service, at plant | 1 kg of water based glue laminated fabric | LCI result
- p. Coating, water based emulsion {GLO} | Finishing | technology mix | textile service for 1 kg of fabric | LCI result

- q. Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result (for product)
- r. Electricity grid mix 1kV-60kV {EU+EFTA+UK} | technology mix | consumption mix, to consumer | 1kV - 60kV | LCI result
- s. Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result

## 7.5. Most relevant elementary flows

### Note

Due to the inaccessibility of disaggregated datasets in the EF 3.1 database, the most relevant direct elementary flows could not be identified at this stage.

## 7.6. Conclusions and recommendations

The main results of the life cycle impact assessment for all EF impact categories (characterized, normalized and weighted) for each representative product are shown in Table 41 through Table 53.

The following impact categories (10/16) were determined to be the most relevant for apparel and footwear products:

- Climate change; particulate matter; acidification; terrestrial eutrophication; marine eutrophication; freshwater ecotoxicity; land use; water use; resource use, minerals and metals; and resource use, fossils.

In general, for most RPs, the most relevant life cycle stages (LCSs) include:

- Raw material acquisition and pre-processing (LCS1); and
- Manufacturing (LCS2).

The most impacting processes per life cycle stage across all RPs are as follows:

- Raw materials acquisition and pre-processing (LCS1):
  - Cashmere fiber {GLO} | raw | production mix | LCI result

- Cotton fibre {GLO} | technology mix | production mix, at farm | "as is" delinted product | LCI result
- Leather, cattle, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- Leather, veal/calf, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- Leather, ovine (sheep), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- Leather, caprine (goat), chrome tanned (wet- blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- Leather, swine, chrome tanned (wet-blue) {GLO} | technology mix | production mix, at tannery | m2 | LCI result
- Nylon 6, fossil fuel-based {GLO} | hydrolytic polymerisation of caprolactam | production mix, at plant | petrochemical based | LCI result
- PET granulates, bottle grade {EU+EFTA+UK} | via purified terephthalic acid (PTA) and ethylene glycol | production mix, at plant | 192.17 g/mol per repeating unit | LCI result
- Silk {GLO} | drying, immersion, brushing, reeling | production mix, at plant | 1 kg | LCI result
- Wool {GLO} | sheep | production mix, at farm | 1 kg wool | LCI result
- Dressed mink fur, farmed, global origin except china {GLO} | technology mix | production mix, at plant | 1kg | LCI result
- Acrylic fiber {GLO} | polymerisation of acrylonitrile with the ethyl acetate, spinning, post-spinning treatment | production mix, at plant | petrochemical based | LCI result
- Styrene-butadiene rubber (SBR) fiber {EU+EFTA+UK} | Emulsion polymerization of styrene and butadiene | production mix, at plant | 23.5 % styrene | LCI result
- Ethylene vinyl acetate copolymer {GLO} | Technology mix | Production mix, at plant | LCI result
- Thermoplastic polyurethane (TPU) {GLO} | reaction of diisocyanates (hard segment) with diols (soft segment) | production mix, at plant | petrochemical based | LCI result

- Viscose fibre {GLO} | virgin production from hardwood sulphite pulp | production mix, at plant | 1kg of product | LCI result
- Elastane fibre / spandex {GLO} | dry spinning, extrusion, texturising | production mix, at plant | 1kg of product | LCI result
- Latex production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
- Zipper tape and puller, metal {GLO} | production, at plant | 1kg of product, brass zipper | LCI result
- Stainless steel hot rolled {RoW} | hot rolling | production mix, at plant | stainless steel | LCI result
- Shoe eyelet, metal {GLO} | production, at plant | 1kg of product, brass based | LCI result
- Plastic bag, LDPE {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | thickness: 0.03 mm, grammage: 0.0275 kg/m<sup>2</sup> | LCI result
- Cardboard, production mix, at plant {GLO} | Kraft Pulping Process | production mix, at plant | 180- 300 kg/m<sup>3</sup> | LCI result
- Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result
- Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result
- Manufacturing (LCS2):
  - Spinning, for knit, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
  - Spinning, for woven, ring-spun {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
  - Spinning, continuous filament (dry) {GLO} | spinning process | production mix | service of spinning 1kg of yarn (raw material excluded) | LCI result
  - Knitting, circular {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result
  - Knitting, flat {GLO} | knitting process | production, at plant | service of knitting fabric | LCI result

- Weaving (different fabric counts) {GLO} | service, Fabric, Weaved, Mix of different counts | production mix, at plant | service, Fabric, Weaved, Mix of different counts | LCI result
- Pre-dye preparation (scouring, etc), knit textile, natural fibers {GLO} | Pre-treatment | production mix, at plant | textile service | LCI result
- Dyeing, batch (incl. piece, jet, jig, kier, yarn), acid dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- Dyeing, batch (incl. piece, jet, jig, kier [fiber], paddle, pad-batch, yarn), direct, sulfur, vat or reactive dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- Dyeing, batch (incl. piece, jet, jig, kier, yarn), disperse or cationic dyes {GLO} | Dyeing | production mix, at plant | textile service for 1 kg of fabric | LCI result
- Printing, screen {GLO} | printing service | production, at plant | service of printing, Screen on 1m2 of fabric | LCI result
- Finishing, stain resistant/stain release {GLO} | pad dry-cure method | production mix, at plant | service | LCI result
- Injection molding, for foam {GLO} | injection process | production mix, at plant | item(s) = pair | LCI result
- Lamination, water based glue {GLO} | lamination process | average service, at plant | 1 kg of water based glue laminated fabric | LCI result
- Coating, water based emulsion {GLO} | Finishing | technology mix | textile service for 1 kg of fabric | LCI result
- Cementing/gluing {GLO} | cementing process | production mix, at plant | service of glueing 1 pair of shoes | LCI result
- Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result
- Distribution (LCS3):
  - Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65 t payload | LCI result
  - Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result

- Injection molding, for foam {GLO} | injection process | production mix, at plant | item(s) = pair | LCI result
- Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result
- Use (LCS4):
  - Handwashing {EU+EFTA+UK} | handwashing process | production mix, at plant | service | LCI result
  - Washing, 40 degrees C, average {EU+EFTA+UK} | washing, warm water | production mix, at plant | service | LCI result
  - Washing, 60 degrees C, average {EU+EFTA+UK} | washing, warm water | production mix, at plant | service | LCI result
  - Washing, dry cleaning {EU+EFTA+UK} | washing process | production mix, at plant | service | LCI result
  - Tumble drying {EU+EFTA+UK} | drying, condenser tumble dryer | production mix, at plant | service | LCI result

Annex I, provided as an Excel file, details the LCI used for this study.

**Note**

Further detailed analysis will be included following the availability of a disaggregated version of the EF 3.1 database.

## 8. Validation statement

This study has been conducted according to the requirements of the PEF method and with the purpose to provide background information and results in support of the PEFCR development. In case there are deviations to these reference documents, these are clearly highlighted and justified.

This PEF-RP study is valid for products in scope sold or consumed in the European Union (EU27), the UK and the European Free Trade Association (EFTA).

The review panel members confirm that they have been independent in their role in accordance with the requirements of the Recommendation 2021/2279 and they have no conflicts of interest regarding this review.

For further insights and findings please refer to the review statement of the PEFCR 3.0 and the review reports in Annex III to the PEFCR 3.0.

## 9. References

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# ANNEX I

Annex I is provided as a separate document, and contains:

- The detailed life cycle inventory analysis;
- The detailed assessment of data quality: data Quality Rating per process in accordance with the PEF method