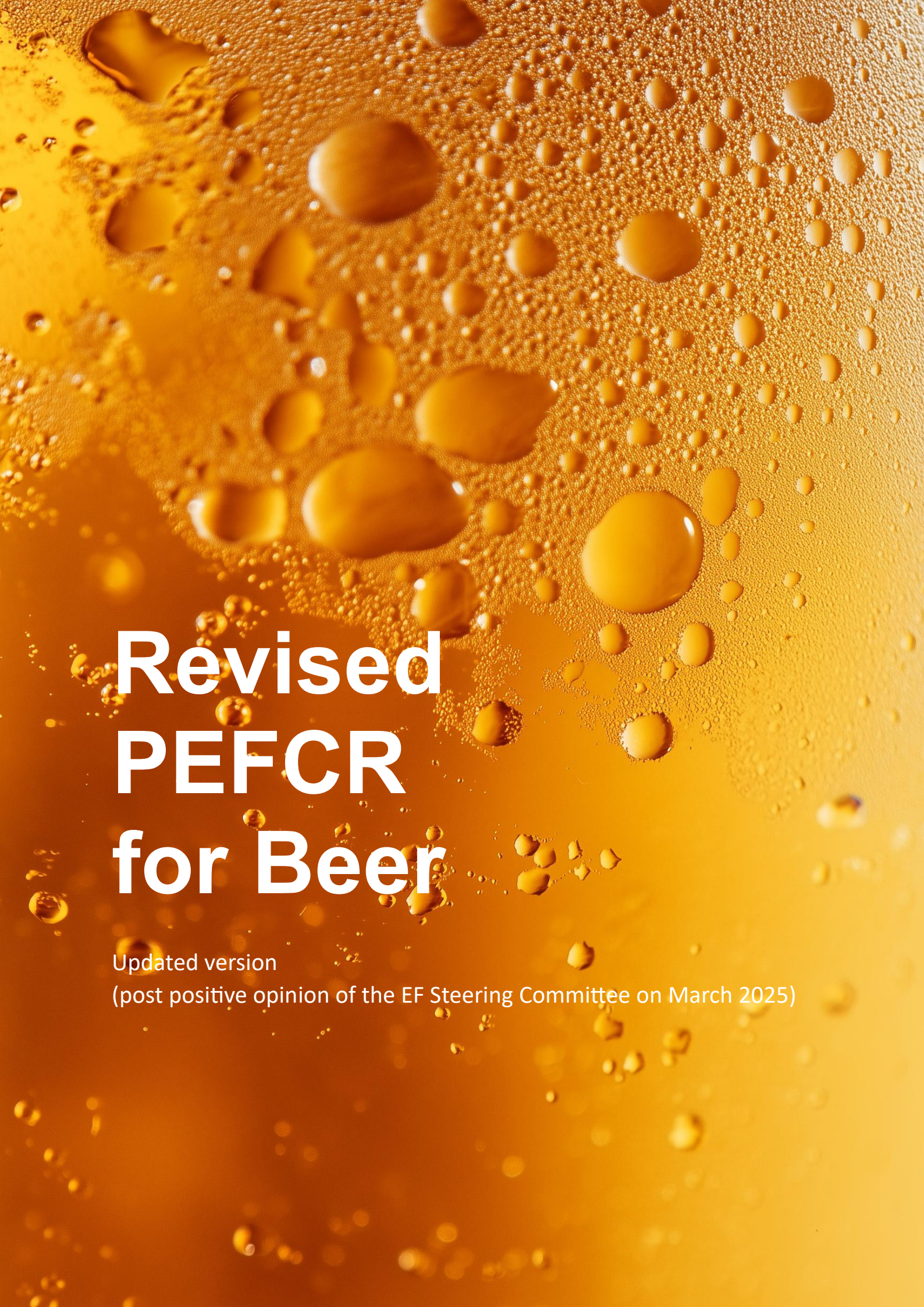

Revised PEFCR for Beer

Updated version
(post positive opinion of the EF Steering Committee on March 2025)

Revised PEFCR for Beer

Note:

Text included in *italics* is wording from:

- Commission Recommendation (EU) 2021/2279 on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products (see template PEFCR)
- the pilot PEFCR for beer.

The italic wording could not be revised in this update.

Updated version (post positive opinion of the EF Steering Committee on March 2025)

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Acronyms

AF	*allocation factor*
AR	*allocation ratio*
B2B	*business to business*
B2C	*business to consumer*
BoM	*bill of materials*
BSI	*British Standards Institution*
CF	*characterisation factor*
CFCs	*chlorofluorocarbons*
CFF	*Circular Footprint Formula*
CPA	*Classification of Products by Activity*
DC	*distribution centre*
DM	*dry matter*
DNM	*Data Needs Matrix*
DQR	*Data Quality Rating*
EAN	*European Article Number*
EC	*European Commission*
EF	*environmental footprint*
EFTA	*European Free Trade Association*
EI	*environmental impact*
EoL	*end of life*
EPD	*Environmental Product Declaration*
FEVE	*European Container Glass Federation*
FU	*functional unit*
GHG	*greenhouse gas*
GR	*geographical representativeness*
GRI	*Global Reporting Initiative*
GWP	*global warming potential*
ha	*hectare*
hl	*hectolitre (=100 litres)*
ILCD	*International Reference Life Cycle Data System*
ILCD-EL	*International Reference Life Cycle Data System – Entry Level*
IPCC	*Intergovernmental Panel on Climate Change*
ISO	*International Organisation for Standardisation*
JRC	*Joint Research Centre*
LCA	*life cycle assessment*
LCDN	*Life Cycle Data Network*
LCI	*life cycle inventory*
LCIA	*life cycle impact assessment*
LCT	*life cycle thinking*
LT	*lifetime*
NGO	*non-governmental organisation*
NMVOC	*non-methane volatile compounds*
P	*precision*
PAS	*publicly available specification*
PCR	*product category rules*
PEF	*product environmental footprint*
PEFCR	*product environmental footprint category rules*
PEF-RP	*PEF study of the representative product*
PET	*Polyethylene Terephthalate*
R1	*recycled content*
R2	*recycling rate*
RF	*reference flow*
RP	*representative product*

SB	*system boundary*
SETAC	*The Society of Environmental Toxicology and Chemistry*
SKU	*stock keeping unit*
SS	supporting study
TAB	*Technical Advisory Board*
TeR	*technological representativeness*
TiR	*time representativeness*
TS	*Technical Secretariat*
UK	*United Kingdom*
UNEP	*United Nations Environment Programme*
UPC	*Universal Product Code*
UUID	*Universally Unique Identifier*
WBCSD	*World Business Council for Sustainable Development*
WRI	*World Resources Institute*
w/w	*mass fraction*
WWTP	*wastewater treatment plant*

Definitions

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*[1] *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_x, NH_3 and SO_x lead to releases of hydrogen ions (H^+) 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.*

Additional technical information *- non-environmental information 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.

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

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'.*

Attributional *- process-based modelling intended to provide a static representation of average conditions, excluding market-mediated effects.*

Average Data *- production-weighted average of specific data.*

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.*

Bill of materials *- a bill of materials or product structure (sometimes bill of material, BOM or associated list) is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture the product in scope of the PEF study. In some sectors it is equivalent to the bill of components.*

Business to business (B2B) *- describes transactions between businesses, such as between a manufacturer and a wholesaler, or between a wholesaler and a retailer.*

Business to consumers (B2C) *- describes transactions between business and consumers, such as between retailers and consumers.*

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_2 and the reference unit is kg CO_2-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.*

Classification *- assigning the material/energy inputs and outputs tabulated in the life cycle inventory to EF impact categories, according to each substance's potential to contribute to each of the EF impact categories considered.*

Climate change *- EF impact category considering all inputs and outputs that result in greenhouse gas (GHG) emissions. The consequences include increased average global temperatures and sudden regional climatic changes.*

Commissioner of the EF study *- organisation (or group of organisations), such as a commercial company or nonprofit organisation, that finances the EF study in accordance with the PEF method and the relevant PEFCR, if available.*

Company-specific data *- refers to directly measured or collected data from one or more facilities (site-specific data) that are representative for the activities of the company (company is used as synonym of organisation). 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 PEFCRs.*

Consumer *- an individual member of the general public purchasing or using goods, property or services for private purposes.*

Co-product *- any of two or more products resulting from the same unit process or product system.*

Cradle to gate *- a partial product supply chain, from the extraction of raw materials (cradle) up to the manufacturer's 'gate'. The distribution, storage, use stage and end of life stages of the supply chain are omitted.*

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.*

Data quality *- characteristics of data that relate to their ability to satisfy stated requirements. Data quality covers various aspects, such as technological, geographical and time-related representativeness, as well as completeness and precision of the inventory data.*

Data quality rating (DQR) *- semi-quantitative assessment of the quality criteria of a dataset, based on technological representativeness, geographical representativeness, time-related representativeness, and precision. The data quality shall be considered as the quality of the dataset as documented.*

Direct elementary flows *(also named elementary flows) - all output emissions and input resource uses that arise directly in the context of a process. Examples are emissions from a chemical process, or fugitive emissions from a boiler directly onsite.*

Direct land use change (dLUC) *- the transformation from one land use type into another, which takes place in a unique land area and does not lead to a change in another system.*

Directly attributable *- refers to a process, activity or impact occurring within the defined system boundary.*

Disaggregation *- the process that breaks down an aggregated dataset into smaller unit process datasets (horizontal or vertical). The disaggregation may help make 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 *- EF 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.*

EF communication vehicles *- all the possible ways that may be used to communicate the results of the EF study to the stakeholders (e.g. labels, environmental product declarations, green claims, websites, infographics, etc.).*

EF-compliant dataset *- dataset developed in compliance with the EF requirements, regularly updated by DG JRC[2].*

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

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.

Environmental aspect *- element of an organisation's activities or products or services that interacts or can interact with the environment.*

Environmental footprint (EF) impact assessment *- phase of the PEF analysis aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product. The impact assessment methods provide impact characterisation factors for elementary flows, to aggregate the impact so as to obtain a limited number of midpoint indicators.*

Environmental footprint (EF) impact assessment method *- protocol for converting life cycle inventory data into quantitative contributions to an environmental impact of concern.*

Environmental footprint (EF) impact category *- class of resource use or environmental impact to which the life cycle inventory data are related.*

Environmental footprint (EF) impact category indicator *- quantifiable representation of an EF impact category.*

Environmental impact *- any change to the environment, whether adverse or beneficial, that wholly or partially results from an organisation's activities, products or services.*

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[2] https://eplca.jrc.ec.europa.eu/permalink/Guide_EF_DATA.pdf
[3] https://ec.europa.eu/energy/intelligent/projects/en/projects/e-track-ii

Eutrophication *- EF impact category related 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.

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

Extrapolated data *- data from a given process that is used to represent a similar process for which data is not available, on the assumption that it is reasonably representative.*

Flow diagram *- schematic representation of the flows occurring during one or more process stages within the life cycle of the product being assessed.*

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

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?'.*

Gate to gate *- a partial product supply chain that includes only the processes carried out on a product within a specific organisation or site.*

Gate to grave *- a partial product supply chain that includes only the distribution, storage, use, and disposal or recycling stages.*

Global warming potential (GWP) *- 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_2 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.

Horizontal averaging *- the action of aggregating multiple unit process datasets or aggregated process datasets in which each provides the same reference flow, to create a new process dataset.*

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.*

Independent external expert *- competent person, not employed in a full-time or part-time role by the commissioner of the EF study or the user of the EF method, and not involved in defining the scope or conducting the EF study.*

Indirect land use change (iLUC) *- this occurs when a demand for a certain land use leads to changes, outside the system boundary, i.e. in other land use types. These indirect effects may be mainly assessed by means of economic modelling of the demand for land or by modelling the relocation of activities on a global scale.*

Input flows *- product, material or energy flow that enters a unit process. Products and materials include raw materials, intermediate products and co-products.*

Intermediate product *- output form of a unit process that in turn is input to other unit processes which require further transformation within the system. An intermediate product is a product that requires further processing before it is saleable to the final consumer.*

Ionising radiation, 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).

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

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 (LCA) *- compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.*

Life cycle impact assessment (LCIA) *- phase of life cycle assessment that aims to understand and evaluate the magnitude and significance of the potential environmental impacts for a system throughout the life cycle.*

The LCIA methods used provide impact characterisation factors for elementary flows to aggregate the impact, to obtain a limited number of midpoint and/or damage indicators.

Life cycle inventory (LCI) *- the combined set of exchanges of elementary, waste and product flows in a LCI dataset.*

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

Loading rate *- ratio of actual load to the full load or capacity (e.g. mass or volume) that a vehicle carries per trip.*

Material-specific *- a generic aspect of a material. For example, the recycling rate of polyethylene terephthalate (PET).*

Multi-functionality *- if a process or facility provides more than one function, i.e. it delivers several goods and/or services ('co-products'), then it is 'multifunctional'. In these situations, all inputs and emissions linked to the process will be partitioned between the product of interest and the other co-products, according to clearly stated procedures.*

Non-elementary (or complex) flows – *in the life cycle inventory, non-elementary flows include all the inputs (e.g. electricity, materials, transport processes) and outputs (e.g. waste, by-products) in a system that need further modelling efforts to be transformed into elementary flows.*

Synonym of 'activity data'.

Normalisation *- after the characterisation step, normalisation is the step in which the life cycle impact assessment results are divided 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.

Displaying the normalised life cycle impact assessment results for the different impact topics next to each other shows 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 an 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.*

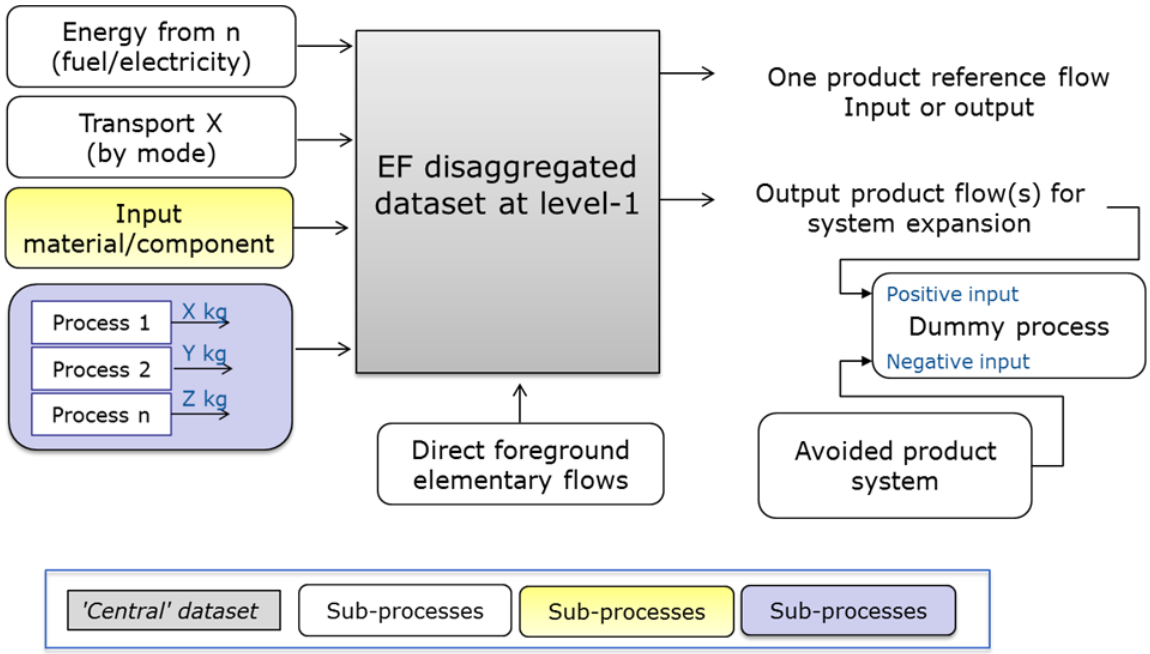

Figure 1. Example of dataset partially disaggregated at Level-1

Particulate matter *- EF impact category that accounts for the adverse effects on human health caused by emissions of particulate matter (PM) and its precursors (NO_x, SO_x, NH_3).*

PEFCR supporting study *- PEF study based on a draft PEFCR. It is used to confirm the decisions taken in the draft PEFCR before the final PEFCR is released.*

PEF profile *- The quantified results of a PEF study. It includes the quantification of the impacts for the various impact categories and the additional environmental information considered necessary to report.*

PEF report *- Document that summarises the results of the PEF study.*

PEF study of the representative product (PEF-RP) *- PEF study carried out on the representative product(s) and intended to identify the most relevant life cycle stages, processes, elementary flows, impact categories and any other major requirements needed for to define the benchmark for the product category/ sub-categories in scope of the PEFCR.*

PEF study *- term used to identify all the actions needed to calculate the PEF results. It includes the modelling, data collection and 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_x) and sunlight.*

High concentrations of ground-level tropospheric ozone damage vegetation, human respiratory tracts and manmade materials, by reacting with organic materials.

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

Primary data *- data from specific processes within the supply chain of the user of the PEF method or user of the PEFCR.*

Such data may take the form of activity data, or foreground elementary flows (life cycle inventory). Primary data are site-specific, company-specific (if multiple sites for the same product) or supply chain specific.

Primary data may be obtained through meter readings, purchase records, utility bills, engineering models, direct monitoring, material/product balances, stoichiometry, or other methods for obtaining data from specific processes in the value chain of the user of the PEF method or user of the PEFCR.

In this method, primary data is a synonym of 'company-specific data' or 'supply chain specific data'.

Product *- any good or service.*

Product category *- group of products (or services) that can fulfil equivalent functions.*

Product category rules (PCRs) *- set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories.*

Product environmental footprint category rules (PEFCRs) *- product category-specific, life cycle-based rules that complement general methodological guidance for PEF studies by providing further specification for a specific product category.*

PEFCRs help to shift the focus of the PEF study towards those aspects and parameters that matter most, and hence increase the relevance, reproducibility and consistency of the results by reducing costs, compared to a study based on the comprehensive requirements of the PEF method.

Only PEFCRs developed by or in cooperation with the European Commission, or adopted by the Commission or as EU acts, are recognised as being in line with this method.

Product flow *- products entering from or leaving to another product system.*

Product system *- collection of unit processes with elementary and product flows, performing one or more defined functions, which model the life cycle of a product.*

Raw material *- primary or secondary material used to produce a product.*

Reference flow *- measure of the outputs from processes in a given product system required to fulfil the function expressed by the functional unit.*

Releases *- emissions to air and discharges to water and soil.*

Representative product (model) *- this may be a real or virtual (non-existing) product. The virtual product should be calculated based on average European market sales-weighted characteristics for 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).

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

***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).*

***Review** - procedure intended to ensure that the process of developing or revising a PEFCR has been carried out in accordance with the requirements provided in the PEF method and part A of Annex II.*

***Review report** - a documentation of the review process that includes the review statement, all relevant information about the review process, the detailed comments from the reviewer(s) and the corresponding responses, and the outcome. The document shall carry the electronic or handwritten signature of the reviewer (or the lead reviewer, if a reviewer panel is involved).*

***Review panel** - team of experts (reviewers) who will review the PEFCR.*

***Reviewer** - independent external expert conducting the review of the PEFCR and possibly taking part in a reviewer panel.*

***Sample** - a subset containing the characteristics of a larger population. Samples are used in statistical testing when population sizes are too large for the test to include all possible members or observations. A sample should represent the whole population and not reflect bias toward a specific attribute.*

***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 rather 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 and other generic data.

Primary data that go through a horizontal aggregation step are considered to be 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.*

***Site-specific data** - directly measured or collected data from one facility (production site).*

A synonym of 'primary data'.

***Single overall score** - sum of the weighted EF results of all environmental impact categories.*

Specific data *- directly measured or collected data representative of activities at a specific facility or set of facilities.*

A synonym of 'primary data'.

Subdivision *- subdividing involves disaggregating multifunctional processes or facilities to isolate the input flows directly associated with each process or facility output. The process is investigated to see whether it may be subdivided. Where subdivision is possible, inventory data should be collected only for those unit processes directly attributable to the products/services of concern.*

Sub-population *- any finite or infinite aggregation of individuals, not necessarily animate, subject to a statistical study that constitutes a homogenous sub-set of the whole population.*

A synonym of 'stratum'.

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

Sub-sample *- a sample of a sub-population.*

Supply chain *- all of the upstream and downstream activities associated with the operations of the user of the PEF method, including the use of sold products by consumers and the end-of-life treatment of sold products after consumer use.*

Supply chain-specific *- refers to a specific aspect of a company's specific supply chain. For example, the recycled content of aluminium produced by a specific company.*

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 ranging from the extraction of raw materials, through processing, distribution, storage and use, to the disposal or recycling stages.*

System boundary diagram *- graphic representation of the system boundary defined for the PEF study.*

Type III environmental declaration *- an environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information.*

Uncertainty analysis *- procedure for assessing uncertainty in the results of a PEF study due to data variability and choice-related uncertainty.*

Unit process *- smallest element considered in the LCI for which input and output data are quantified.*

Unit process, black box *- process chain or plant-level unit process. This covers horizontally averaged unit processes across different sites. Also covers multi-functional unit processes where the different co-products undergo different processing steps within the black box, hence causing allocation problems for this dataset*[4]*.*

[4] *More details can be found in the Guide for EF-compliant datasets at https://eplca.jrc.ec.europa.eu/permalink/Guide_EF_DATA.pdf.*

Unit process, single operation *- unit operation type unit process that cannot be further subdivided. Covers multifunctional processes of the unit operation type[5].*

Upstream *- occurring along the supply chain of purchased goods/ services prior to entering the system boundary.*

User of the PEFCR *- stakeholder producing a PEF study based on a PEFCR.*

User of the PEF method *- stakeholder producing a PEF study based on the PEF method.*

User of the PEF results *- stakeholder using the PEF results for any internal or external purpose.*

Validation *- confirmation – by the environmental footprint verifier – that the information and data in the PEF study, PEF report and communication vehicles are reliable, credible and correct.*

Validation statement *- conclusive document aggregating the conclusions from the verifiers or the verification team regarding the EF study. This document is mandatory and shall carry the electronic or handwritten signature of the verifier or (where a verification panel is involved) the lead verifier.*

Verification *- conformity assessment process carried out by an environmental footprint verifier to demonstrate whether the PEF study has been carried out in compliance with Annex I.*

Verification report *- documentation of the verification process and findings, including detailed comments from the verifier(s), as well as the corresponding responses. This document is mandatory, but it may be confidential. The document shall carry the electronic or handwritten signature of the verifier or (where a verification panel is involved) the lead verifier.*

Verification team *- team of verifiers who will verify the EF study, EF report and EF communication vehicles.*

Verifier *– independent external expert performing a verification of the EF study and possibly taking part in a verification team.*

Vertical aggregation *- technical or engineering-based aggregation refers to vertical aggregation of unit processes that are directly linked within a single facility or process train. Vertical aggregation involves combining unit process datasets (or aggregated process datasets) together, linked by a flow.*

Waste *- substances or objects which the holder intends (or is required) to dispose of.*

Water use *- EF impact category that represents the relative available water remaining per area in a watershed, after demand from humans and aquatic ecosystems has been met. It assesses the potential for water deprivation, to either humans or ecosystems, based on the assumption that the less water remaining available per area, the more likely it is that another user will be deprived.*

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[5] *More details can be found in the Guide for EF-compliant datasets at https://eplca.jrc.ec.europa.eu/permalink/Guide_EF_DATA.pdf.*

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.*

1. Introduction

The Product Environmental Footprint (PEF) method provides detailed and comprehensive technical rules on how to conduct PEF studies that are more reproducible, consistent, robust, verifiable and comparable. Results of PEF studies are the basis for the provision of EF information and they may be used in a diverse number of potential fields of applications, including in-house management and participation in voluntary or mandatory programmes.

For all requirements not specified in this Product Environmental Footprint Category Rule (PEFCR) the user of the PEFCR shall refer to Commission Recommendation (EU) 2021/2279.

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

The Beer PEFCR TS agreed to update the PEFCR along the lines as spelled out in European Commission call issued in January 2022 and entitled 'Information on the update of the pilot PEFCRs'. The changes implemented in this updated PEFCR concern:

- the use of EF 3.0 datasets:
- the use of the PEFCR template as made available in Commission Recommendation (EU) 2021/2279;
- obvious clerical mistakes which are corrected;
- additional clarification is provided to help the user correctly implement the PEFCR.

1.1 Terminology: shall, should and may

This PEFCR uses precise terminology to indicate the requirements, the recommendations and options that could be chosen when a PEF study is conducted.
The term "shall" is used to indicate what is required in order for a PEF study to be in conformance with this PEFCR.

The term "should" is used to indicate a recommendation rather than a requirement. Any deviation from a "should" requirement has to be justified when developing the PEF study and made transparent.

The term "may" is used to indicate an option that is permissible. Whenever options are available, the PEF study shall include adequate argumentation to justify the chosen option.

2. General information about the PEFCR

2.1 Technical Secretariat

Table 1.
Organisation of Technical Secretariat

Name of the organisation	***Type of organisation***	***Name of the members***
The Brewers of Europe *info@brewersofeurope.eu*	*Industry* *Brewing* *EU association* *TS coordinator*	*Anna-Maria De Smet*
AB-InBev	*Industry* *Brewing Company*	*Viktor Klochko*
Carlsberg Group	*Industry* *Brewing Company*	*Georg Schöner*
HEINEKEN	*Industry* *Brewing Company*	*Cor Waringa*
Mahou San Miguel	*Industry* *Brewing Company*	*Juan Francisco Ciriza*
European Aluminium	*Industry* *Aluminium Sector* *EU association*	*Maarten Labberton* *(until 31.12.2024)* *Andy Doran* *(as from 01.01.2025)* *Benedetta Nucci,* *Christian Leroy*
The European Container Glass Federation – FEVE	*Industry* *Glass containers* *EU association*	*Vanessa Chesnot* *Fabrice Rivet*
Beverage Industry Environmental Roundtable – BIER	*Industry Beverages* *International association*	*Daniel Pierce* *(until 31.10.2024)* *Erica Pann* *(as from 01.11.2024)*
Mérieux NutriSciences	*Consultant*	*Jasper Scholten* *Iana Câmara Salim*

2.2 Consultations and stakeholders

This PEFCR is a revision of the Beer PEFCR (European Commission, 2018), which was developed in the PEF pilot phase and which expired on 31 December 2020. This revision has been developed in a transparent manner and with the information on the different steps made available on the dedicated wiki page of the EU pilots' website: https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/Beer+PEFCR.

The Technical Secretariat of the Beer PEFCR has invited relevant stakeholders to participate in the PEFCR development. The relevant stakeholders for the PEFCR development include, amongst others, representatives from suppliers, farm and trade associations, consumers, government representatives, non-governmental organisations (NGOs), public agencies, independent parties and certification bodies. The identified relevant stakeholders were

proactively informed by the Technical Secretariat about the opportunity to take part in the different public consultations.

Table 2.
Consultations and stakeholders

	1st consultation	***2nd consultation***	***3rd consultation***	**4th consultation**
Type	*Online and physical*	*Online*	*Online*	Online
Start	*15.09.2014*	*15.09.2015*	*02.08.2016*	01.09.2024
End	*31.10.2014*	*18.10.2015*	*15.09.2016*	03.10.2024
Number of participating stakeholders (online)	*2*	*7*	*11*	3
Number of participating stakeholders (physical)	*11* *RDC Environment* *Euromalt* *Umicore* *FoodDrinkEurope* *European Aluminium* *The European Container Glass Federation* *Beverage Can Makers Europe* *Industrial Minerals* *Versuchs- und Lehranstalt für Brauerei Berlin* *British Agriculture Bureau*	*Not applicable*	*Not applicable*	Not applicable
Number of comments	*14*	*70*	*117*	22
Of which	*RDC Environment – 12* *British Agriculture Bureau – 2*	*ADEME – 8* *APEAL (steel) - 10* *EUROMALT – 3* *European Aluminium – 10* *Technical University of Denmark – 15* *The European Container Glass Federation – 14* *Spanish brewer – 10*	*ADEME – 9* *Belgium Federal Ministry – 10* *European Commission - 37* *Metal Packaging Europe – 15* *Spanish brewer – 9* *The European Container Glass Federation - 8* *UK maltster – 2* *UAPME - 3*	EF helpdesk (studio Fieschi & soci Srl) – 10 Glimpact – 11 TS - 1

2.3 Review panel and review requirements of the PEFCR

Table 3.
Review panel and review requirements of the PEFCR

Name of the member	***Affiliation***	***Role***
An De Schryver	*Pré Sustainability*	*LCA expert and chair*
Stig Irving Olsen	*Toxicon v/Stig Olsen*	*LCA and brewer expert*
Andrea Fontanella	*Ergo srl*	*LCA researcher and consultant*

The reviewers have verified that the following requirements are fulfilled:

(a) *The PEFCR has been developed in accordance with the requirements provided in Annex I and Annex II of Commission Recommendation (EU) 2021/2279;*
(b) *The PEFCR supports the creation of credible, relevant and consistent PEF profiles;*
(c) *The PEFCR scope and the representative products are adequately defined;*
(d) *The functional unit, allocation and calculation rules are adequate for the product category under consideration;*
(e) *Datasets used in the PEF-RPs and the supporting studies are relevant, representative, reliable, and in compliance with data quality requirements;*
(f) *The selected additional environmental and technical information are appropriate for the product category under consideration and the selection is done in accordance with the requirements stated in Annex I;*
(g) *The model of the RP and corresponding benchmark (if applicable) represent correctly the product category or sub-category;*
(h) *The RP models, disaggregated in line with the PEFCR and aggregated in ILCD format, are EF compliant following the rules available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml;*
(i) *The RP model in its corresponding excel version is compliant with the rules outlined in section A.2.3 of Annex II of Commission Recommendation (EU) 2021/2279;*
(j) *The Data Needs Matrix is correctly implemented;*
(k) *The classes of performance, if identified, are appropriate for the product category.*
(l) *The public review reports are provided in Annex 3 of this PEFCR.*

The review panel shall produce: a public review report for each PEF-RP and a public review report for the final PEFCR.

2.4 Review statement

This PEFCR was developed in compliance with the PEF Method adopted by the Commission on December 2021 (2021/2279). During the PEF Pilot phase, a specific PEFCR for beer was also established.

Following the light review procedure (rules provided in “LIGHT REVISION PROCEDURE OF PEFCRS AND OEFSRS DEVELOPED DURING THE PILOT PHASE”), we confirm that (i) the BEER PEFCR was developed during the EF pilot phase in formal cooperation with the Commission, (ii) the scope and the representative product staid the same, apart from some market changes due to the Brexit and (iii) the default EF compliant datasets are updated to EF3.1 and some small obvious mistakes are updated as part of the revision of the pilot PEFCR/OEFSR. The revised PEFCR is compliant with the latest Commission Recommendation 2021/22792 to the extent possible. Certain inconsistencies with the PEF requirements are still present as a heritage from the previously approved version and cannot be resolved in the scope of a light review process.

The representative product correctly describes the average product sold in Europe (EU+EFTA) for the product category in scope of this PEFCR. PEF studies carried out in compliance with this PEFCR would reasonably lead to reproducible results and the information included therein may be used to make comparisons and comparative assertions under the prescribed conditions (see section on limitations).

2.5 Geographic validity

This PEFCR is valid for products in scope sold or consumed in the EU+EFTA.

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

2.6 Language

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

2.7 Conformance to other documents

This PEFCR has been prepared in conformance with the following documents:

(a) Commission Recommendation (EU) 2021/2279 of 15 December 2021 on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations (European Commission, 2021).
(b) The 2018 Beer PEFCR (incl. additional files and corrigendum).
(c) The checklist for the review procedure as discussed at the Technical Advisory Board (TAB).
(d) The EF3.1 reference packages
(See https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml).

3. PEFCR scope

The main objective of this PEFCR is to develop a consistent set of rules to calculate the relevant environmental impacts of beer.

3.1 Product classification

The CPA code for the products included in this PEFCR is C11.0.5 - Manufacture of beer.

Beer is a beverage obtained as a result of a fermentation of a wort produced from water, a starch source – generally provided through cereals (whether or not processed), hops (whether or not processed) and possibly other carbohydrate matter.

The CPA code includes;

- *Manufacture of malt liquors, such as beer, ale, porter and stout.*
- *Manufacture of low alcohol or non-alcoholic beer.*

3.2 Representative product

The representative product is based on the volumes of beer sold in the EU in 2021.
*Table **4** contains the market shares of different beer types. Data is obtained from the beverage database of* Global Data, formally Canadean (Global data, 2022). *Table **5** contains the recipes made by Campden BRI of the different beer types included.*

Table 4.
Determination of the representative product, based on volumes of beer types sold in EU (2021)

Beer types	Market share EU 2021 (%)
Lager beer	84.13
Wheat beer	3.88
Ale	0.69
Beer mixes	3.95
Other top fermented	2.83
Flavoured beer	1.68
Stout beer	0.58
Dark beer	1.1
Others	0.88
Seasonal beer	0.28

Lager beer is split up into 'full malt' and 'non full-malt' lager because it is almost 90% of the total volume. No recipes are used for others and seasonal beer. These volumes were divided proportionately so the total is 100%.

The packaging mix is based on the packaging mix from 2019[6] of the EU + EFTA *and the cooling mix is a consequence of packaging mixes. Figure 2 provides an overview of the benchmark beer. Please note that the representative product is not on the market, it does not exist. There is only one representative product for beer, so no subcategories exist.*

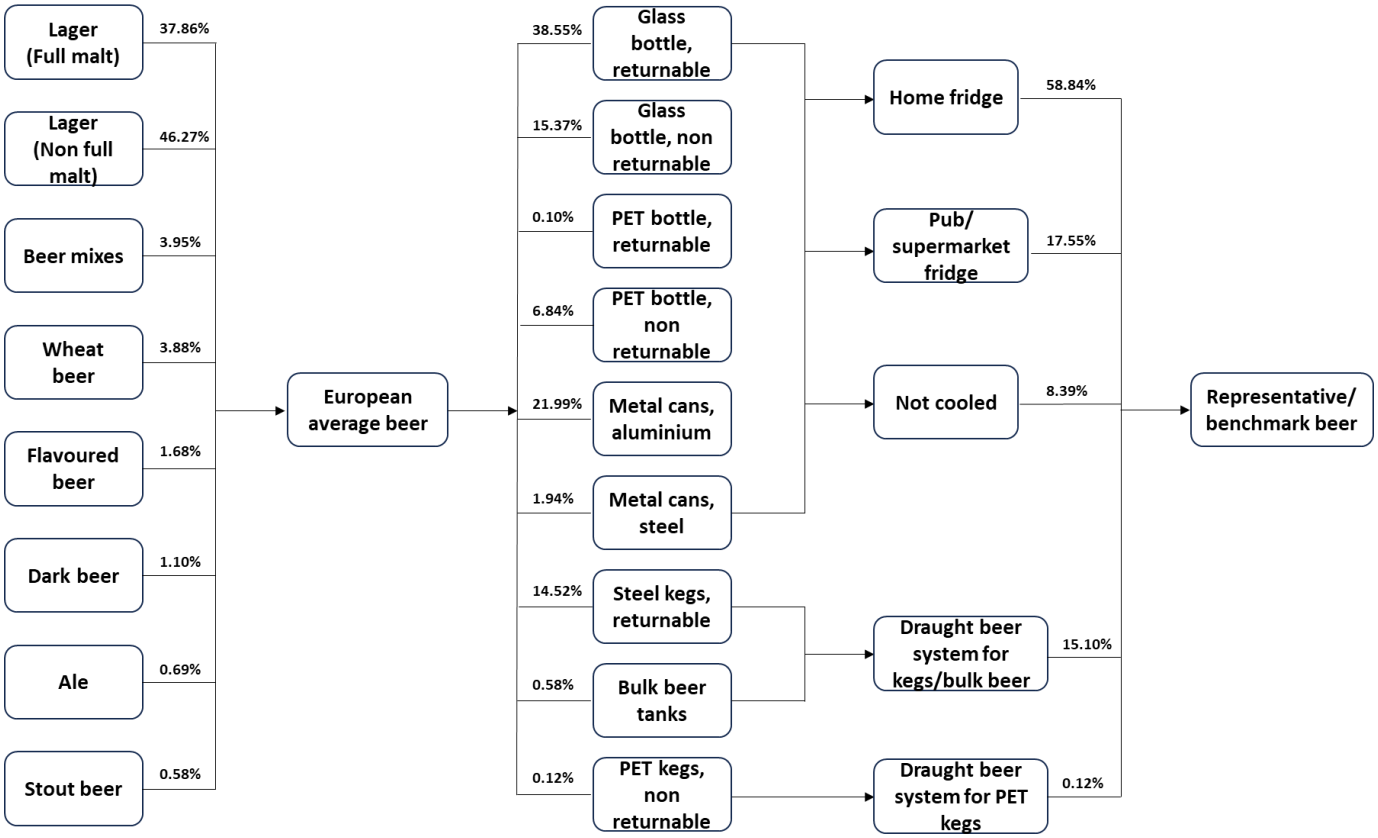


Figure 2. Determination of the representative product, based on volumes of beer types sold in EU (2021) - Source: Global Data (2022)

[6] The covid crisis had a huge impact on consumption in the hospitality sector. Therefore, it is not considered appropriate to use data from 2021 (the latest data sets available in Global Data at the time of the review of the Beer PEFCR), as it would provide misinformation on the packaging mix.

Table 5.
Determination of the representative product, based on volumes of beer types sold in EU (2021)

	Lager beer full malt	Lager beer non full malt	Wheat beer	Ale	Beer mixes	Other top fermented	Flavoured beer	Stout beer	Dark beer
Characterising ingredients	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**
Malted cereals									
Malted barley	16	10.5	7	11.5	6.13		12.5	10.5	14
Malted wheat			8.5						
Malted barley extract (solid)									
Crystal malt			0.5	1	0.50		1		1.5
Roast malt									0.5
Malted oats									
Malted sorghum									
Raw cereals									
Barley torrefied									
Barley flaked		2						4	
Barley flour									
Barley roasted								1.5	
Wheat torrefied									
Wheat flaked									
Wheat flour									
Maize flaked		2		1.5	1		1		
Maize flour									
Maize grits									
Rice flaked									
Rice grits									
Rice flour									
Rye									
Oats									
Buckwheat									
Sorghum									
Sugars									
Cane sugar									
Beet sugar									
Barley syrup									
Invert sugar				1.50					
Malt extract (liquid)									
High maltose syrup		1.50							
Glucose syrup					2.5				
Fructose syrup					2.5				
Hops/hop products									
Hops (cones)									
Hop pellets	0.02	0.02	0.02	0.03	0.0004			0.04	0.02
Liquid CO2 extract	0.0125	0.0125	0.005	0.015				0.0125	0.0125
Isomerised kettle extract					0.0008				
Essential oils	0.001								
"Tetrahop"				0.0007					
"Rho" iso-alpha-acid							0.0096		

Table 5.(Ctd)
Determination of the representative product, based on volumes of beer types sold in EU (2021)

	Lager beer full malt	Lager beer non full malt	Wheat beer	Ale	Beer mixes	Other top fermented	Flavoured beer	Stout beer	Dark beer
Other Flavouring ingredients	kg/hl	kg/hl	kg/hl	kg/hl	kg/hl	kg/hl	kg/hl	kg/hl	kg/hl
Honey									
Fruit concentrates					10		0.5		
Whole fruit							0.5		
Spices/herbs							0.1		
Additives									
Miscellaneous									
Ascorbic acid/ascorbate					0.002				
Benzoic acid/benzoates					0.01				
Caramel				0.15	0.075		0.01		
Citric acid					0.001				
Gumarabic									
Sulphites				0.0005					
Lactic acid					0.0075		0.015		
Lysozyme									
Propane-1,2-diol alginate				0.01	0.005		0.01		
Sorbic acid/sorbates									
Sweeteners									
Acesulfame K					0.02				
Aspartame					0.03				
Aspartame/acesulfame k salt									
Neohesperidine DC									
Neotame									
Saccharin					0.005				
Steviol									
Sucralose									
Processing aids									
Yeast DRY	0.016	0.016	0.016	0.0155	0.013		0.015	0.016	0.016
Enzymes									
Cytolytic enzyme blends		0.001		0.001	0.0005	0.001	0.001	0.001	0.001
Amylolytic blends		0.004			0.002	0.004	0.004	0.004	0.004
Proteases						0.003			
Fermentation blends									
Acetolactatedecarboxylase						0.002			
Proline-specific endoprotease		0.002		0.002	0.001	0.002	0.002		
Filter aids									
Diatomaceous earth (calcined)	0.066	0.066			0.033	0.066	0.066	0.066	0.066
Diatomaceous earth (uncalcined)									
Diatomaceous earth (flux calcined)									
Perlite	0.019	0.019			0.0095	0.019	0.019	0.019	0.019
Filter sheets				0.003	0.0015	0.003	0.003		
Cartridge filters	0.001	0.001		0.0005	0.0005	0.001	0.001	0.001	0.001
Cellulose fibres									
PVP									
PVPP	0.002	0.002		0.001	0.001	0.002	0.002		0.002
Silica hydrogel	0.012	0.012		0.006	0.006	0.012	0.012		0.012
Silica xerogel									
Bentonite									

Table 5. (Ctd)
Determination of the representative product, based on volumes of beer types sold in EU (2021)

	Lager beer full malt	Lager beer non full malt	Wheat beer	Ale	Beer mixes	Other top fermented	Flavoured beer	Stout beer	Dark beer
Antifoam	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**	**kg/hl**
dimethylpolysiloxane		0.1		0.1	0.05	0.1	0.1	0.1	0.1
Fining agents									
Tannic acid									
Isinglass				0.3					
Polysaccharide auxiliary finings									
Polysilicate auxiliary finings				0.3					
Silica sol									
Carrageenan		0.002		0.002	0.001		0.002	0.002	0.002
Other inputs in the brewing process									
Brewing salts and pH regulators	**0.05**	**0.05**	**0.05**	**0.05**	**0.25**	**0.05**	**0.05**	**0.05**	**0.05**
Calcium chloride				0.05				0.05	0.05
Calcium sulphate		0.01		0.04	0.005		0.005	0.04	0.04
calcium hydroxide									
citric acid									
hydrochloric acid									
phosphoric acid									
potassium hydroxide									
sodium carbonate									
sulphuric acid									
Yeast foods									
Yeast foods									
Zinc chloride/sulphate		0.00007		0.00007	0.000035		0.00007	0.00007	0.00007
Cleansers									
Nitric acid	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
Peracetic acid	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Phosphoric acid									
Quaternary ammonium compounds									
Sodium hydroxide	0.509	0.509	0.509	0.509	0.509	0.509	0.509	0.509	0.509
Sodium hypochlorite	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Sulphamic acid									
Sulphuric acid									

The Bill of Materials (BoM), as defined in the PEFCR, is based on the functional unit of 1 hectolitre of beer. The definition of BoM always relates to the inputs[7] needed to achieve 1 functional unit.

[7] https://dictionary.cambridge.org/dictionary/english/bill-of-materials

3.3 Functional unit and reference flow

The functional unit (FU) is 1 hectolitre[8] of beer.

Table 6 *defines the key aspects used to define the FU.*

Table 6.
Key aspects of the FU

What?	*A refreshing beer consumed in a social setting[9]*
How much?	*One hectolitre of beer (1 hl)*
How well?	*A beer at the advised serving temperature (normally between 0 °C to 20 °C)*
How long?	*Until at least 1 month after production*

If the beer cannot be preserved 1 month after production, the default losses, set at 2% (see also section 6.5), must be increased to 7%.

For communication purposes the results may be translated to stock keeping units (SKUs) or a drinking unit, but the volume the results relate to shall be stated with the results."

The reference flow is the amount of product needed to fulfil the defined function and shall be measured in 1 hectolitre as consumed equal to 102 litres as volume sold from the brewery to both on- and off-trade . All quantitative input and output data collected in the study shall be calculated in relation to this reference flow.

[8] *1 hectolitre (hl) is 100 litres.*
[9] *A beer consumed responsibly by a healthy adult, as part of a balanced diet and lifestyle.*

3.4 System boundary

*Figure 3 provides the system boundary of beer including for which LCS company-specific data shall be collected and it is indicated for each LCS which situation of the DNM is applicable. Table **7** provides descriptions for each LCS. Due to the harmonisation requirements in LCS naming, the LCS as mentioned in Annex I of Commission Recommendation (EU) 2021/2279 (European Commission, 2021) is also listed in italic in the first column of Table **7** (See also Annex I - section 4.2 of the Commission Recommendation (EU) 2021/2279). The TS of beer decided not to use the required LCS naming because too many stages would be aggregated and relevant information couldn't be interpreted anymore from PEF studies (e.g. all beer ingredients, packaging materials and its inbound distribution would be aggregated into one LCS). The remodelling of the benchmark was also performed by using the LCS names from the system diagram.*

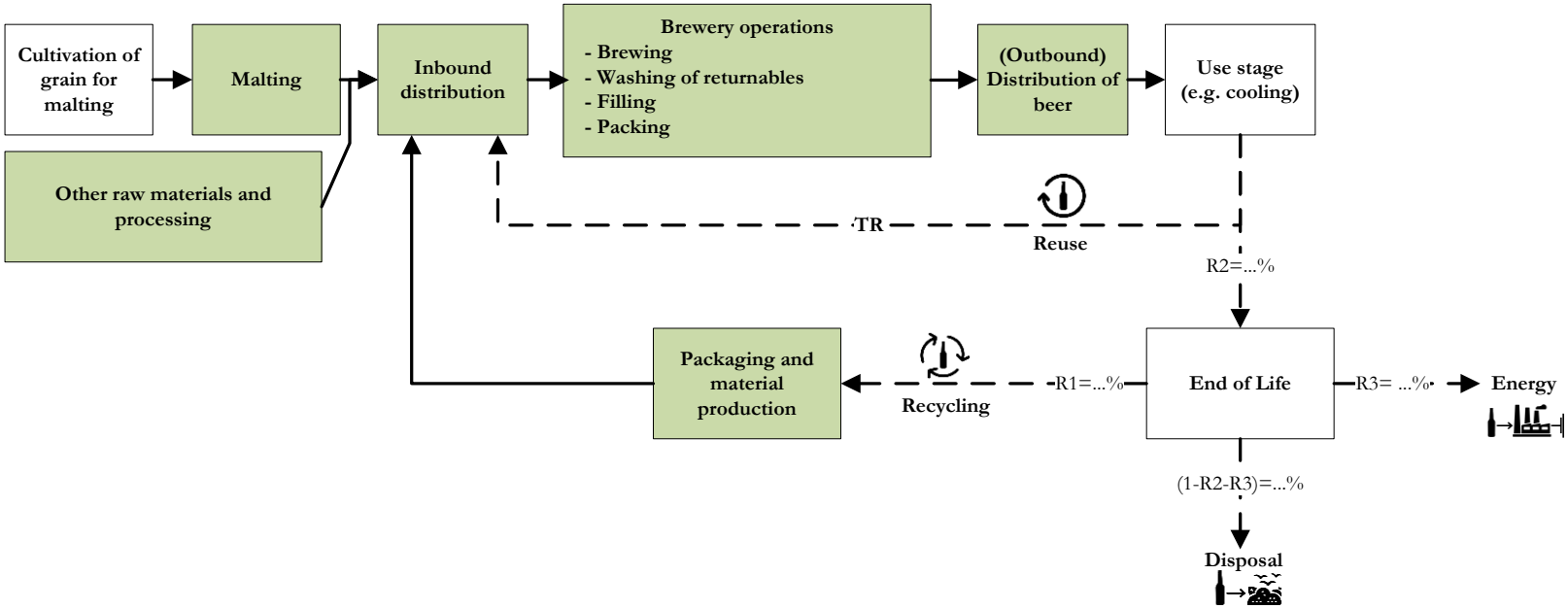


Figure 3. System diagram of beer including all life cycle stages (LCS). The green boxes are LCSs where company-specific data shall be used (see section 4 for more details). Secondary data may be used for the white boxes. Please note that processes within the LCS "Malting", "Processing of other raw materials" and "Packaging and material production" can be in situation 2 or 3 depending on the data requirements as explained in section 4. TR = Triprate

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

Table 7.
Life cycle stages

Life cycle stage	***Short description of the processes included***
Cultivation of grain for malting *Raw material acquisition and pre-processing*	*The lifecycle of beer starts with the 'Cultivation of grain for malting'. In this cultivation stage the following processes are taken into account: fertilizer production and application; manure application; fuel production and combustion; water consumption for irrigation; pesticide production and application; infrastructure (machinery, storage, tractor, shed, etc.). This life cycle stage stops at the gate of the farm.* *No company-specific data requirements are mandatory for this LCS.*
Malting *Raw material acquisition and pre-processing*	*This life cycle stage includes the malting of the cultivated grain for malting and it includes: transport of crops to the processing plant; energy consumption; water consumption; the application of auxiliary materials and waste water treatment. This life cycle stage stops at the gate of the malting plant.* *Company-specific data requirements may be applicable to this LCS and are listed in section 5.1.*
Other raw materials and processing *Raw material acquisition and pre-processing*	*This life cycle stage includes the cultivation and processing of other non-malted raw materials which are purchased by the brewery to brew the beer for example hops, sugar syrups or fruit concentrate. This life cycle stage stops at the gate of the processing plant.* *Company-specific data requirements may be applicable to this LCS and are listed in section 5.1.*
Packaging material production *Raw material acquisition and pre-processing*	*This life cycle stage includes all activities to produce packaging (e.g. glass bottles, cans, kegs, crown caps). It includes also the extraction of raw materials (e.g. silica sand, iron ore) and recycling materials. This life cycle stage stops at the gate of the packaging production plant (e.g. can maker, glass bottle plant, PET bottle preform producer, et cetera).* *Company-specific data requirements are applicable to this LCS and are listed in section 5.1.*
Inbound distribution *Raw material acquisition and pre-processing*	*This life cycle stage includes all transport activities to get the beer ingredients and the packaging materials to the brewery.* *Company-specific data requirements are applicable to this LCS and are listed in section 5.1*
Brewery operations *Manufacturing / Production of the main product*	*The brewing process includes all processes at the production sites for brewing and filling of beer, including water consumption and energy consumption. This life cycle stage stops at the gate of the brewery.* *Company-specific data requirements are applicable to this LCS and are listed in section 5.1*

Table 7. (Ctd)
Life cycle stages

Life cycle stage	***Short description of the processes included***
Distribution of beer *Product distribution and storage*	*When the packaging has been filled, the beer is distributed to the retail and consumption stage. This is called the life cycle stage 'Distribution of beer'. Distribution of beer shall include: distances travelled via truck, train, van, barge ship, ocean ship or air plane; loading capacity of the transport modalities (load factor and return trips); distribution of empty returnables back to the brewery.* *Company-specific data requirements are applicable to this LCS and are listed in section 5.1.*
Use stage	*The 'Use stage' includes: energy consumption for cooling (i.e. home cooling, cooling via draught beer installations or cooling in fridges in bars and restaurants); refilling of lost refrigerants. This life cycle stage stops when the packaging is disposed (e.g. in the bin at home, the pub, in the park).* *No company-specific data requirements are mandatory for this LCS.*
End-of-life	*The end-of-life life cycle stage includes;* *- Collection, sorting and cleaning of used packaging materials.* *- Melting of aluminium scrap to aluminium ingot.* *- Substitution of virgin packaging materials when the used materials will be recycled.* *- Disposal to landfill of packaging materials.* *- Incineration of packaging materials.* *- Credits when energy is recovered from the incineration of packaging materials.* *This life cycle stage is fully defined by the Circular Footprint Formula (CFF).* *This life cycle stops;* *- At the point of substitution to new packaging materials, or* *- When the packaging materials are incinerated, or* *- When the packaging materials are landfilled.* *No company-specific data requirements are mandatory for this LCS.*

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

Each PEF study done in accordance with this PEFCR shall provide in the PEF study a diagram indicating the activities falling in situation 1, 2 or 3 of the data needs matrix.

3.5 List of EF impact categories

*Each PEF study carried out in compliance with this PEFCR shall calculate the PEF-profile including all EF impact categories listed in table **8**.*

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

Table 8.
EF3.1 midpoint impact categories with their indicator, unit, and underlying life cycle impact assessment (LCIA) method. *updated in the EF3.1 and described in the report (Andreasi Bassi et al., 2023). The adaptation of all the other impact categories can be found in (Fazio et al., 2018).

EF Impact category	Indicator	Unit	Characterization model	Robustness
*Climate change**	*Radiative forcing as Global Warming Potential (GWP100)*	*kg $CO_{2\,eq}$*	*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 (CTU_h)*	*CTUh*	*Based on USEtox model 2.1* (Fantke et al., 2017), adapted *as in* Saouter et al., 2018)	*III*
*Human toxicity, non-cancer**	*Comparative Toxic Unit for humans (CTU_h)*	*CTUh*	*Based on USEtox model 2.1* (Fantke et al., 2017), *adapted as in* Saouter et al., 2018)	*III*
Particulate matter	*Human health effects associated with exposure to PM2.5.*	*disease incidences*	*PM model* (Fantke et al., 2016 *in UNEP 2016)*	*I*
Ionising radiation, human health	*Human exposure efficiency relative to U^{235}*	*kBq U^{235} $_{eq}$*	*Human health effect model as developed by* Dreicer et al., 1995 (Frischknecht et al., 2000)	*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+ $_{eq}$*	*Accumulated Exceedance* (Seppälä et al., 2006, Posch et al., 2008)	*II*
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* (Huijbregts et al., 2016)	*II*

Table 8 (Ctd.)
EF3.1 midpoint impact categories with their indicator, unit, and underlying life cycle impact assessment (LCIA) method. *updated in the EF3.1 and described in the report (Andreasi Bassi et al., 2023). The adaptation of all the other impact categories can be found in (Fazio et al., 2018).

EF Impact category	Indicator	Unit	Characterization model	Robustness
*Ecotoxicity, freshwater**	*Comparative Toxic Unit for ecosystems (CTU_e)*	*CTUe*	*Based on USEtox model 2.1 (Fantke et al., 2017), adapted as in Saouter et al., 2018*	*III*
Land use	*Soil quality index[10]*	*Dimensionless (pt)*	*Soil quality index based on LANCA model (De Laurentiis et al., 2019) and on the LANCA CF version 2.5 (Horn & Maier, 2018)*	*III*
Water use	*User deprivation potential (deprivation-weighted water consumption)*	*m^3 water eq of deprived water*	*Available WAter REmaining (AWARE) model (Boulay et al., 2018; UNEP, 2016)*	*III*
Resource use, 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	*Abiotic resource depletion – fossil fuels (ADP-fossil)*	*MJ*	*van Oers et al., 2002 as in CML 2002 method, v.4.8*	*III*

The full list of normalization factors and weighting factors are available in Annex 1.

The full list of characterization factors is available in the EF reference package 3.1 at this link:
https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml

3.6 Additional technical information

The following additional technical information shall be reported in PEF studies:

- *Trip rates of returnable packaging materials.*
- *The coverage (in % w/w based on the BoM of the brewery) of company-specific data in the life cycle stages malting, other raw materials and processing, and packaging and material production.*

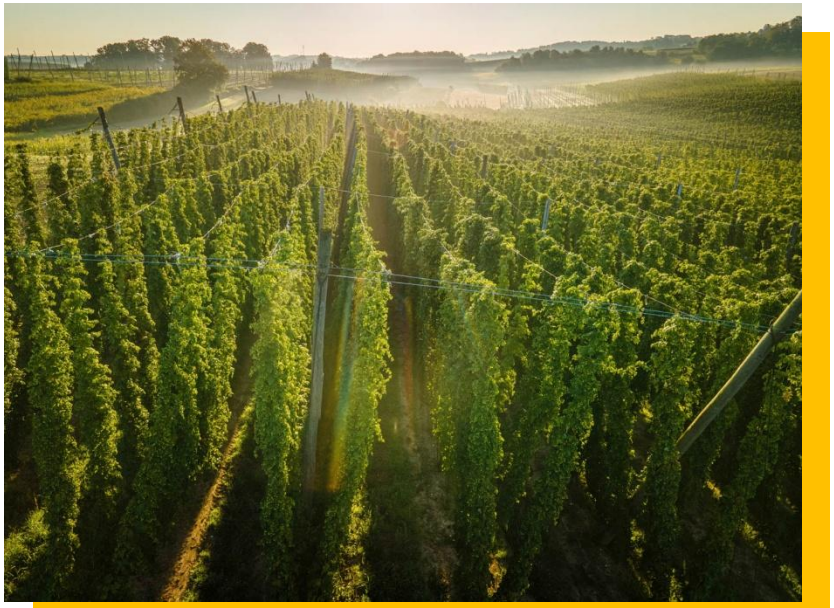
3.7 Additional environmental information

It is unclear if biodiversity is relevant for this PEFCR. Biodiversity was tested in a supporting study but with difficulties of relevant datasets/flows. The LCS cultivation and packaging will probably mostly influence biodiversity based on this test.

[10] 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 LANCA model for assessing impacts due to land use as *reported in De Laurentiis et al,* 2019.

The following 6 impact categories are relevant for biodiversity: Climate change, Eutrophication aquatic freshwater, Eutrophication aquatic marine, Acidification, Water use, Land use. Four of these 6 impact categories are the most relevant in this PEFCR so biodiversity is indirectly covered. The limitation is that this PEFCR does not have company-specific data requirements on cultivation and for meaningful biodiversity assessments detailed company specific data will be required. We strongly advocate for developments of intermediate product PEFCRs with the focus on cultivation, based on company-specific data and which focus on developing/selecting methods to perform biodiversity impact assessments.

No additional environmental information shall be included.



3.8 Limitations

Function of packaging to preserve beer over time

The definition of the functional unit (i.e., how long) sets a minimum requirement of preservation. The type of packaging is one of the key parameters influencing the preservation period of the beer: for instance, up to 6 months for beer packed in PET bottle, more than 6 months for beer packed in other packaging materials.

3.9 Comparisons and comparative assertions

PEF studies carried out in compliance with this PEFCR would reasonably lead to reproducible results and the information included therein may be used to make comparisons and comparative assertions under the prescribed conditions. Comparisons and comparative assertions are allowed only if PEF studies are conducted in compliance with a this PEFCR.

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

4.1 Most relevant EF impact categories

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

- Climate change
- Resource use, fossils
- Ecotoxicity, freshwater
- Particulate Matter
- Resource use, minerals and metals
- Land use
- Acidification
- Eutrophication, marine

4.2 Most relevant life cycle stages

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

- Cultivation of grain for malting
- Packaging and material production
- Brewery operations
- Use stage
- End-of-life

4.3 Most relevant processes

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

Table 9.
List of the most relevant processes (Climate change). Total contribution = 80.6%.

Climate Change	UUID	Cultivation of grain for malting	Malting	Other raw materials and processing	Inbound distribution	Packaging and material production	Brewery operations	Distribution of beer	Use stage	End of Life
Solid board box	10fcccac-a13c-4650-b093-8102724bd342					2.10%				
Electricity grid mix 1kV-60kV	34960d4d-af62-43a0-aa76-adc5fcf57246		0.80%						13.50%	
Aluminium ingot mix	84edb17a-79de-4cd7-8340-02b289b30312									3.80%
Thermal energy from natural gas	81675341-f1af-44b0-81d3-d108caef5c28		1.20%				4.40%			
Thermal energy from light fuel oil (LFO)	e7510ad9-4bfa-4113-94b0-426e5f430c98		1.50%				0.10%			
Steel cold rolled coil	3f445970-7d74-4d19-8be7-f9fba0b454b4								1.20%	0.70%
Barley grain; ES	d2090bfe-6970-42c0-af0d-59e971df53cf	1.30%								
Barley grain; DE	3bba2dd4-07ba-4c6b-9fe0-2f4b6a637815	1.60%								
Barley grain; FR	d6643b5f-5c5d-4063-8a0e-4ae7c1d21388	1.10%								
Articulated lorry transport, Euro 4, Total weight >32 t (without fuel)	e1ded83e-a02f-42cd-92f9-81cce21a3a98	0.60%			0.70%			4.40%		0.50%
Container glass, ER, Recycled Content 100%	ab4e945f-9955-4414-b3fb-d42507cc4e2d					0.90%				4.30%
Container glass, virgin	5ccf94ab-173c-4688-bcc8-d434166be45e					14.30%				8.40%
Can beverage, body aluminium	4ae8619c-4eb7-42ea-9105-eb5ee9e4ed6e					8.10%				
Can beverage, sanitary end aluminium	95275ae7-af41-48aa-bef9-8259f1b31e71					2.30%				
Cap, ECCS steel	ef4e440e-05b3-4dd7-afbc-f24b4e625634					1.20%				
Electricity from hard coal	6d68bce7-71c6-4f30-b390-8b28983bc187						1.60%			

Table 10.
List of the most relevant processes (Resource use, fossils). Total contribution = 81.1%.

Resource use, fossils	UUID	Cultivation of grain for malting	Malting	Other raw materials and processing	Inbound distribution	Packaging and material production	Brewery operations	Distribution of beer	Use stage	End of Life
Solid board box	10fcccac-a13c-4650-b093-8102724bd342					2.30%				
Electricity grid mix 1kV-60kV	34960d4d-af62-43a0-aa76-adc5fcf57246		1.00%						17.40%	
Aluminium ingot mix	84edb17a-79de-4cd7-8340-02b289b30312									4.00%
Thermal energy from natural gas	81675341-f1af-44b0-81d3-d108caef5c28		1.40%				5.40%			
Thermal energy from light fuel oil (LFO)	e7510ad9-4bfa-4113-94b0-426e5f430c98		1.50%				0.10%			
Kraft paper, uncoated	03dea8f0-44e0-4bf3-a862-bb572c9d5f5e									1.20%
Articulated lorry transport, Euro 4, Total weight >32 t (without fuel)	e1ded83e-a02f-42cd-92f9-81cce21a3a98	0.60%			0.80%			4.60%		0.60%
Container glass, ER, Recycled Content 100%	ab4e945f-9955-4414-b3fb-d42507cc4e2d					1.00%				5.20%
Container glass, virgin	5ccf94ab-173c-4688-bcc8-d434166be45e					13.20%				7.80%
Can beverage, body aluminium	4ae8619c-4eb7-42ea-9105-eb5ee9e4ed6e					8.00%				
Can beverage, sanitary end aluminium	95275ae7-af41-48aa-bef9-8259f1b31e71					2.30%				
PET bottle, transparent	7d518e67-59cd-4f12-a5af-8f158aa3fa1f					1.50%				
Electricity from hard coal	6d68bce7-71c6-4f30-b390-8b28983bc187					1.20%				

Table 11.
List of the most relevant processes (Ecotoxicity, freshwater). Total contribution = 81.9%.

Ecotoxicity, freshwater	UUID	Cultivation of grain for malting	Malting	Other raw materials and processing	Inbound distribution	Packaging and material production	Brewery operations	Distribution of beer	Use stage	End of Life
Tetrafluoroethylene production	b9840962-2b9a-4228-9dc8-4846a2196a6b	13.40%								
High fructose corn syrup	02439b8f-e6c0-5930-a4ef-6e04a265bb3a			4.80%						
Electricity grid mix 1kV-60kV	34960d4d-af62-43a0-aa76-adc5fcf57246		0.10%						2.00%	
Aluminium ingot mix	84edb17a-79de-4cd7-8340-02b289b30312									7.60%
Barley, flaked	72548fec-d8f2-5cdb-978a-7ff9b4dffdc9	2.40%								
Barley grain; GB	5bdaca17-d5e9-4b18-b4ee-b2af932f9e04	2.70%								
Barley grain; ES	d2090bfe-6970-42c0-af0d-59e971df53cf	10.50%								
Barley grain; DE	3bba2dd4-07ba-4c6b-9fe0-2f4b6a637815	11.00%								
Barley grain; GR	8d0a3908-d4c2-499c-9cdc-ef92c285aef0	2.0%								
Barley grain; FR	d6643b5f-5c5d-4063-8a0e-4ae7c1d21388	3.30%								
Barley grain; IT	72684db4-ee1c-4c04-b21f-eba91941e23e	2.40%								
Container glass, virgin	5ccf94ab-173c-4688-bcc8-d434166be45e					12.40%				7.30%

Table 12.
List of the most relevant processes (Particulate matter). Total contribution = 80.8%.

Particulate matter	UUID	Cultivation of grain for malting	Malting	Other raw materials and processing	Inbound distribution	Packaging and material production	Brewery operations	Distribution of beer	Use stage	End of Life
Maize flaked	07b65f7c-e671-46d1-bea5-dcd8eadb5cfc	2.30%								
Solid board box	10fcccac-a13c-4650-b093-8102724bd342					4.20%				
Electricity grid mix 1kV-60kV	34960d4d-af62-43a0-aa76-adc5fcf57246		0.50%						8.10%	
Aluminium ingot mix	84edb17a-79de-4cd7-8340-02b289b30312									2.60%
Secondary Copper Cathode	af91267f-51b4-42d0-a2ff-9c71bcb3d578								1.40%	
Stainless steel cold rolled	468733f6-fc88-4da5-b9ff-e548059234c5					1.20%			2.30%	
Kraft paper, uncoated	03dea8f0-44e0-4bf3-a862-bb572c9d5f5e									1.40%
Steel cold rolled coil	3f445970-7d74-4d19-8be7-f9fba0b454b4								1.80%	1.10%
Barley, flaked	72548fec-d8f2-5cdb-978a-7ff9b4dffdc9	1.30%								
Barley grain; PL	c594abec-b704-4e23-aa60-d89258eb0c61	1.40%								
Barley grain; GB	5bdaca17-d5e9-4b18-b4ee-b2af932f9e04	1.80%								
Barley grain; ES	d2090bfe-6970-42c0-af0d-59e971df53cf	4.40%								
Barley grain; DE	3bba2dd4-07ba-4c6b-9fe0-2f4b6a637815	3.70%								
Barley grain; FR	d6643b5f-5c5d-4063-8a0e-4ae7c1d21388	2.90%								
Articulated lorry transport, Euro 4, Total weight >32 t (without fuel)	e1ded83e-a02f-42cd-92f9-81cce21a3a98	0.30%			0.40%			2.10%		0.30%
Container glass, ER, Recycled Content 100%	ab4e945f-9955-4414-b3fb-d42507cc4e2d					0.70%				3.70%
Container glass, virgin	5ccf94ab-173c-4688-bcc8-d434166be45e					11.90%				7.00%
Can beverage, body steel	7086f405-906e-403e-9216-921c17191ec5					1.30%				
Can beverage, body aluminium	4ae8619c-4eb7-42ea-9105-eb5ee9e4ed6e					6.90%				
Can beverage, sanitary end aluminium	95275ae7-af41-48aa-bef9-8259f1b31e71					2.00%				
Cap, ECCS steel	ef4e440e-05b3-4dd7-afbc-f24b4e625634					1.80%				

Table 13.
List of the most relevant processes (Resource use, minerals and metals). Total contribution = 84.2%.

Resource use, minerals and metals	UUID	Cultivation of grain for malting	Malting	Other raw materials and processing	Inbound distribution	Packaging and material production	Brewery operations	Distribution of beer	Use stage	End of Life
Secondary Copper Cathode	af91267f-51b4-42d0-a2ff-9c71bcb3d578								39.00%	
Stainless steel cold rolled	468733f6-fc88-4da5-b9ff-e548059234c5					6.90%			13.00%	
Container glass, virgin	5ccf94ab-173c-4688-bcc8-d434166be45e					2.70%				1.60%
PET bottle, transparent	7d518e67-59cd-4f12-a5af-8f158aa3fa1f					16.40%				
Cap, ECCS steel	ef4e440e-05b3-4dd7-afbc-f24b4e625634					4.60%				

Table 14.
List of the most relevant processes (Land use). Total contribution = 81.28%.

Land use	UUID	Cultivation of grain for malting	Malting	Other raw materials and processing	Inbound distribution	Packaging and material production	Brewery operations	Distribution of beer	Use stage	End of Life
Solid board box	10fcccac-a13c-4650-b093-8102724bd342					6.70%				
Secondary Copper Cathode	af91267f-51b4-42d0-a2ff-9c71bcb3d578								40.60%	
Kraft paper, uncoated	03dea8f0-44e0-4bf3-a862-bb572c9d5f5e									4.20%
Barley, flaked	72548fec-d8f2-5cdb-978a-7ff9b4dffdc9	2.30%								
Barley grain; PL	c594abec-b704-4e23-aa60-d89258eb0c61	2.70%								
Barley grain; GB	5bdaca17-d5e9-4b18-b4ee-b2af932f9e04	2.90%								
Barley grain; ES	d2090bfe-6970-42c0-af0d-59e971df53cf	6.50%								
Barley grain; DE	3bba2dd4-07ba-4c6b-9fe0-2f4b6a637815	4.80%								
Barley grain; FR	d6643b5f-5c5d-4063-8a0e-4ae7c1d21388	8.90%								
Barley grain; DK	42495898-b05d-4f6c-afb9-d1004c48ec93	1.70%								

Table 15.
List of the most relevant processes (Acidification). Total contribution = 81.00%.

Acidification	UUID	Cultivation of grain for malting	Malting	Other raw materials and processing	Inbound distribution	Packaging and material production	Brewery operations	Distribution of beer	Use stage	End of Life
Maize flaked;	07b65f7c-e671-46d1-bea5-dcd8eadb5cfc	2.40%								
Solid board box	10fcccac-a13c-4650-b093-8102724bd342					1.50%				
Electricity grid mix 1kV-60kV	34960d4d-af62-43a0-aa76-adc5fcf57246		0.50%						8.00%	
Aluminium ingot mix	84edb17a-79de-4cd7-8340-02b289b30312									2.80%
Stainless steel cold rolled	468733f6-fc88-4da5-b9ff-e548059234c5					0.90%			1.80%	
Kraft paper, uncoated	03dea8f0-44e0-4bf3-a862-bb572c9d5f5e									1.20%
Barley grain; PL	c594abec-b704-4e23-aa60-d89258eb0c61	1.30%								
Barley grain; GB	5bdaca17-d5e9-4b18-b4ee-b2af932f9e04	1.90%								
Barley grain; ES	d2090bfe-6970-42c0-af0d-59e971df53cf	1.40%								
Barley grain; DE	3bba2dd4-07ba-4c6b-9fe0-2f4b6a637815	6.10%								
Barley grain; FR	d6643b5f-5c5d-4063-8a0e-4ae7c1d21388	1.80%								
Barley grain; DK	42495898-b05d-4f6c-afb9-d1004c48ec93	1.20%								
Articulated lorry transport, Euro 4, Total weight >32 t (without fuel)	e1ded83e-a02f-42cd-92f9-81cce21a3a98	0.70%			0.90%			5.40%		0.70%
Container glass, ER, Recycled Content 100%	ab4e945f-9955-4414-b3fb-d42507cc4e2d					1.20%				6.00%
Container glass, virgin	5ccf94ab-173c-4688-bcc8-d434166be45e					14.70%				8.60%
Can beverage, body aluminium	4ae8619c-4eb7-42ea-9105-eb5ee9e4ed6e					7.80%				
Can beverage, sanitary end aluminium	95275ae7-af41-48aa-bef9-8259f1b31e71					2.20%				

Table 16.
List of the most relevant processes (Eutrophication, marine). Total contribution = 80.89%.

Eutrophication, marine	UUID	Cultivation of grain for malting	Malting	Other raw materials and processing	Inbound distribution	Packaging and material production	Brewery operations	Distribution of beer	Use stage	End of Life
Maize flaked;	07b65f7c-e671-46d1-bea5-dcd8eadb5cfc	3.80%								
High fructose corn syrup	02439b8f-e6c0-5930-a4ef-6e04a265bb3a			2.40%						
Solid board box	10fcccac-a13c-4650-b093-8102724bd342					2.00%				
Electricity grid mix 1kV-60kV	34960d4d-af62-43a0-aa76-adc5fcf57246		0.20%						2.80%	
Barley, flaked	72548fec-d8f2-5cdb-978a-7ff9b4dffdc9	3.30%								
Wheat grain;	0f8ec2a7-37d4-468c-8e9d-2c3151f2506a	1.40%								
Barley grain; PL	c594abec-b704-4e23-aa60-d89258eb0c61	3.40%								
Barley grain; GB	5bdaca17-d5e9-4b18-b4ee-b2af932f9e04	5.70%								
Barley grain; ES	d2090bfe-6970-42c0-af0d-59e971df53cf	9.90%								
Barley grain; CZ	ac34dfa9-c3f4-4d5d-ad22-d4bfbf0822ad	1.80%								
Barley grain; DE	3bba2dd4-07ba-4c6b-9fe0-2f4b6a637815	11.10%								
Barley grain; FR	d6643b5f-5c5d-4063-8a0e-4ae7c1d21388	6.40%								
Barley grain; DK	42495898-b05d-4f6c-afb9-d1004c48ec93	3.10%								
Barley grain; FI	abcc0c3a-960c-40a4-930c-e7f8a3003cca	1.70%								
Articulated lorry transport, Euro 4, Total weight >32 t (without fuel)	e1ded83e-a02f-42cd-92f9-81cce21a3a98	0.60%			0.80%			4.60%		0.60%
Container glass, ER, Recycled Content 100%	ab4e945f-9955-4414-b3fb-d42507cc4e2d					0.50%				2.80%
Container glass, virgin	5ccf94ab-173c-4688-bcc8-d434166be45e					6.20%				3.70%
Can beverage, body aluminium	4ae8619c-4eb7-42ea-9105-eb5ee9e4ed6e					2.10%				

4.4 Data gaps and proxies

Frequently encountered data gaps on company-specific data and how to deal with them:

- *Packaging and material production:*
  - *Bill of Materials (BoM): It could be that raw materials are used which are not listed in the default BoM so for which also no default EF-compliant datasets are listed. The approach as listed in section A.4.4.2. of Commission Recommendation (EU) 2021/2279, about which datasets to use, shall be applied.*
- *Brewery operations:*
  - *Beer ingredient: It could be that beer ingredients are used which are not listed in the default BoM so for which also no default EF-compliant datasets is listed. The approach as listed in section A.4.4.2. of Commission Recommendation (EU) 2021/2279, about which datasets to use, shall be applied.*
  - *Reuse rates: Please apply the approach as stated in section 6, about packaging reuse rates.*

The list of data gaps in available datasets and the proxies to be used by PEF studies are listed in the associated supplementary information named "Supporting material revised PEFCR for beer- Company specific data" (Annex 4.1). One example is "Malt extract (liquid)" for which no EF-compliant dataset is available. The supporting material states (see worksheet brewery in Annex 4.1) that the dataset to be used as proxy is "Roast malt from malting at plant per kg". All proxies are in line with the proxies used in the benchmark model. Another example is fruit concentrates, for which no EF-compliant dataset is available. The supporting material indicates *(see worksheet brewery in Annex 4.1)* that the dataset to be used as a proxy is " high fructose corn syrup; technology mix; production mix, at plant".

Activities related to the beer loss itself are excluded in this PEFCR study.

5. Life cycle inventory

All newly created datasets shall be EF or ILCD-EL compliant (see rules in section B 5.5 of Commission Recommendation (EU) 2021/2279).

Sampling is not allowed.

5.1 List of mandatory company-specific data

The following life cycle stages shall be modelled with company-specific data:

- *At least 60%*[11] *(based on w/w*[13] *of the BoM from the beer) of the sum of malting and other raw materials and processing;* the other share (40% w/w) can be derived from secondary data. Section 6.1.2 provides information about default data to be used.
    - *Please note that only company-specific data is needed for malting and processing of the crops in the LCS 'Other raw materials and processing'. No company-specific data is required for cultivating the crops (before they are processed).*
- *At least 80% (based on w/w of the BoM from the beer) of the primary packaging materials;* the other share (20% w/w) can be derived from secondary data. Section 6.1.3 provides information about default data to be used.
- *At least 60% (based on w/w of the BoM from the beer) of inbound distribution;* the other share (40% w/w) can be derived from secondary data. Section 6.1.4 provides information about default data to be used.
- *Brewery operations.*

See Section 3.2 for definition of BoM from the Beer.

*Studies which do not fulfil above requirements are not compliant to this PEFCR. All relevant information to fulfil above requirements on company-specific data (e.g. activity data, datasets to be used) is listed in the associated supplementary information named "*Supporting material revised PEFCR for beer -– Company- specific data*" (See Annex 4.1). The activity data request on raw materials for container glass is provided as an example in the below Table **17**. In the supporting material are also the DQRs of the EF-compliant datasets embedded.*

Example Glass bottle production

Table 17 shows example of activity data that shall be collected and the default datasets of the sub-processes linked to the activity data within the Glass bottle production process. The full list of all processes is included in the supporting material – worksheet 'Glass bottle production' (Annex 4.1).

[11] Water, a main ingredient of beer, does not count against the 60%. The mass fraction abbreviation w/w is sometimes also called the 'percentage by mass' or the 'percentage by weight'.

Table 17.
Example of the activity data request from the supporting material (please see the supporting material worksheet 'Glass bottle production' in Annex 4.1 for an overview of all required activity data)

Requirements for data collection purposes				**Requirements for modelling purposes**							
Glass bottle production	Company specific data shall be gathered over a period of 12 months (full reporting year) and not be older than 3 years.	1000 kg	Default dataset to be used	Dataset source (i.e. node)	UUID	TiR	TeR	GeR	P	DQR*	
Inputs:											
Post consumer glass cullets		kg	Container glass, ER, Recycled Content 100% Recycled container glass (all sizes) to be used for glass bottles and food jars Production mix. Technology mix. EU-28 + EFTA 1 kg of formed and finished recycled container glass	https://lcdn.thinkstep.com/ (Sphera)	ab4e945f-9955-4414-b3fb-d42507cc4e2d	2.00	2.00	2.00	2.00	2.00	
Silica sand		kg	Silica sand production; technology mix; production mix, at plant; 100% active substance	http://ecoinvent.lca-data.com/ (Ecoinvent)	573168e4-8f9e-46a3-a684-6187deeea33d	1.00	1.00	1.00	2.00	1.25	

* Note that DQR needs to be adapted by the practitioner.

Table 17. (Ctd)
Example of the activity data request from the supporting material (please see the supporting material worksheet 'Glass bottle production' in Annex 4.1 for an overview of all required activity data)

Requirements for data collection purposes				**Requirements for modelling purposes**								**Remarks**
Glass bottle production	Company specific data shall be gathered over a period of 12 months (full reporting year) and not be older than 3 years.	1000 kg	Default dataset to be used	Dataset source (i.e. node)	UUID	TiR	TeR	GeR	P	DQR*	
Inputs:												
Synthetic soda		kg	Soda production; technology mix; production mix, at plant; 100% active substance	http://ecoinvent.lca-data.com/ (Ecoinvent)	546d4097-a453-4706-ac17-389325a04b6f	1.00	2.00	2.00	2.00	1.75	
Natural soda		kg	Soda production; technology mix; production mix, at plant; 100% active substance	http://ecoinvent.lca-data.com/ (Ecoinvent)	546d4097-a453-4706-ac17-389325a04b6f	1.00	2.00	2.00	2.00	1.75	
Limestone		kg	Calcium carbonate production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/ (Ecoinvent)	616b719c-0787-4329-a076-318e7adad458	1.00	1.00	1.00	2.00	1.25	Proxy data gap

* Note that DQR needs to be adapted by the practitioner.

Table 17. (Ctd)
Example of the activity data request from the supporting material (please see the supporting material worksheet 'Glass bottle production' in Annex 4.1 for an overview of all required activity data)

Requirements for data collection purposes				**Requirements for modelling purposes**							**Remarks**
Glass bottle production	Company specific data shall be gathered over a period of 12 months (full reporting year) and not be older than 3 years.	1000 kg	Default dataset to be used	Dataset source (i.e. node)	UUID	TiR	TeR	GeR	P	DQR*	
Inputs:											
Dolomite		kg	Dolomite grinding dolomite grinding production mix, at plant 2.90 g/cm3	https://lcdn.thinkstep.com/ (Sphera)	d1ca8b8c-99a5-41ef-b7ed-b314aed266dc	2.00	3.00	3.00	2.00	2.50	
Feldspar		kg	Feldspar (mining, open pit) feldspar mining, washing, drying production mix, at plant 2.56 g/cm3	https://lcdn.thinkstep.com/ (Sphera)	f0529d11-796d-4607-aec5-b9b816a37c0e	2.00	3.00	3.00	2.00	2.50	
Oxygen		kg	Oxygen production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/ (Ecoinvent)	b12a9897-9ebb-41e9-8c3b-18db23ecd99e	1.00	1.00	1.00	2.00	1.25	

* Note that DQR needs to be adapted by the practitioner.

5.2 List of processes expected to be run by the company

There are no further processes expected to be run by the company in addition to those listed as mandatory company-specific data.

5.3 Data quality requirements

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

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

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

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

5.3.1 Company-specific datasets

The DQR shall be calculated at the level-1 disaggregation, before any aggregation of sub-processes or elementary flows is performed. The DQR of company-specific datasets shall be calculated as following:

1) *Select the most relevant activity data and direct elementary flows: most relevant activity data are the ones linked to sub-processes (i.e. secondary datasets) that account for at least 80% of the total environmental impact of the company-specific dataset, listing them from the most contributing to the least contributing one. Most relevant direct elementary flows are defined as those direct elementary flows contributing cumulatively at least with 80% to the total impact of the direct elementary flows.*
2) *Calculate the DQR criteria TeR, TiR, GeR and P for each most relevant activity data and each most relevant direct elementary flow. The values of each criterion shall be assigned based on Table **18**.*
    a. *Each most relevant direct elementary flow consists of the amount and elementary flow naming (e.g. 40 g carbon dioxide). For each most relevant elementary flow, the user of the PEFCR shall evaluate the 4 DQR criteria named TeR_{-EF}, TiR_{-EF}, GeR_{-EF}, P_{EF}. For example, the user of the PEFCR shall evaluate the timing of the flow measured, for which technology the flow was measured and in which geographical area.*
    b. *For each most relevant activity data, the 4 DQR criteria shall be evaluated (named T_eR_{-AD} TiRAD, GeR_{-AD}, P_{AD}) by the user of the PEFCR.*
    c. *Considering that the data for the mandatory processes shall be company-specific, the score of P cannot be higher than 3, while the score for TiR, TeR, and GeR cannot be higher than 2 (The DQR score shall be ≤1.5).*
3) *Calculate the environmental contribution of each most relevant activity data (through linking to the appropriate sub-process) and each most relevant direct elementary flow to the total sum of the environmental impact of all most-relevant activity data and direct elementary flows, in % (weighted, using all EF impact categories). For example, the newly developed dataset has only two most relevant activity data, contributing in total to 80% of the total environmental impact of the dataset:*

a. *Activity data 1 carries 30% of the total dataset environmental impact. The contribution of this process to the total of 80% is 37.5% (the latter is the weight to be used).*
b. *Activity data 2 carries 50% of the total dataset environmental impact. The contribution of this process to the total of 80% is 62.5% (the latter is the weight to be used).*

4) *Calculate the TeR, TiR, GeR and P criteria of the newly developed dataset as the weighted average of each criteria of the most relevant activity data and direct elementary flows. The weight is the relative contribution (in %) of each most relevant activity data and direct elementary flow calculated in step 3.*
5) *The user of the PEFCR shall calculate the total DQR of the newly developed dataset using Equation 1, where TeR, TiR, GeR and P are the weighted average* calculated as specified in point (4).

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

Table 18.
How to assess the value of the DQR criteria for datasets with company-specific

Rating	***P_{EF} and P_{AD}***	***TiR_{EF} and TiR_{AD}***	***TeR_{EF} and TeR_{AD}***	***GeR_{EF} and GeR_{AD}***
1	*Measured/calculated and externally verified*	*The data refers to the most recent annual administration period with respect to the EF report publication date*	*The elementary flows and the activity data explicitly depict the technology of the newly developed dataset*	*The activity data and elementary flows reflect the exact geography where the process modelled in the newly created dataset takes place*
2	*Measured/ calculated and internally verified, plausibility checked by reviewer*	*The data refers to maximum 2 annual administration periods with respect to the EF report publication date*	*The elementary flows and the activity data are a proxy of the technology of the newly developed dataset*	*The activity data and elementary flows partly reflect the geography where the process modelled in the newly created dataset takes place*
3	*Measured/ calculated/ literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer*	*The data refers to maximum three annual administration periods with respect to the EF report publication date*	*Not applicable*	*Not applicable*
4-5	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*

***P_{EF}**: Precision for elementary flows; **P_{AD}**: Precision for activity data; **TiR_{EF}**: Time Representativeness for elementary flows; **TiR_{AD}**: Time representativeness for activity data; **TeR_{EF}**: Technology representativeness for elementary flows; **TeR_{AD}**: Technology representativeness for activity data; **GeR_{EF}**: Geographical representativeness for elementary flows; **GeR_{AD}:** Geographical representativeness for activity data.*

5.4 Data needs matrix (DNM)

*All processes required to model the product and outside the list of mandatory company-specific data (listed in section 5.1) shall be evaluated using the Data Needs Matrix (see Table **19**). The user of the PEFCR shall apply the DNM to evaluate which data is needed and shall be used within the modelling of its PEF, depending on the level of influence the user of the PEFCR (company) has on the specific process. The following three cases are found in the DNM and are explained below:*

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

***2. Situation 2:** the process is not run by the company applying the PEFCR but the company has access to (company-)specific information;*

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

5.4.1 Processes in situation 1

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

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

5.4.1.1 Situation 1/Option 1

For all processes run by the company and where the user of the PEFCR applies company-specific data. The DQR of the newly developed dataset shall be evaluated as described in section 5.3.1.

5.4.1.2 Situation 1/Option 2

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

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

5.4.2 Processes in situation 2

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

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

5.4.2.1 Situation 2/Option 1

For all processes not run by the company and where the user of the PEFCR applies company-specific data, the DQR of the newly developed dataset shall be evaluated as described in section 5.3.1.

Table 19.
Data Needs Matrix (DNM)[12]. *Disaggregated datasets shall be used.

		Most relevant process	***Other process***
Situation 1: process run by the company using the PEFCR	*Option 1*	*Provide company-specific data (as requested in the PEFCR) and create a company-specific dataset, in aggregated form (DQR≤1.5)[13]* *Calculate the DQR values (for each criterion + total)*	
	Option 2		*Use default secondary dataset in PEFCR, in aggregated form (DQR≤3.0)* *Use the default DQR values*
Situation 2: process not run by the company using the PEFCR but with access to company-specific information	*Option 1*	*Provide company-specific data (as requested in the PEFCR) and create a company-specific dataset, in aggregated form (DQR≤1.5)* *Calculate the DQR values (for each criterion + total)*	
	Option 2	*Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤3.0)** *Re-evaluate the DQR criteria within the product specific context*	
	Option 3		*Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤4.0)** *Use the default DQR values.*
Situation 3: process not run by the company using the PEFCR and without access to company specific information	Option 1	*Use default secondary data set in aggregated form (DQR≤3.0)* *Re-evaluate the DQR criteria within the product specific context*	
	Option 2		*Use default secondary data set in aggregated form (DQR≤4.0)* *Use the default DQR values*

[12] *The options described in the DNM are not listed in order of preference.*
[13] *Company-specific datasets shall be made available to the Commission.*

5.4.2.2 Situation 2/Option 2

The user of the PEFCR shall use company-specific activity data for transport and shall substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets, starting from the default secondary dataset provided in the PEFCR. Please note that the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required.

*The user of the PEFCR shall make the DQR context-specific by re-evaluating TeR and TiR using the Table **20**. The criteria GeR shall be lowered by 30%[14] and the criteria P shall keep the original value.*

5.4.2.3 Situation 2/Option 3

The user of the PEFCR shall apply company-specific activity data for transport and shall substitute the subprocesses used for electricity mix and transport with supply-chain specific EF compliant datasets, starting from the default secondary dataset provided in the PEFCR.

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

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

Table 20.
How to assess the value of the DQR criteria when secondary datasets are used.

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

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

5.4.3 Processes in situation 3

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

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

5.4.3.1 Situation 3/Option 1

In this case, the user of the PEFCR shall make the DQR values of the dataset used context-specific by re-evaluating TeR, TiR and GeR, using the table provided (adapted from Table **20)**. *The criteria P shall keep the original value.*

5.4.3.2 Situation 3/Option 2

For the non-most relevant processes, the user of the PEFCR shall apply the corresponding secondary dataset listed in the PEFCR together with its DQR values.
If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the original dataset.

5.5 Datasets to be used

This PEFCR lists the secondary datasets to be applied by the user of the PEFCR. Whenever a dataset needed to calculate the PEF profile is not among those listed in this PEFCR, then the user shall choose between the following options (in hierarchical order):

1) *Use an EF compliant dataset available on one of the nodes of the Life Cycle Data Network[15];*
2) *Use an EF compliant dataset available in a free or commercial source;*
3) *Use another EF compliant dataset considered to be a good proxy. In such case this information shall be included in the 'limitations' section of the PEF report;*
4) *Use an ILCD-EL compliant dataset as proxy. These datasets shall be included in the 'limitations' section of the PEF report. A maximum of 10% of the single overall score may be derived from ILCD-EL compliant datasets. The nomenclature of the elementary flows of the dataset shall be aligned with the EF reference package used in the rest of the model[16] ;*
5) *If no EF compliant or ILCD-EL compliant dataset is available, it shall be excluded from the PEF study. This shall be clearly stated in the PEF report as a data gap and validated by the PEF study and PEF report verifiers.*

5.6 How to calculate the average DQR of the study

To calculate the average DQR of the PEF study, the user of the PEFCR shall calculate separately the TeR, TiR, GeR and P for the PEF study as the weighted average of all most relevant processes, based on their relative environmental contribution to the total single overall score. The calculation rules explained in section 4.6.5.8 of Annex I (Commission Recommendation (EU) 2021/2279) shall be used.

[15] http://eplca.jrc.ec.europa.eu/LCDN/
[16] http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml

5.7 Allocation rules

The following allocation rules shall be used by the user of this PEFCR study:

Table 21.
Allocation rules

Process	Allocation rule	Modelling instructions
Processing of crops to beer ingredients	*Economic allocation*	*Economic allocation shall be conducted with allocation factors calculated based on the company-specific data or based on the accompanying MS Excel file named: "Feed for food producing animals_v5 - Life cycle inventory.xlsx" of the feed PEFCR when no company-specific data is applied (See Annex 4.3).*
Distribution	*Physical allocation*	*Allocation of transport emissions to transported products shall be done on the basis of physical causality, such as mass or volume.*
Malting	*No allocation*	*Avoid allocation, by putting 100% of the impact on beer if the co-products are used for animal feed purposes[17].* *Use the Circular Footprint Formula in all other cases. (e.g. discharged to a pond, landfilling).*
Brewery operations – allocation between beverages	*Physical allocation*	*Physical allocation shall be applied based on the produced volume.*
Brewery operations – allocation between beverages and other co-products (e.g. brewers' grain)	*No allocation*	*Avoid allocation, by putting 100% of the impact on beer if the co-products are used for animal feed purposes. See also the sensitivity analysis in Annex 4.2.*

5.8 Electricity modelling

The following electricity mix shall be used in hierarchical order:

(a) *Supplier-specific electricity product shall be used if for a country there is a 100% tracking system in place, or if:*
  (i) *available, and*
  (ii) *the set of minimum criteria to ensure the contractual instruments are reliable is met.*

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

(c) *The 'country-specific residual grid mix, consumption mix' shall be used. Country-specific means the country in which the life cycle stage or activity occurs. This may be an EU country or non-EU country. The residual grid mix prevents double counting with the use of supplier-specific electricity mixes in (a) and (b).*

(d) *As a last option, the average EU residual grid mix, consumption mix (EU+EFTA), or region representative residual grid mix, consumption mix, shall be used.*

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

[17] *Avoiding of allocation is applicable only for this PEFCR. The avoidance of allocation is not authorised for the environmental impact of brewers' grain which leaves the brewery because this could bias the choice in feed ingredients in compound feeds (which is out of scope of this PEFCR).*

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

Set of minimum criteria to ensure contractual instruments from suppliers

A supplier-specific electricity product/ mix may only be used if the user of the PEF method ensures that the contractual instrument meets the criteria specified below. If contractual instruments do not meet the criteria, then country-specific residual electricity consumption-mix shall be used in the modelling.

The list of criteria below is based on the criteria of the GHG Protocol Scope 2 Guidance[18]–. A contractual instrument used for electricity modelling shall:

Criterion 1 – Convey attributes

1) *Convey the energy type mix associated with the unit of electricity produced.*
2) *The energy type mix shall be calculated based on delivered electricity, incorporating certificates sourced and retired (obtained or acquired or withdrawn) on behalf of its customers. Electricity from facilities for which the attributes have been sold off (via contracts or certificates) shall be characterized as having the environmental attributes of the country residual consumption mix where the facility is located.*

Criterion 2 – Be a unique claim

1) *Be the only instruments that carry the environmental attribute claim associated with that quantity of electricity generated.*
2) *Be tracked and redeemed, retired, or cancelled by or on behalf of the company (e.g. by an audit of contracts, third party certification, or may be handled automatically through other disclosure registries, systems, or mechanisms).*

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

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

Datasets for residual grid mix, consumption mix, per energy type, per country and per voltage are made available by data providers.

If no suitable dataset is available, the following approach should be used:

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

[18] *World Resources Institute (WRI) and World Business Council for Sustainable Development WBCSD (2015): GHG Protocol Scope 2 Guidance. An amendment to the GHG Protocol. Corporate Standard*

Activity data related to non-EU country consumption mix per detailed energy type shall be determined based on:

1) *Domestic production mix per production technologies;*
2) *Imported quantity and from which neighbouring countries;*
3) *Transmission losses;*
4) *Distribution losses;*
5) *Type of fuel supply (share of resources used, by import and / or domestic supply).*

These data may be found in the publications of the International Energy Agency (IEA (www.iea.org).

Available LCI datasets per fuel technologies. The LCI datasets available are generally specific to a country or a region in terms of:

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

Allocation rules:

Table 22.
Allocation rules for electricity

Process	Physical relationship	Modelling instructions
The same allocation rules shall be applied for electricity as mentioned in section 5.7 and Table **21**.	*The same allocation rules shall be applied for electricity as mentioned in section 5.7 and* Table **21**.	*The same allocation rules shall be applied for electricity as mentioned in section 5.7 and* Table **21**.

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

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

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

On-site electricity generation:

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

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

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

1) *If possible, apply subdivision. Subdivision applies both to separate electricity productions or to a common electricity production where you may allocate based on electricity amounts the upstream and direct emissions to your own consumption and to the share you sell out of your company (e.g. if a company has a windmill on its production site and exports 30% of the produced electricity, emissions related to 70% of produced electricity should be accounted in the PEF study).*
2) *If not possible, direct substitution shall be used. The country-specific residual consumption electricity mix shall be used as substitution[19].*
   Subdivision is considered as not possible when upstream impacts or direct emissions are closely related to the product itself.

5.9 Climate change modelling

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

1) ***Climate change – fossil:*** *This sub-category includes emissions from peat and calcination/carbonation of limestone. The emission flows ending with '(fossil)' (e.g., 'carbon dioxide (fossil)' and 'methane (fossil)') shall be used, if available.*
2) ***Climate change – biogenic:*** *This sub-category covers carbon emissions to air (CO2, CO and CH4) originating from the oxidation and/or reduction of biomass by means of its transformation or degradation (e.g. combustion, digestion, composting, landfilling) and CO_2 uptake from the atmosphere through photosynthesis during biomass growth – i.e. corresponding to the carbon content of products, biofuels or aboveground plant residues, such as litter and dead wood. Carbon exchanges from native forests[20] shall be modelled under sub-category 3 (incl. connected soil emissions, derived products, residues). The emission flows ending with '(biogenic)' shall be used.*

   A simplified modelling approach shall be used when modelling foreground emissions.

   The product life cycle or part of the life cycle does not have a carbon storage beyond 100 years and therefore credits from biogenic carbon storage must not be modelled.
3) ***Climate change – land use and land use change****: This sub-category accounts for carbon uptakes and emissions (CO2, CO and CH4) originating from carbon stock changes caused by land use change and land use. This sub-category includes biogenic carbon exchanges from deforestation, road construction or other soil activities (including soil carbon emissions). For native forests, all related CO_2 emissions are included and modelled under this sub-category (including connected soil emissions, products derived from native forest[21] and residues), while their CO_2 uptake is excluded. The emission flows ending with '(land use change)' shall be used.*

   For land use change, all carbon emissions and removals shall be modelled following the modelling guidelines of PAS 2050:2011 (BSI 2011) and the supplementary document PAS2050-1:2012 (BSI 2012) for horticultural products. PAS 2050:2011 (BSI 2011): 'Large emissions of GHGs can result as a consequence of land use change. Removals as a direct result of land use change (and not as a result of long-term management practices) do not usually occur, although it is recognized that this could

[19] *For some countries, this option is a best case rather than a worst case.*
[20] *Native forests – represents native or long-term, non-degraded forests. Definition adapted from Table 8 in the Annex of Commission Decision C(2010)3751 on guidelines for the calculation of land carbon stocks for the purpose of Annex V of Directive 2009/28/EC.*
[21] *Following the instantaneous oxidation approach in IPCC 2013 (Section 2).*

happen in specific circumstances. Examples of direct land use change are the conversion of land used for growing crops to industrial use or conversion from forestland to cropland. All forms of land use change that result in emissions or removals are to be included. Indirect land use change refers to such conversions of land use as a consequence of changes in land use elsewhere. While GHG emissions also arise from indirect land use change, the methods and data requirements for calculating these emissions are not fully developed. Therefore, the assessment of emissions arising from indirect land use change is not included.

The GHG emissions and removals arising from direct land use change shall be assessed for any input to the life cycle of a product originating from that land and shall be included in the assessment of GHG emissions. The emissions arising from the product shall be assessed on the basis of the default land use change values provided in PAS 2050:2011 Annex C, unless better data is available. For countries and land use changes not included in this annex, the emissions arising from the product shall be assessed using the included GHG emissions and removals occurring as a result of direct land use change in accordance with the relevant sections of the IPCC (2006). The assessment of the impact of land use change shall include all direct land use change occurring not more than 20 years, or a single harvest period, prior to undertaking the assessment (whichever is the longer). The total GHG emissions and removals arising from direct land use change over the period shall be included in the quantification of GHG emissions of products arising from this land on the basis of equal allocation to each year of the period[22].

1) Where it can be demonstrated that the land use change occurred more than 20 years prior to the assessment being carried out, no emissions from land use change should be included in the assessment.
2) Where the timing of land use change cannot be demonstrated to be more than 20 years, or a single harvest period, prior to making the assessment (whichever is the longer), it shall be assumed that the land use change occurred on 1 January of either:

the earliest year in which it can be demonstrated that the land use change had occurred; or

on 1 January of the year in which the assessment of GHG emissions and removals is being carried out.

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

1) where the country of production is known and the previous land use is known, the GHG emissions and removals arising from land use change shall be those resulting from the change in land use from the previous land use to the current land use in that country (additional guidelines on the calculations can be found in PAS 2050-1:2012);
2) where the country of production is known, but the former land use is not known, the GHG emissions arising from land use change shall be the estimate of average emissions from the land use change for that crop in that country (additional guidelines on the calculations can be found in PAS 20501:2012);
3) where neither the country of production nor the former land use is known, the GHG emissions arising from land use change shall be the weighted average of the average land use change emissions of that commodity in the countries in which it is grown.

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

Knowledge of the prior land use can be demonstrated using a number of sources of information, such as satellite imagery and land survey data. Where records are not available, local knowledge of prior land use can be used. Countries in which a crop is grown can be determined from import statistics, and a cutoff threshold of not less than 90% of the weight of imports may be applied. Data sources, location and timing of land use change associated with inputs to products shall be reported' [end of quote from PAS 2050:2011]

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

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

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

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

5.10 Modelling of end of life and recycled content

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

The circular footprint formula (CFF) is used to model the end of life of products as well as the recycled content and is a combination of 'material + energy + disposal', i.e.:

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

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

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

With the following parameters
***A:** allocation factor of burdens and credits between supplier and user of recycled materials.*
***B:** allocation factor of energy recovery processes. It applies both to burdens and credits. It shall be set to zero for all PEF studies.*
***Qs_{in}:** quality of the ingoing secondary material, i.e. the quality of the recycled material at the point of substitution.*
***Qs_{out}:** quality of the outgoing secondary material, i.e. the quality of the recyclable material at the point of substitution.*
***Q_p:** quality of the primary material, i.e. quality of the virgin material.*
***R_1:** it is the proportion of material in the input to the production that has been recycled from a previous system.*
***R_2:** it is the proportion of the material in the product that will be recycled (or reused) in a subsequent system. R2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R2 shall be measured at the output of the recycling plant.*

R_3: *it is the proportion of the material in the product that is used for energy recovery at EoL.*
$E_{recycled}$ (E_{rec}): *specific emissions and resources consumed (per functional unit) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.*
$E_{recyclingEoL}$ (E_{recEoL}): *specific emissions and resources consumed (per functional unit) arising from the recycling process at EoL, including collection, sorting and transportation process.*
E_v: *specific emissions and resources consumed (per functional unit) arising from the acquisition and preprocessing of virgin material.*
E^*_v: *specific emissions and resources consumed (per functional unit) arising from the acquisition and preprocessing of virgin material assumed to be substituted by recyclable materials.*
E_{ER}: *specific emissions and resources consumed (per functional unit) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, etc.).*
$E_{SE,heat}$ and $E_{SE,elec}$: *specific emissions and resources consumed (per functional unit) that would have arisen from the specific substituted energy source, heat and electricity respectively.*
ED: *specific emissions and resources consumed (per functional unit) arising from disposal of waste material at the EoL of the analysed product, without energy recovery.*
$X_{ER,heat}$ and $X_{ER,elec}$: *the efficiency of the energy recovery process for both heat and electricity.*
LHV: *lower heating value of the material in the product that is used for energy recovery.*

6. Life cycle stages[23]

6.1 Raw material acquisition and pre-processing

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

6.1.1 Cultivation of grain for malting

The applicant shall use the available EF-compliant datasets for the cultivation of crops. Company-specific data shall not be used.

6.1.2 Malting/Other raw materials and processing

All processing of raw materials shall be linked to the bill of materials of the beer under study. Figure 4 provides the overall simplified process flow of processing beer ingredients.

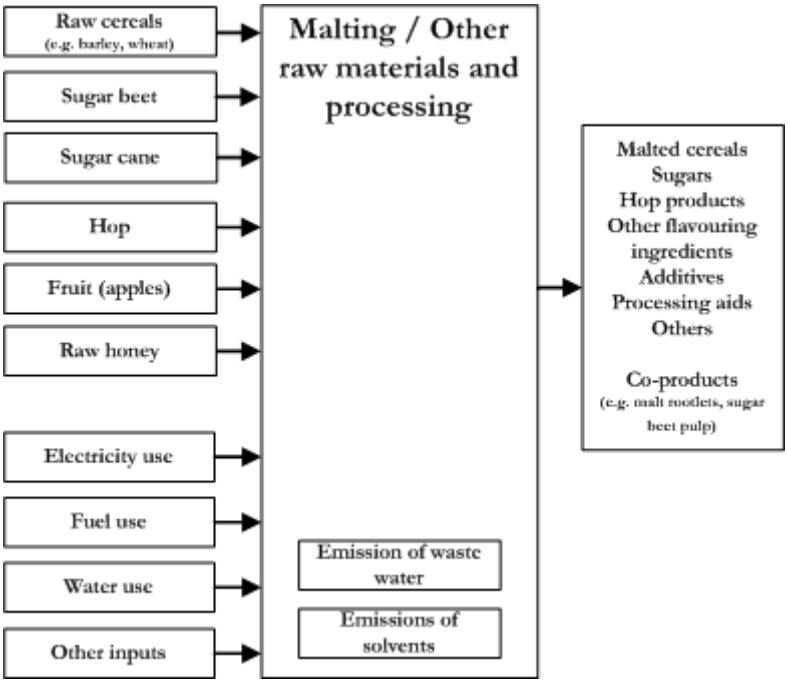


Figure 4: Simplified process flow of malting / Other raw materials and processing.

Malting data and other raw material processing data shall be based on company-specific data for at least 60% (w/w) of the beer ingredients used for the beer (see section 5 on data requirements). The activity data as in the associated supporting material file (see worksheet Maltery in Annex 4.1) shall be collected and connected to the EF-compliant datasets as stated in the supporting material. The company-specific data shall be gathered over a period of 12 months (to even out the impact of seasonality). For the other 40% (w/w) of the beer ingredients used for the beer EF-compliant datasets may be used as listed in the supporting material.

Please note that the supporting material is available for malting (see worksheet Maltery in Annex 4.1) but not for other processing steps (e.g. wet milling, sugar processing) of beer ingredients because this is very ingredient specific. New supporting material shall be

[23] *Relevant information (e.g. activity data, datasets) to be used is listed in the associated supplementary information named "*Annex PEFCR for beer -– Company-specific data*"). The full list of all processes is also included in the* same document.

developed and provided to the verifier of the PEF study. The overall data requests shall have the same level of detail as the existing supporting materials and contains the following elements as a minimum:

- *Geographical location of production plant*
- *Bill of materials*
- *Mass balance of input and output*
- *Thermal energy use and source of energy*
- *Electricity use and its source*
- *Economic prices of the outputs (if the process is multifunctional)*
- *Water use and water type (e.g. tap water, surface water)*
- *Waste water*

The default transport distances are 500km for raw materials to the processing or malting plant. A Euro4 >32ton truck with a utilization rate of 50% shall be used (UUID = f8a8ff8c-3144-471f-9e01-69455f81bed5).

If certain emissions (e.g. NOx, SO2) are measured (in case of abatement), and reported in the company-specific supporting material, the on-site emission profile shall be corrected to these measured emissions.

6.1.3 Packaging and material production

Packaging material is split into primary, secondary and tertiary packaging material according to the definitions of the Global Protocol on Packaging Sustainability 2.0 and Figure 5: Primary, secondary and tertiary packaging material (The Consumer Goods Forum, 2011).

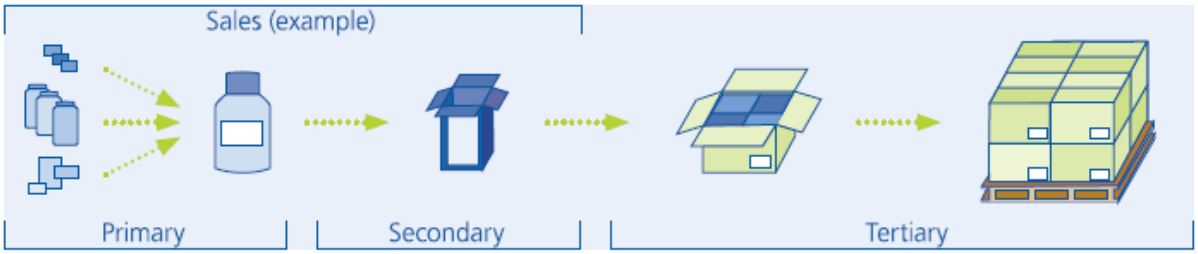


Figure 5: Primary, secondary and tertiary packaging material

80% (w/w) of the primary packaging material production used for the beer under study shall be based on company-specific data as described in section 5.3.1. Activity data shall be gathered over a period of 12 months (to even out the impact of seasonality). Company-specific data are not required for the extraction of the raw materials for a packaging unit (such as silica sand for glass) but only for the packaging supplier processes. This means that at least company-specific data is required from the following packaging material life cycle stages:

- *Glass bottle production plants.*
- *Can body production plants.*
- *Can lid/end production plants.*
- *PET keg / bottle / preform production plants.*
- *Metal keg production plants.*

For the other 20% (w/w) of primary packaging materials and non-primary packaging materials (so secondary and tertiary packaging) used for the beer under study EF-compliant datasets shall be used when primary data is lacking.

*The company-specific data which shall be collected including the background datasets which shall be used are listed in the associated supplementary information named "*Supporting material revised PEFCR for beer– Company-specific data*" (see worksheets 'Glass bottle production', 'Steel keg production' and 'PET keg - bottle production' in Annex 4.1).The company-specific data shall be specific for the plant where the primary packaging material is produced (so no average of multiple production locations). The raw material input (e.g. post-consumer glass cullets) shall be packaging specific based on a yearly average. The other input/output may be yearly averages of the plant.*

The default transport distances are 500km for virgin materials to the packaging production location and 100km for recycled materials. A Euro4 >32ton truck with a utilization rate of 50% shall be used (UUID = f8a8ff8c-3144-471f-9e01-69455f81bed5).

It shall be justified in the PEF study if other datasets are used than those stated in the supporting material.

If certain emissions (e.g. NOx, SO2) are measured (in case of abatement), and reported in the company-specific supporting material, the on-site emission profile shall be corrected to these measured emissions.

Guidance on how to model the production of glass bottles with company-specific data

*The point of substitution is at level 1 when glass is modelled based on company-specific data. This means that Ev is the sum of all the emission profiles of the virgin raw materials (e.g. sand, dolomite, etc) used for the specific beer bottle in the BoM and Ev = E*v. $E_{recycled}$ is the collection, sorting and transportation of glass cullets to the glass factory and $E_{recycled} = E_{recyclingEoL}$.*

Because the point of substitution is at level 1 (before the gate of the glass factory), the CFF is applied on the raw materials and the additional resources and emissions of the glass factory can be calculated and added to the raw materials. This means that the glass factory itself is not part of the CFF.

The following process emissions coming from the carbon in the virgin glass raw materials and emitted from the furnace shall be applied (based on company-specific data from supporting studies):

- *Soda: 0.478 kg CO2-eq. / kg soda*
- *Dolomite: 0.415 kg CO2-eq. / kg dolomite*
- *Limestone/Chalk: 0.440 kg CO2-eq. / kg limestone/chalk*

Guidance of aluminium can bodies, steel can bodies and aluminium can ends with company-specific data

The point of substitution is at level 2. The company-specific data provides at least:

- *how much recycled content is included in the can body/end.*
- *the energy use to produce the can body/end.*
- *The mass balance to produce the can body/end.*

The recycled content shall be reflected in the Ev and Er parameters in the disaggregated can body/end dataset. The disaggregated datasets which shall be used are:

- *Can beverage, body aluminium Aluminium production, can forming, cleaning, drying, printing and varnishing, baking production mix, at plant body aluminium, 2.7 g/cm3*
  - UUID: 4ae8619c-4eb7-42ea-9105-eb5ee9e4ed6e
- *Can beverage, body steel; Steel production, can forming, cleaning, drying, printing and varnishing, baking production mix, at plant body steel*
  - UUID: 7086f405-906e-403e-9216-921c17191ec5

- *Can beverage, sanitary end aluminium Aluminium production, can forming, cleaning, drying, printing and varnishing, baking production mix, at plant aluminium, 2.7 g/cm3*
    - UUID: 95275ae7-af41-48aa-bef9-8259f1b31e71

1. *Please see section 4.4.8.8 of the Commission Recommendation (EU) 2021/2279 for more guidance on how to model the pre-consumer scrap.*

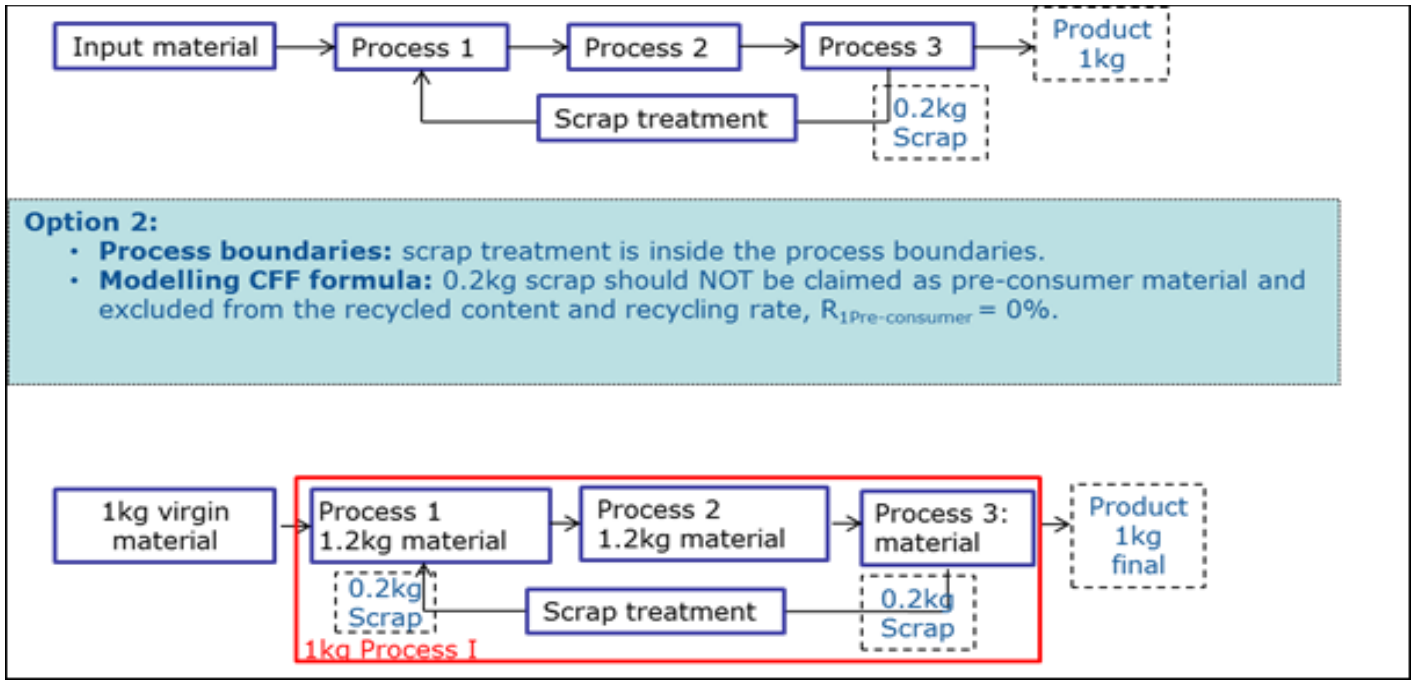


Figure 6: Modelling option when pre-consumer scrap is not claimed as pre-consumer recycled content (option 2 taken from section 4.4.8.8 of the Commission Recommendation (EU) 2021/2279).

*Table **23** provides a default list of EF-compliant datasets which may be used in PEF studies when no company-specific data is required.*

Table 23.
Default list of EF-compliant datasets which shall be used (if applicable) in PEF studies when no company-specific data is required

Packaging type	**EF-compliant dataset name**	**UUID and link to node**
Metal caps	Cap, ECCS steel metal production, cap manufacturing production mix, at plant ESSC steel Cap, tin plated steel; metal production, cap manufacturing; production mix, at plant; tin plated steel	ef4e440e-05b3-4dd7-afbc-f24b4e625634 03953301-bfd0-4064-af89-c0b6523b681f
Plastic caps	Screw cap, HDPE raw material production, plastic injection moulding production mix, at plant 0.91-0.96 g/cm3, 28 g/mol per repeating unit	fa433faf-53fe-4fd1-a6c7-40ded5eee307
Paper labels	Label, paper Kraft pulping process, label production production mix, at plant thickness: 77 µm, grammage: 90 g/m2	7db01ade-8476-4c20-9c0b-7faff30d9f9f
Plastic labels	Label, plastic Polymerisation of ethylene, label production by extrusion production mix, at plant thickness: 100 µm, grammage: 0.0943 kg/m2	3087a31b-a9f1-4fad-ad9b-2d7b88111f60
Shrink foil	Plastic bag, LDPE raw material production, plastic extrusion production mix, at plant thickness: 0.03 mm, grammage: 0.0275 kg/m2	d53d7b71-871e-45ac-8268-81f822514f0a
Trays	Solid board box Kraft Pulping Process, pulp pressing and drying production mix, at plant 280 g/m2, R1=47%	10fcccac-a13c-4650-b093-8102724bd342
Aluminium can body	Can beverage, body aluminium Aluminium production, can forming, cleaning, drying, printing and varnishing, baking production mix, at plant body aluminium, 2.7 g/cm3	4ae8619c-4eb7-42ea-9105-eb5ee9e4ed6e
Aluminium can end/lid	Can beverage, sanitary end aluminium Aluminium production, can forming, cleaning, drying, printing and varnishing, baking production mix, at plant aluminium, 2.7 g/cm3	95275ae7-af41-48aa-bef9-8259f1b31e71
Steel can body	Can beverage, body steel Steel production, can forming, cleaning, drying, printing and varnishing, baking production mix, at plant body steel	7086f405-906e-403e-9216-921c17191ec5
Virgin container glass	Container glass, virgin Virgin container glass (all sizes) to be used for glass bottles and food jars Production mix. Technology mix. EU-28 + EFTA 1 kg of formed and finished container glass	5ccf94ab-173c-4688-bcc8-d434166be45e
Recycled container glass	Container glass, ER, Recycled Content 100% (provided by FEVE) - Aggregated; Recycled container glass (all sizes) to be used for glass bottles and food jars; Production mix. Technology mix. EU-28 + EFTA; 1 kg of formed and finished container glass	ab4e945f-9955-4414-b3fb-d42507cc4e2d
PET bottle	PET bottle, transparent raw material production, blow moulding production mix, at plant 192.17 g/mol per repeating unit	7d518e67-59cd-4f12-a5af-8f158aa3fa1f

Please note that the skeletons from can making are not post-consumer and shall not be included as recycled content (R_1) or as recycling rate (R_2).

Guidance on how to model steel beer tanks

The weight of a 1000 litre tank is 47.2 kg stainless steel. The assumed trip rate is 250 based on 25 refills per year for 10 years.

Reuse rates

Reuse rate is the number of times a packaging material is used (e.g., filled) at the factory. This is often also called trip rates, reuse time or number of rotations. This may be expressed as the absolute number of reuse or as % of reuse rate (See section 4.4.9 of Commission Recommendation (EU) 2021/2279).

For example: a reuse rate of 80% equals 5 reuses. Equation 2 describes the conversion:

$$\textbf{Number of reuse} = \frac{1}{100\% - \%\ reuse\ rate}$$ [Equation 2]

The number of reuses applied here refers to the total number of uses during the life of a packaging. It includes both the first use and all the following reuses.

A packaging return system can be organised by the company owning the packaging material (company owned pools) or can be organised at a higher level by a third party e.g., the government or a pooler (third party operated pools). This may have an influence on the lifetime of the material as well as the data source to be used. Therefore, it is important to separate these two return systems.

For company owned packaging pools the reuse rate shall be calculated using supply-chain-specific data. Depending on the data available within the company, two different calculation approaches may be used (see Option a and b presented below). Returnable glass bottles are used as example but the calculations also apply for other company owned reusable packaging.

Option a: use supply-chain-specific data, based on accumulated experience over the lifetime of the previous glass bottle pool. This is the most accurate way of calculating the reuse rate of bottles for the previous bottle pool and is a proper estimate for the current bottle pool. The following supply chain-specific data is collected:

- *Number of bottles filled during the lifetime of the bottle pool (#Fi)*
- *Number of bottles at initial stock plus purchased over the lifetime of the bottle pool (#B)*

Reuse rate of the bottle pool $= \frac{\#\ F_i}{\#B}$ [Equation 3]

The net glass use (kg glass/l beverage) $= \frac{\#B \times (kg\ glass/bottle)}{\#F_i}$ [Equation 4]

This calculation option shall be used:

1) *With data of the previous bottle pool when the previous and current bottle pool are comparable. Meaning, the same product category, similar bottle characteristics (e.g., size), comparable return systems (e.g., way of collection, same consumer group and outlet channels), etc.*
2) *With data of the current bottle pool when future estimations/extrapolations are available on (i) the bottle purchases, (ii) the volumes sold, and (iii) the lifetime of the bottle pool.*

The data shall be supply-chain-specific and shall be verified by an external verification, including the reasoning of this method choice.

Option b: *If no real data is tracked the calculation shall be done partly based on assumptions. This option is less accurate due to the assumptions made and therefore conservative/safe estimates shall be used. The following data is needed:*

- *Average number of rotations of a single bottle, during one calendar year (if not broken). One loop consists of filling, delivery, use, back to brewer for washing (#Rot)*
- *Estimated lifetime of the bottle pool (LT, in years)*
- *Average percentage of loss per rotation. This refers to the sum of losses at consumer and the bottles scrapped at filling sites (%Los)*

Reuse rate of the bottle pool $= \frac{LT}{(LT \times \%Los) + \left(\frac{1}{\#Rot}\right)}$ *[*Equation 5*]*

This calculation option shall be used when option a) is not applicable (e.g., the previous pool is not usable as reference). The data used shall be verified during the verification and validation process, including the reasons for choosing between option 'a' and option 'b'.

The following reuse rates shall be used by those PEFCRs that have third party operated reusable packaging pools in scope, unless data of better quality is available:

- *Glass bottles: 30 trips for beer and water[24], 5 trips for wine[25]*
- *Plastic crates for bottles: 30 trips[26]*
- *Plastic pallets: 50 trips (Nederlands Instituut voor Bouwbiologie en Ecologie, 2014)[27]*
- *Wooden pallets: 25 trips (Nederlands Instituut voor Bouwbiologie en Ecologie, 2014)[28]*

The raw material consumption of reusable packaging shall be calculated by dividing the actual weight of the packaging by the reuse rate.

The reuse rate affects the quantity of transport that is needed per FU. The transport impact shall be calculated by dividing the one-way trip impact by the number of times this packaging is reused.

Modelling the recycled content

The following formula is used to model the recycled content:

$$(1 - R_1)E_V + R_1 \times \left(AE_{recycled} + (1 - A)E_V \times \frac{Q_{Sin}}{Q_p}\right)$$ *[*Equation 6*]*

*[24] The reuse rates for third party operated glass bottle pools was largely discussed within the packaging working group. Literature provides values between 5 and 50 reuse rates but is mainly outdated. The study of Deloitte (2014) is most recent but provides values within the German context only. It can be questioned if these results are directly applicable for the European context. However, the study provides results for both company owned pools (23 trips, considering all foreign bottles as exchanged) and third party operated pools (36 trips, considering all foreign bottles as exchanged). It shows that the reuse rates for third party operated pools are ±1.5 times higher than for company owned pools. As first approximation the packaging working group proposes to use this ratio to extrapolate the average reuse rates for company owned pools (20 trips) towards average reuse rates for third party operated pools (20*1.5= 30 trips).*

[25] Assumption based on monopoly system of Finland.
http://ec.europa.eu/environment/waste/studies/packaging/finland.pdf

[26] Technical approximation as no data source could be found. Technical specifications guarantee a lifetime of 10 years. A return of 3 times per year (between 2 to 4) is taken as first approximation.

[27] The less conservative number is used.

[28] Half of plastic pallets is used as approximation.

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

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

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

6.1.4 Inbound distribution

Inbound distribution of all components of the BoM (e.g. beer ingredients, packaging materials) shall be included in this LCS with the following approach:

60% (based on w/w of the BoM from the beer) of the inbound transport to and from the brewery shall be based on the following approach:

- *most common used modalities (e.g. truck, barge) and load capacities with company specific load factors. When these company-specific load factors are not available the following load factors shall be used:*
  - *80% for ingredients.*
  - *50% for glass bottles (non-returnable and returnable).*
  - *20% for can bodies, PET kegs and PET bottles (non-returnable and returnable).*
  - *40% for steel kegs (non-returnable and returnable).*
  - *100% for can ends and PET preforms (and base parts for kegs).*
- *weighted average distances between the production location and the location of the brewery.*

The other 40% (based on w/w of the BoM from the beer) maybe assumed to be identical as the 60% (w/w). So, for the other 40% (based on w/w of the BoM from the beer) it is not needed to investigate the used modalities and load capacities but the average of the 60% (based on w/w of the BoM from the beer) can be taken into account.

6.2 Manufacturing/Brewery operations

*Figure 7 visualizes the brewery operations (brewing, washing returnables, filling and packing). Brewery operations shall be based 100% on company-specific data. Activity data shall be gathered over a period of 12 months (to even out the impact of seasonality). The company-specific data which shall be collected including the background datasets (or proxies in case of data gaps) which shall be used are listed in the associated supplementary information named "*Supporting material revised PEFCR for beer – Company-specific data*" (see worksheet 'Brewery' in Annex 4.1).*

The company-specific data shall be specific for the brewery plant where the beer is produced. The input of beer ingredients and packaging materials shall be beer specific. The other input/output may be yearly averages of the brewery.

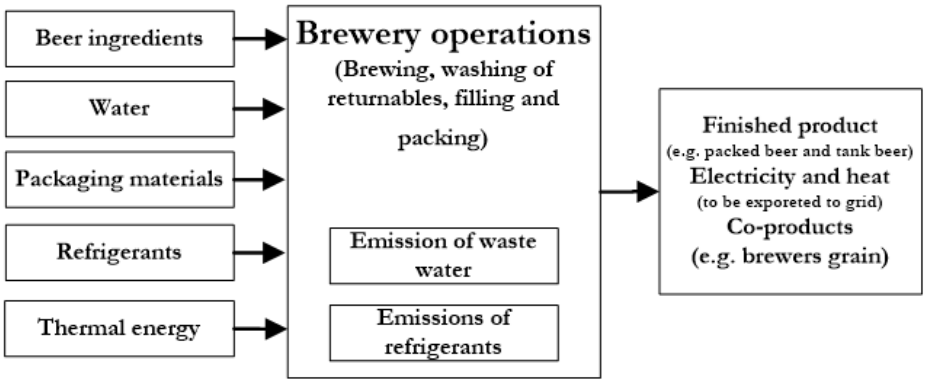


Figure 7 Simplified process flow of brewery operations

All input for washing returnables, filling and packing shall also be included in above activity data. The energy and resources used for cleaning and refilling of reusable packaging shall be included in the overall energy and resource use.

It shall be justified in the PEF study if other datasets are used than those stated in the supporting material (see worksheet 'Brewery' in Annex 4.1).

If certain emissions (e.g. NOx, SO_2) are measured (in case of abatement), and reported in the company-specific supporting material, the on-site emission profile shall be corrected to these measured emissions.

Refrigerants
The dataset for the production of refrigerants which shall be used is 'Tetrafluoroethylene production (UUID = b9840962-2b9a-4228-9dc8-4846a2196a6b)'. The emitted/leaked refrigerants shall be based on the amount of refrigerants used to refill the cooling systems. The correct ILCD elementary flows shall be used to simulate the leaked refrigerants. The refrigerant emissions are modelled as emissions to the air compartment.

On-site and third-party waste water treatment plant
Biogenic methane and N2O emissions from the on-site waste water treatment plant (WWTP), third party WWTP and effluent discharged to the surface water shall be calculated by making use of equation 6.4 and 6.7 from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). The following default emission factors shall be used:

- *Maximum CH4 producing capacity (B0): 0.25 kg CH4/kg COD*
- *Methane Correction Factor (MCF): 0.1*
- *Emission factor for N2O emissions from discharged to wastewater ($EF_{EFFLUENT}$): 0.005 kg N2O-N/kg –N*

Specific situations: Co-production and on-site PET blow moulding
If another beverage than beer is produced at the brewery (co-production) or if blow moulding of PET packaging material occurs on-site the beverage plant data shall be subdivided to isolate the input flows directly associated with other brewery operations and it shall be stated clearly in the PEF study how this subdivision was performed.

Specific situations: Co-packing[29]
Company-specific data shall be used for the additional transport and the co-packing plant if the beer is packed at another site or by a co-packer.

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

PEFCRs that include reusable packaging shall account for the additional energy and resource used for cleaning, repairing or refilling.

6.3 Distribution stage

Transport from factory to final client (including consumer transport) shall be modelled within this life cycle stage. The final client is defined as the person who will consume/drink the beer. In case supply-chain-specific information is available for one or several transport parameters, they may be applied following the Data Needs Matrix.

[29] Co-packing stands for the packing done via an outsourced party. In the case of co-packing the bottling is not taking place at brewers' premises and therefore additional transport and activity data of the co-packer shall be included.

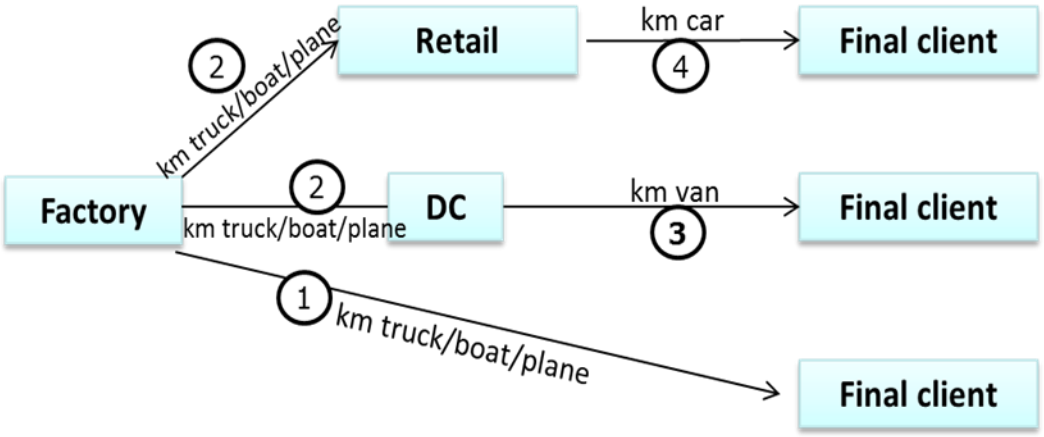


Figure 8. Distribution scenarios

For the distribution of the final product to retail, DC and/or the final client (route 1, 2 and 3 in Figure 8) a weighted average distance from brewery to the point of sales should be calculated taking into account yearly data of sold product.

This weighted average distance should consider the following distribution routes:

- *distance from brewery /factory to retail or/and DC (route 2);*
- *distance from brewery /factory to final client (route 1).*

The yearly transport modes effectively used shall be applied to each distribution route. The load factor shall be based on the mass and volume of the packed functional unit per packaging solution for the outbound transport. These masses, volumes and load factors shall be reported.

The default distance to be applied when company-specific data is not available for route 1 and 2 is 304 km (taken from the screening study).

Route 3 and 4 shall be based on the following default distribution scenario (as described in the Commission Recommendation (EU) 2021/2279):

- *Route 3: 40% of the functional unit (= 102 litres*0.4) from DC to final client:*
  - *100% Local: 250 km round trip by van (lorry <7.5t, EURO 0-5, utilisation ratio of 64%; UUID: f26aea52-151e-4358-aa74-f33f887c3a1d)*

- *Route 4: 60%[30] of the functional unit (= 102 litres*0.6) from retail to final client:*
  - *62%: 5 km, by passenger car (average; UUID: 1ead35dd-fc71-4b0c-9410-7e39da95c7dc), PEFCR specific allocation*
  - *5%: 5 km round trip, by van (lorry <7.5t, EURO 0-5 with utilisation ratio of 20%6; UUID (f26aea52-151e-4358-aa74-f33f887c3a1d)*
  - *33%: no impact modelled*

Please note that route 1 is assumed to be 0% in this default distribution scenario.

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

[30] The 60% is based on the cooling mix. 52.5% is assumed to be cooled at home and 7.5% is not cooled (52.5% + 7.5% = 60%)

The waste of products during the distribution and retail shall be included in the modelling and is represented in the overall 2% losses which are accounted for in the use-stage.

6.4 Use stage

Figure 9 provides the overall simplified process flow of the use stage.

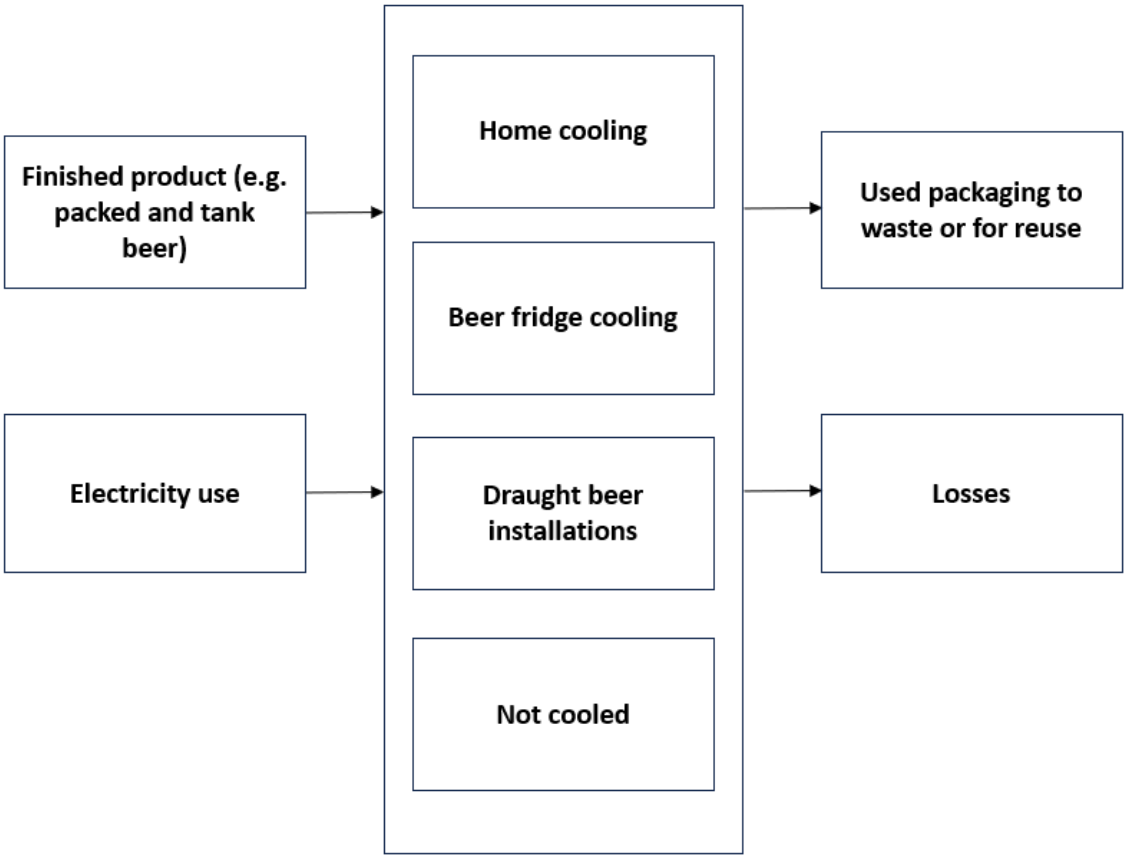


Figure 9. Simplified process flow of the use stage.

The cooling of beer shall be modelled with the same secondary data as benchmark.

*Table **25** provides cooling scenarios related to primary packaging types.*

***Table 25**.*
Cooling scenarios related to packaging type. Please note that the same energy use is used for cans, glass and PET bottles. This energy use is based on the cooling mix with its associated energy use (all in italic).

Type of cooling	Primary packaging types	Cooling mix related to packaging type	Energy use *(kWh/hl)*
Home fridge	*Glass, PET bottles and cans*	*69.4%*	*30*
Pub/supermarket fridge	*Glass, PET bottles and cans*	*20.7%*	*35*
Not cooled	*Glass, PET bottles and cans*	*9.9%*	*0*
Home fridge / Pub/supermarket fridge / Not cooled	**Glass, PET bottles and cans**	**100%**	**28**
Draught beer system	**Steel, PET kegs and beer tanks**	**100%**	**33.6**

Please note that the potential impact of the lost beer itself is not taken into account (e.g. eutrophication).

The user of the PEFCR shall report the DQR (for each criterion + total) for all the datasets used.

For the use stage the consumption grid mix shall be used. The electricity mix shall reflect the ratios of sales between EU countries/regions. To determine the ratio a physical unit shall be used based on the FU. Where such data are not available, the average EU mix (EU+EFTA), or region-representative consumption mix, shall be used.

A default loss during the use stage of 2% shall be applied when no better and justified assumption is available. This 2% is based on company-specific data of approximately 1% to 2% losses from the brewers in the TS.

If the beer cannot be preserved 1 month after production, the default losses, set at 2%, must be increased to 7%.

Losses shall be modelled that every LCS is multiplied with 1+loss% (so 1,02 for the default loss scenario).

The impact/emissions of the lost beer in a municipal waste treatment shall not be included in this LCS or in any other LCS (e.g. End-of-life).

6.5 End of life

The end of life stage begins when the product in scope and its packaging is discarded by the user and ends when the product is returned to nature as a waste product or enters another product's life cycle (i.e. as a recycled input). In general, it includes the waste of the product in scope, such as the food waste and primary packaging.

Other waste (different from the product in scope) generated during the manufacturing, distribution, retail, use stage or after use shall be included in the life cycle of the product and modelled at the life cycle stage where it occurs.

Please note that this LCS only includes the waste of packaging.

*The amounts which enter the end of life LCS shall be based on the company-specific data from brewery operations. The end-of-life shall be modelled by applying the datasets as listed Table **26** and the parameters as listed in Table **27**. The CFF parameters and used dataset information shall be provided in the PEF study if applicable if other packaging materials are used which are not listed in Table **26** and Table **27**.*

Table 26
Datasets to be used in the CFF per packaging material

Packaging material	CFF part	CFF parameter	Simple UUID name	UUID	*Default DQR*			
					P	***Ti_R***	***G_R***	***Te_R***
Glass bottle	*Material (EoL)*	$E_{recyclingEoL}$	container glass, ER, Recycled content (Glass cullet) 100%	ab4e945f-9955-4414-b3fb-d42507cc4e2d	2	2	2	2
Glass bottle	*Material (EoL)*	E^*_v	E*v = Ev (see section 6.1.3)	Not applicable				
Glass bottle	*Energy*	*N/A*	Waste incineration of inert material	55cd3dde-21f9-47f8-8f15-bc319c732107	2	1	1	2
Glass bottle	*Disposal*	E_d	Landfill of inert (glass)	01196227-0627-440c-9f2f-94b8f1e7d1ad	2	2	2	2
Steel can body, keg or tank	*Material (EoL)*	$E_{recyclingEoL}$	Recycling of steel into steel scrap| collection, transport, pretreatment, remelting	7bd54804-bcc4-4093-94e4-38e4facd4900	2	2	2	2
Steel can body, keg or tank	*Material (EoL)*	E^*_v	Stainless steel cold rolled; hot rolling; production mix, at plant; stainless steel	468733f6-fc88-4da5-b9ff-e548059234c5	2	3	2	2
Steel can body, keg or tank	*Energy*	*N/A*	Waste incineration of ferro metals	2cbdc30b-e608-4fcf-a380-fdda30b1834e	2	1	1	2
Steel can body, keg or tank	*Disposal*	E_d	Landfill of inert (steel)	33d6d221-f91d-4a33-9b00-9fb1ea8cd3ca	2	2	2	2
Aluminium can body or end	*Material (EoL)*	$E_{recyclingEoL}$	Recycling of aluminium into aluminium scrap - from post-consumer	c4f3bfde-c15f-4f7f-8d35-bed6241704db	2	2	2	2
Aluminium can body or end	*Material (EoL)*	E^*_v	Aluminium ingot mix (high purity) | primary production	84edb17a-79de-4cd7-8340-02b289b30312	2	2	2	2
Aluminium can body or end	*Energy*	*N/A*	Waste incineration of non-ferro metals, aluminium, more than 50µm	f2c7614e-a50c-4f77-b49c-76472649acd6	2	1	1	2
Aluminium can body or end	*Disposal*	E_d	Landfill of inert (aluminium)	3f7d5e8a-a112-4585-9e2f-dc8b667d66dc	2	2	2	2
PET bottle or keg	*Material (EoL)*	$E_{recyclingEoL}$	Polyethylene terephthalate (PET) granulate secondary	49a42d24-84be-42d5-8fe4-48efad0f4487	2	2	2	2
PET bottle or keg	*Material (EoL)*	E^*_v	PET granulates, bottle grade via purified terephthalic acid (PTA) and ethylene glycol	61042919-2439-45d0-ba10-66e221167a24	2	2	1	1
PET bottle or keg	*Energy*	*N/A*	Waste incineration of PET| waste-to-energy plant with dry flue gas treatment	773b8f01-2263-4d3d-a6f9-11dd316d4a58	2	1	1	2

Table 26(Ctd)
Datasets to be used in the CFF per packaging material

Packaging material	CFF part	CFF parameter	Simple UUID name	UUID	*Default DQR*			
					P	***Ti_R***	***G_R***	***Te_R***
PET bottle or keg	*Disposal*	E_d	Landfill of plastic waste	f2bea0f5-e4b7-4a2c-9f34-4eb32495cbc6	2	2	2	2
Paper products	*Material (EoL)*	$E_{recyclingEoL}$	Containerboard production, linerboard, testliner	099ad124-7cd4-5063-9b65-37eb5f9e599c	1.13	1.75	1.51	1.10
Paper products	*Material (EoL)*	E^*_v	Kraft paper, uncoated Kraft Pulping Process,	03dea8f0-44e0-4bf3-a862-bb572c9d5f5e	2	3	3	2
Paper products	*Energy*	*N/A*	Waste incineration of paper and board| waste-to-energy plant with dry flue gas treatment	b6ce954d-deb4-4c16-907a-c67b71e1e862	2	1	1	2
Paper products	*Disposal*	E_d	Landfill of paper and paperboard waste	86ff0001-4794-4df5-a1d4-083a9d986b62	2	2	2	2

Table 27.
CFF parameters per type of packaging which shall be applied based on PEF guidance 6.3, Annex C

Packaging material	***A***	***R_1***	***R_2***	***Q_{Sin}/Q_p***	***Q_{Sout}/Q_p***	***B^{31}***	***R_3***
Glass bottle	*0.2*	*Company-specific*	*Country specific*	*1*	*1*	*0*	*Country specific*
Steel can body, keg or tank	*0.2*	*Company-specific*	*Country specific*	*1*	*1*	*0*	*Country specific*
Aluminium can body or end	*0.2*	*Company-specific*	*Country specific*	*1*	*1*	*0*	*Country specific*
PET bottle or keg (mechanical recycling)	*0.5*	*Company-specific*	*Country specific*	*0.9*	*0.9*	*0*	*Country specific*
Paper products	*0.2*	*Company-specific*	*Country specific*	*0.85*	*0.85*	*0*	*Country specific*
Glass bottle	*0.2*	*52%*	*Country specific*	*1*	*1*	*0*	*Country specific*
Steel can body, keg or tank	*0.2*	*0%*	*Country specific*	*1*	*1*	*0*	*Country specific*
Aluminium can body or end	*0.2*	*0%*	*Country specific*	*1*	*1*	*0*	*Country specific*
PET bottle or keg (mechanical recycling)	*0.5*	*0%*	*Country specific*	*0.9*	*0.9*	*0*	*Country specific*
Metal caps	*0.2*	*0%*	*Country specific*	*1*	*1*	*0*	*Country specific*
Plastic caps	*0.5*	*0%*	*Country specific*	*0.9*	*0.9*	*0*	*Country specific*
Paper labels	*0.5*	*21%*	*Country specific*	*0.85*	*0.85*	*0*	*Country specific*
Plastic labels	*0.5*	*0%*	*Country specific*	*0.9*	*0.9*	*0*	*Country specific*
Shrink foil	*0.5*	*0%*	*Country specific*	*0.9*	*0.9*	*0*	*Country specific*
Cardboard trays	*0.2*	*47%*	*Country specific*	*0.85*	*0.85*	*0*	*Country specific*

[31] From PEF guidance 6.3: In PEF studies and benchmark calculations the B value shall be equal to 0 as default.

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

The end of life shall be modelled using the circular footprint formula and rules provided in section 'End of life modelling' of this PEFCR and in the PEF method, together with the default parameters listed in Table **26** and Table **27**.

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

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

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

Following the evaluation for recyclability, the appropriate R_2 values (supply-chain specific or default) shall be used. If one criterion is not fulfilled or the sector-specific recyclability guidelines indicate limited recyclability an R_2 value of 0% shall be applied[32].

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

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

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

The reuse rate determines the quantity of packaging material (per product sold) to be treated at the end of life. The amount of packaging treated at the end of life shall be calculated by dividing the actual weight of the packaging by the number of times this packaging was reused.

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

7. Results

7.1 Benchmark values

Table 28
Characterised benchmark values for 1 hl of beer

Impact category	Unit	Life cycle - excl. use stage	Total life cycle
Climate change, total	kg CO2 eq	50.15	67.88
Climate change - fossil			
~~Climate change - biogenic~~			
~~Climate change – land use and land use change~~			
Ozone depletion	kg CFC-11 $_{eq}$	1.17E-06	6.50E-06
Particulate matter	disease incidence	2.88E-06	3.73E-06
Ionising radiation, human health	kBq U235 eq	3.21	9.05
Photochemical ozone formation, human health	kg NMVOC eq	0.162	0.196
Acidification	mol H+ $_{eq}$	0.294	0.358
Eutrophication, terrestrial	mol N $_{eq}$	1.04	1.17
Eutrophication, freshwater	kg P $_{eq}$	0.0038	0.0041
Eutrophication, marine	kg N $_{eq}$	0.224	0.236
Human toxicity, cancer	CTUh	5.09E-08	1.18E-07
Human toxicity, non-cancer	CTUh	8.82E-07	1.05E-06
Ecotoxicity	CTUe	1890	2004
Land use	Dimensionless (pt)	2637	4959
Water use	m^3 water eq of deprived water	32.91	38.41
Resource use, minerals and metals	kg Sb $_{eq}$	0.00018	0.00049
Resource use, fossils	MJ	633	917

Table 29.
Normalised benchmark values for 1 hl of beer

Impact category	Life cycle - excl. use stage	Total life cycle
Climate change (total)	0.007	0.009
Climate change - fossil		
~~Climate change - biogenic~~		
~~Climate change – land use and land use change~~		
Ozone depletion	2.23E-05	0.00012
Particulate matter	0.005	0.006
Ionising radiation, human health	0.0008	0.0021
Photochemical ozone formation, human health	0.004	0.005
Acidification	0.005	0.006
Eutrophication, terrestrial	0.006	0.007
Eutrophication, freshwater	0.002	0.003
Eutrophication, marine	0.011	0.012
Human toxicity, cancer	0.003	0.007
Human toxicity, non-cancer	0.007	0.008
Ecotoxicity	0.033	0.035
Land use	0.003	0.006
Water use	0.003	0.003
Resource use, minerals and metals	0.003	0.008
Resource use, fossils	0.009	0.014

Table 30.
Weighted benchmark values for 1 hl of beer

Impact category	Life cycle excl. use stage	Total life cycle
Climate change (total)	0.0014	0.0019
Climate change - fossil		
~~Climate change - biogenic~~		
~~Climate change – land use and land use change~~		
Ozone depletion	1.41E-06	7.84E-06
Particulate matter	0.0004	0.0006
Ionising radiation, human health	3.81E-05	0.0001
Photochemical ozone formation, human health	0.00020	0.00024
Acidification	0.0003	0.0004
Eutrophication, terrestrial	0.00021	0.00025
Eutrophication, freshwater	6.71E-05	7.16E-05
Eutrophication, marine	0.0003	0.0004
Human toxicity, cancer	6.28E-05	0.00015
Human toxicity, non-cancer	0.00013	0.00015
Ecotoxicity	0.0006	0.0007
Land use	0.0003	0.0005
Water use	0.0002	0.0003
Resource use, minerals and metals	0.0002	0.0006
Resource use, fossils	0.0008	0.001

7.2 PEF profile

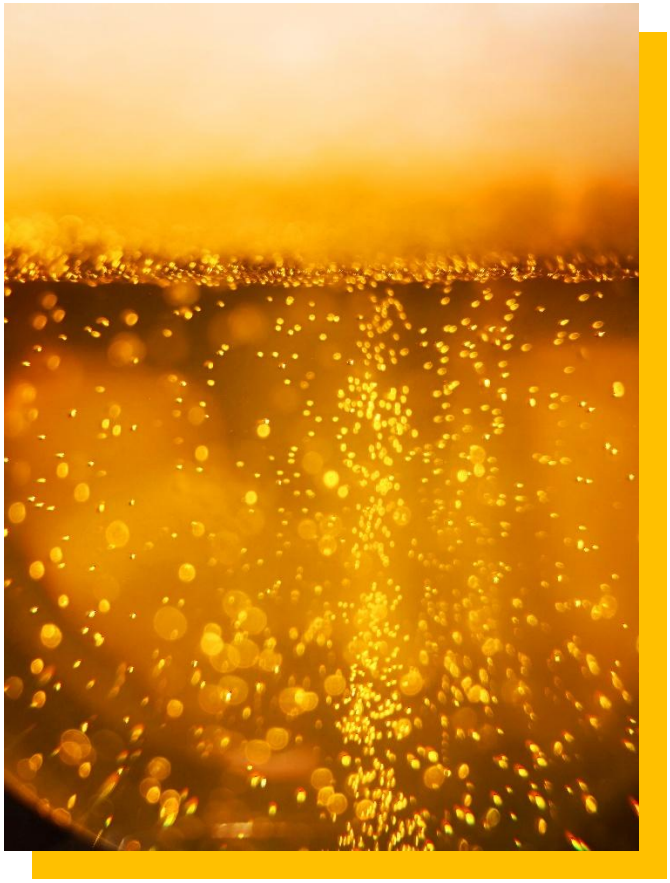
The user of the PEFCR shall calculate the PEF profile of its product in compliance with all requirements included in this PEFCR. The following information shall be included in the PEF report:

a) *full life cycle inventory;*
b) *characterised results in absolute values, for all impact categories (as a table);*
c) *normalised results in absolute values, for all impact categories (as a table);*
d) *weighted result in absolute values, for all impact categories (as a table);*
e) *the aggregated single overall score in absolute values.*

Together with the PEF report, the user of the PEFCR shall develop an aggregated EF compliant dataset of its product in scope. This dataset shall be made available to the European Commission and may be made public. The disaggregated version may remain confidential.

7.3 Classes of performance

This updated PEFCR does not include information on classes of performance.



8. Verification

The verification of a PEF study/ report carried out in compliance with this PEFCR shall be done according to all the general requirements included in section 9 of the Annex I of Commission Recommendation (EU) 2021/2279, including part A of this Annex, and the requirements listed below.

The verifier(s) shall verify that the PEF study is conducted in compliance with this PEFCR.

In case policies implementing the PEF method define specific requirements regarding verification and validation of PEF studies, reports and communication vehicles, the requirements in said policies shall prevail.

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

1) *the verifier(s) shall check if the correct version of all impact assessment methods was used. For each of the most relevant EF impact categories (ICs), at least 50% of the characterisation factors shall be verified, while all normalisation and weighting factors of all ICs shall be verified. In particular, the verifier(s) shall check that the characterisation factors correspond to those included in the EF impact assessment method the study declares compliance with[33]. This may also be done indirectly, for example:*

   a) Export the EF-compliant datasets from the LCA software used to do the PEF study and run them in Look@LCI[141] to obtain LCIA results. If Look@LCI results are within a deviation of 1% from the results in the LCA software, the verifier(s) may assume that the implementation of the characterisation factors in the software used to do the PEF study was correct;
   b) Compare the LCIA results of the most relevant processes calculated with the software used to do the PEF study with the ones available in the metadata of the original dataset. If the compared results are within a deviation of 1%, the verifier(s) may assume that the implementation of the characterisation factors in the software used to do the PEF study was correct

2) *cut-off applied (if any) fulfils the requirements at section 4.6.4 of Annex I of Commission Recommendation (EU) 2021/2279.*

3) *all datasets used shall be checked against the data requirements (sections 4.6.3 and 4.6.5. of Annex I) of Commission Recommendation (EU) 2021/2279.*

4) *For at least 80% (in number) of the most relevant processes (as defined in section 6.3.3 of Annex I), the verifier(s) shall validate all related activity data and the datasets used to model these processes. If relevant, CFF parameters and datasets used to model them shall also be validated in the same way. The verifier(s) shall check that the most relevant processes are identified as specified in section 6.3.3 of Annex I of Commission Recommendation (EU) 2021/2279;*

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

5) *For at least 30% (in number) of all other processes (corresponding to 20% of the processes as defined in section 6.3.3 of Annex I) the verifier(s) shall validate all related activity data and the datasets used to model these processes. If relevant, CFF parameters and datasets used to model them shall also be validated in the same way;*

6) *The verifier(s) shall check that the datasets are correctly implemented in the software (i.e. LCIA results of the dataset in the software are within a deviation of 1% to the ones in the metadata). At least 50% (in number) of the datasets used to model most relevant processes and 10% of those used to model other processes shall be checked.*

In particular, verifier(s) shall verify if the DQR of the process satisfies the minimum DQR as specified in the DNM for the selected processes.

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

The verification of the PEF report shall be carried out by randomly checking enough information to provide reasonable assurance that the PEF report fulfils all the conditions listed in section 8 of Annex I of Commission Recommendation (EU) 2021/2279, including part A of this Annex.

9. References

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Annex 1 List of EF normalisation and weighting factors

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

The full list of characterization factors for EF 3.1 is available at this link: https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml [34]

Normalization and weighting factors are available at:
https://eplca.jrc.ec.europa.eu/permalink/EF3_1/Normalisation_Weighting_Factors_EF_3.1.xlsx

Table 31.
Normalization factors. (Reference year: 2010; population: 6.895.889.018 persons)

Impact category	Unit	Normalisation factor	Normalisation factor per person	Impact assessment robustness	Inventory coverage completeness	Inventory robustness
Climate change, total	Kg $CO_{2\ eq}$	5,21E+13	7,55E+03	I	II	I
Ozone depletion	kg CFC-11 $_{eq}$	3,61E+08	5,23E-02	I	III	II
Human Toxicity, cancer	CTUh	1,19E+05	1,73E-05	III	III	III
Human Toxicity, non-cancer	CTUh	8,88E+05	1,29E-04	III	III	III
Particulate matter	Disease incidence	4,11E+06	5,95E-04	I	I/II	I/II
Ionising radiation, human health	kBq $U^{235}{}_{eq}$	2,91E+13	4,22E+03	II	II	III
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	2,82E+11	4,09E+01	II	III	I/II
Acidification	mol H+ $_{eq}$	3,83E+11	5,56E+01	II	II	I/II
Eutrophication, terrestrial	mol N $_{eq}$	1,22E+12	1,77E+02	II	II	I/II
Eutrophication, freshwater	Kg P $_{eq}$	1,11E+10	1,61E+00	II	II	III
Eutrophication, marine	Kg N $_{eq}$	1,35E+11	1,95E+01	II	II	II/III
Ecotoxicity, freshwater	CTUe	3,91E+14	5,67E+04	III	III	III
Land use	• Dimensionless (pt) • kg biotic production • kg soil • m^3 water • m^3 groundwater	5,65E+15	8,19E+05	III	II	II

[34] *Please note that the weighting factors are expressed in % and thus shall be divided by 100 before applying in the calculations.*

Table 31 (Ctd)
Normalization factors. (Reference year: 2010; population: 6.895.889.018 persons)

Impact category	Unit	Normalisation factor	Normalisation factor per person	Impact assessment robustness	Inventory coverage completeness	Inventory robustness
Water use	m3 water $_{eq}$ of deprived water	7,91E+13	1,15E+04	III	I	II
Resource use, minerals and metals	kg Sb $_{eq}$	4,39E+08	6,36E-02	III	I	II
Resource use, fossils	MJ	4,48E+14	6,50E+04	III	I	II

Table 32.
European weighting factors

	Aggregated weighting set	Robustness factors	Calculation	Final weighting factors
	(50:50)	(scale 1-0.1)		
	A	B	C = A* B	C scale to 100
Climate change	12.9	0.87	11.18	21.06
Ozone depletion	5.58	0.6	3.35	6.31
Human Toxicity, cancer	6.8	0.17	1.13	2.13
Human Toxicity, non-cancer	5.88	0.17	0.98	1.84
Particulate matter	5.49	0.87	4.76	8.96
Ionizing radiation, human health	5.7	0.47	2.66	5.01
Photochemical ozone formation, human health	4.76	0.53	2.54	4.78
Acidification	4.94	0.67	3.29	6.2
Eutrophication, terrestrial	2.95	0.67	1.97	3.71
Eutrophication, freshwater	3.19	0.47	1.49	2.8
Eutrophication, marine	2.94	0.53	1.57	2.96
Ecotoxicity, freshwater	6.12	0.17	1.02	1.92
Land use	9.04	0.47	4.22	7.94
Water use	9.69	0.47	4.52	8.51
Resource use, minerals and metals	6.68	0.6	4.01	7.55
Resource use, fossils	7.37	0.6	4.42	8.32

Annex 2 PEF study template

Table 33.
PEF study template

ITEM	*Included in the study (Y/N)*	*Section*	*Page*
[This column shall list all the items that shall be included in PEF studies. One item per row shall be listed. This column shall be completed by the TS]	**[The PEF study shall indicate if the item is included or not in the study]**	**[The PEF study shall indicate in which section of the study the item is included]**	**[The PEF study shall indicate in which page of the study the item is included]**
Summary			
General information about the product			
General information about the company			
Diagram with system boundary and indication of the situation according to DNM			
List and description of processes included in the system boundaries			
List of co-products, by-products and waste			
List of activity data used			
List of secondary datasets used			
Data gaps			
Assumptions			
Goal and scope of the study			
(sub)category to which the product belongs			
DQR calculation of each dataset used for the most relevant processes and the new ones created.			
DQR (of each criterion and total) of the study			
PEF results			
Additional information to be included in the PEF (Environmental and technical information)			

Annex 3 Review reports of the PEFCR and PEF-RP

[Insert here the critical review panel reports of the PEFCR and PEF-RP(s), including all findings of the review process and the actions taken by the Technical Secretariat to answer the comments of the reviewers.]

Annex 4 Other annexes

Annex 4.1 Supporting material PEFCR for beer final version -– Company- specific data

*This PEFCR has associated supplementary information in MS Excel with the file name "*Supporting material revised PEFCR for beer -– Company- specific data*". This file shall be available where also this PEFCR is available.*

Annex 4.2 Sensitivity analysis to allocation choices at brewery for brewers' grains

Please note that this sensitivity analysis was performed in 2016 so an old Life Cycle Impact Assessment method and CFF is used.

To	*The Brewers of Europe*
From	*Jasper Scholten and Roline Broekema (Blonk Consultants)*
Subject	*Sensitivity analysis to allocation choices at brewery for brewers' grains*

In the screening study of the PEF beer pilot all the environmental impact is allocated to beer and zero impact is allocated to brewery co-products like brewers' grains when these co-products are used usefully (e.g. animal feed). The end of life PEF formula has to be applied if these co-products are not used usefully (e.g. dumped to landfill).

The question has risen how sensitive the results are to this choice for allocation. This sensitivity analysis investigates the impact of 1hl of beer when the choice is made for ***economic allocation****,* ***mass allocation*** *(based on dry matter) and* ***system expansion*** *(brewers' grains replace rapeseed meal at the dairy farm).*

In economic allocation >99% of the environmental impact is allocated towards the beer. In mass allocation, which is based on dry matter content, 99% of the environmental impact is allocated to the brewers' grains. For mass allocation this is an assumption, as we do not have specific data on the dry matter content of the beer.

In system expansion the environmental impact of the product which is replaced by the brewers' grains in case of ***animal feed*** *at the dairy farm, is deducted from the environmental impact of the beer. The assumption is made that a specific amount of product is equivalent to the brewers' grains produced at the brewery. In (Scholten, 2011) it was investigated that 1.7 kg dry matter of brewers' grains (dry matter content is 25%) is equivalent to and replaces 2.0 kg dry matter of rapeseed meal (dry matter content is 88.5%) in the daily ration of Dutch dairy cows (see table 3.1 and 3.2). The increase of brewers' grains and the decrease of rapeseed meal in the ration of dairy cows is calculated based on the energy and protein requirements of a cow with a yield of 25 kg fat and protein corrected milk (FCPM) per day. The energy requirement is 16,767 VEM per day per cow and the protein requirement is 1,403 gDVE per day per cow. The other available feed materials are grass silage, maize silage and concentrates. The rapeseed meal and the brewers' grains are used to cover 100% of the nutritional requirements (VEM and DVE).*

The average European brewery produces 4.69 kg dry matter of brewers' grains per hl of beer, which is equal to 6.23 kg of rapeseed mail (as is).

Table 3.1: Daily ration with BSG

	VEM kg dm	DVE kg dm	Input kg dm	Total VEM	Total DVE
Grass silage	888	67	8.0	7,104	536
Maize silage	937	52	2.5	2,343	130
Concentrates	940	90	6.0	5,640	540
Spent grain	947	137	1.7	1,610	233
			Totals	**16,696**	**1,439**

Table 3.2: Daily ration without BSG and with rapeseed meal

	VEM kg dm	DVE kg dm	Input kg dm	Total VEM	Total DVE
Grass silage	888	67	8.0	7,104	536
Maize silage	937	52	2.5	2,343	130
Concentrates	940	90	6.0	5,640	540
Spent grain	947	137	-	-	-
Rapeseed meal	848	126	2.0	1,696	252
DDGS	1,079	171	-	-	-
			Totals	**16,783**	**1,458**

*Focusing on the brewery only, the environmental impact is displayed in Table **34**.*

Table 34.
Sensitivity to allocation choices for the impact of the brewery specifically, per hl of beer

Impact category	***Unit/hl***	***Current: No allocation to brewers' grains***	***Economic allocation: 99% to beer***	***Mass allocation (dm): 99% to brewers' grain***	***System expansion: 1.7 kg dm brewers' grains replaces 2.0 kg dm rapeseed meal***
Climate change	*kg CO2 eq*	*7.11*	*7.03*	*0.07*	*2.91*
Ozone depletion	*kg CFC-11 eq*	*9.12E-07*	*9.03E-07*	*9.12E-09*	*8.85E-07*
Human toxicity, cancer effects	*CTUh*	*1.52E-07*	*1.50E-07*	*1.52E-09*	*4.58E-08*
Human toxicity, non-cancer effects	*CTUh*	*7.93E-07*	*7.85E-07*	*7.93E-09*	*-2.68E-06*
Particulate matter	*kg PM2.5 eq*	*2.08E-03*	*2.06E-03*	*2.08E-05*	*3.18E-04*
Ionizing radiation HH	*kBq U235 eq*	*1.61*	*1.59*	*0.02*	*1.57*
Photochemical ozone formation	*kg NMVOC eq*	*0.01*	*0.01*	*1.16E-04*	*1.79E-03*
Acidification	*molc H+ eq*	*0.02*	*0.02*	*2.14E-04*	*-0.05*
Terrestrial eutrophication	*molc N eq*	*0.04*	*0.04*	*4.15E-04*	*-0.27*
Freshwater eutrophication	*kg P eq*	*1.01E-03*	*9.99E-04*	*1.01E-05*	*-1.49E-03*
Marine eutrophication	*kg N eq*	*0.01*	*0.01*	*6.45E-05*	*-0.05*
Freshwater ecotoxicity	*CTUe*	*11.50*	*11.39*	*0.12*	*-6.01*
Land use	*kg C deficit*	*8.22*	*8.14*	*0.08*	*-125.16*
Water resource depletion	*m3 water eq*	*0.08*	*0.08*	*7.72E-04*	*0.08*
Mineral, fossil & ren resource depletion	*kg Sb eq*	*1.52E-04*	*1.51E-04*	*1.52E-06*	*1.51E-04*

*Focusing on the full lifecycle of beer, the environmental impact is displayed in Table **35**.*

Table 35.
Sensitivity to allocation choices for the impact of the full lifecycle of beer, per hl of beer

Impact category	*Unit/hl*	*Current: No allocation to brewers' grains*	*Economic allocation: 99% to beer*	*Mass allocation (dm): 99% to brewers' grains*	*System expansion: 1.7 kg dm brewers' grains replaces 2.0 kg dm rapeseed meal*
Climate change	*kg CO2 eq*	*114.80*	*113.95*	*30.74*	*110.60*
Ozone depletion	*kg CFC-11 eq*	*2.54E-05*	*2.54E-05*	*2.01E-05*	*2.54E-05*
Human toxicity, cancer effects	*CTUh*	*7.94E-06*	*7.89E-06*	*2.41E-06*	*7.84E-06*
Human toxicity, non-cancer effects	*CTUh*	*3.64E-05*	*3.61E-05*	*8.04E-06*	*3.29E-05*
Particulate matter	*kg PM2.5 eq*	*0.05*	*0.05*	*0.02*	*0.05*
Ionizing radiation HH	*kBq U235 eq*	*17.33*	*17.21*	*5.95*	*17.29*
Photochemical ozone formation	*kg NMVOC eq*	*0.58*	*0.57*	*0.16*	*0.57*
Acidification	*molc H+ eq*	*1.07*	*1.06*	*0.26*	*1.00*
Terrestrial eutrophication	*molc N eq*	*3.28*	*3.25*	*0.60*	*2.96*
Freshwater eutrophication	*kg P eq*	*0.03*	*0.03*	*4.58E-03*	*0.02*
Marine eutrophication	*kg N eq*	*0.51*	*0.51*	*0.10*	*0.46*
Freshwater ecotoxicity	*CTUe*	*607.58*	*603.75*	*228.39*	*590.07*
Land use	*kg C deficit*	*484.55*	*480.04*	*37.94*	*351.17*
Water resource depletion	*m3 water eq*	*1.43*	*1.42*	*0.08*	*1.43*
Mineral, fossil & ren resource depletion	*kg Sb eq*	*1.31E-03*	*1.31E-03*	*7.01E-04*	*1.31E-03*

The comparison between the different allocation options is visualized for climate change in Figure 10.

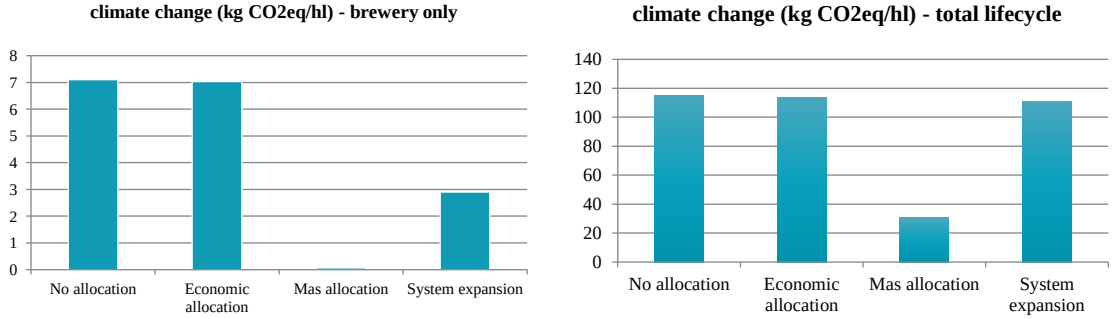

Figure 10: Sensitivity to allocation choices for the impact on climate change, for the brewery only and the total lifecycle

Economic allocation will not influence the environmental impact of beer in a very significant way, while mass allocation allocates almost all environmental impact to the brewers' grains. This effect is the same when focusing on the brewery only as well as on the total lifecycle of beer.

The choice for system expansion has a great impact on the environmental impact when focusing on the brewery only (-60% for climate change), but the relevance of the choice is less when focusing on the total lifecycle of beer (-4% for climate change). For some of the impact categories (like acidification) it would even become beneficial for the environment to produce beer, because the production of beer would help reduce the impact on acidification.

*Regarding system expansion there is another interesting comparison to be made: What is the impact of 1kg (dry matter) of brewers' grains according to system expansion compared to the environmental impact of the raw material which is used for the production of beer (mainly malted barley)? The comparison is made in Table **36**.*

Table 36.
Environmental impact of brewers' grains compared to malted barley

Impact category	*Unit/hl*	*Impact of 1kg brewers' grains DM*	*Impact of 1kg malted barley DM*
Climate change	*kg CO2 eq*	*0.90*	*0.82*
Ozone depletion	*kg CFC-11 eq*	*5.71E-09*	*5.16E-08*
Human toxicity, cancer effects	*CTUh*	*2.26E-08*	*2.30E-08*
Human toxicity, non-cancer effects	*CTUh*	*7.40E-07*	*7.79E-07*
Particulate matter	*kg PM2.5 eq*	*3.76E-04*	*3.93E-04*
Ionizing radiation HH	*kBq U235 eq*	*0.01*	*3.91E-02*
Photochemical ozone formation	*kg NMVOC eq*	*2.10E-03*	*1.99E-03*
Acidification	*molc H+ eq*	*0.02*	*0.01*
Terrestrial eutrophication	*molc N eq*	*0.07*	*0.06*
Freshwater eutrophication	*kg P eq*	*5.33E-04*	*3.72E-04*
Marine eutrophication	*kg N eq*	*0.01*	*0.01*
Freshwater ecotoxicity	*CTUe*	*3.73*	*4.62*
Land use	*kg C deficit*	*28.44*	*16.40*
Water resource depletion	*m3 water eq*	*3.73E-04*	*2.28E-03*
Mineral, fossil & ren resource depletion	*kg Sb eq*	*3.53E-07*	*6.72E-07*

This means that the co-product of the brewery (brewers' grains) has a higher environmental impact, regarding many impact categories, than the basic raw material (malted barley) which is used for brewing of beer.

Another remark about system expansion is the substitution differs between regions, type of animals and throughout the year (availability of feed materials) so a default substitute cannot easily be found and the complexity of PEF studies will increase.

Conclusion

Choosing economic allocation will not lead to large differences in environmental of beer impact compared to the results of the screening, for the brewery nor for the total lifecycle, as most of the economic revenue is derived from the beer.

Choosing mass allocation based on dry matter content will lead to large differences in environmental impact of beer compared to the results of the screening, for the brewery as well as for the total lifecycle, as most of the dry matter content is in the brewers' grains.

Choosing system expansion will lead to large differences in environmental impact of beer compared to the results of the screening for the brewery but will not lead to large differences in environmental impact of beer compared to the results of the screening for the total lifecycle.

Another consideration regarding system expansion is the fact that the co-product of the brewery (brewers' grains) actually has a larger environmental impact that the basic raw material which is used for the brewing of beer (malted barley), from the perspective that 1.7 kg dry matter of brewers' grains equals 2.0 kg dry matter of rapeseed meal.

Annex 4.3 Supporting material PEFCR for feed

This PEFCR has associated supplementary information in MS Excel with the file name "Feed for food producing animals_v5 - Life cycle inventory (24-10-2024).xlsx". This file shall be available where also the Feed PEFCR is available.

Annex 5 Part C list of default CFF parameters

Part C of Annex II is available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml .

The list of values in part C of Annex II is periodically reviewed and updated by the European Commission; users of the PEF method are invited to check and use the most updated values provided in the Annex.

Annex 6 Documentation of changes compared to the pilot beer PEFCR

In this section an overview is provided of the most relevant adaptations implemented during the partial revision of the beer PEFCR. Please note that the previous beer PEFCR was developed with other requirements and deliverables and that the update is only a partial update so no new methodological aspects/changes could be made or included.

1. **From EF2.0 to EF3.1 datasets**
    - The PEFCR for beer was using EF2.0 datasets, which were substituted by EF 3.1 datasets.
2. **Packaging Mix**
    - Pilot PEFCR: The packaging mix of the pilot PEFCR for beer was based on the 2010 packaging mix of the EU27, including Norway, Switzerland, and Turkey (The Brewers of Europe, 2012). The cooling mix is a consequence of the packaging mix.
    - Revised PEFCR: The packaging mix is based on the 2019 packaging mix of the EU + EFTA which also initiated a change in the cooling mix because this mix is directly connected to the type of packaging.
3. **Substitution of Dataset for returnable steel kegs/tanks**
    - For returnable steel kegs/tanks, the dataset *'Steel cold rolled coil blast furnace route single route, at plant carbon steel*' (UUID 3f445970-7d74-4d19-8be7-f9fba0b454b4) was substituted by *'Stainless steel cold rolled; hot rolling; production mix, at plant; stainless steel*' (UUID 468733f6-fc88-4da5-b9ff-e548059234c5) because this better fits with the actual applied technology.
4. **Update of Figure 9: The use stage process flow**
    - The water use was removed from the use stage process flow because there was, and is, not a water use input in the model.
5. **EF2.0 to EF3.1 reference package**
    - The EF2.0 method was replaced by the EF3.1 method. The revised PEFCR now also includes toxicity indicators, as the Commission Recommendation (EU) 2021/2279 (European Commission, 2021) now requires their use, which was not required in the pilot PEFCR. The toxicity indicators are: Human toxicity, cancer; Human toxicity, non-cancer; and Ecotoxicity, freshwater.
6. **Revised structure of the PEFCR**
    - The structure of this revised PEFCR has been changed as much as possible to adjust to the new template of Annex I of Commission Recommendation (EU) 2021/2279 (European Commission, 2021). However, important points where this revised PEFCR could not align with are:
        - The classes of performances (Section 7.3) were not included in this revised PEFCR because methodological aspects cannot be included or revised in a partial update.
        - There is no representative product report available because during the pilot PEFCR the screening studies were not required to be updated and delivered to the EC, so this report does not exist.
        - The most important direct elementary flows (See Section A.6.1.4 of Commission Recommendation (EU) 2021/2279) are not included in this revised PEFCR because these were not allowed to be included during the pilot PEFCR and no new aspects could be included.
        - In a partial revision the LCIA results are not allowed to change over a maximum (10% for the impact categories and 5% for the overall score) and the list of most relevant impact categories, life cycle stages, processes and direct elementary flows do not change. It is acknowledge by the EC that this requirement can never be met when the method and datasets from the EC already tricker much higher changes.