PEFCR for Beer

Note: the text included in *italics* in each section shall not be modified when drafting the PEFCR. Further text can be added if relevant.

The order of sections and their titles shall not be modified.

FINAL version V1.1 (post positive opinion of the EF Steering Committee on 18 April 2018)

Publication date: February 2020 (original publication date: June 2018)

Date of expiration: 31st of December 2021 (validity of secondary datasets accompanying this PEFCR).

Contents

Acronyms

A	= Allocation factor of burdens and credits between supplier and user of recycled materials
B2B	= Business to business
B2C	= Business to consumer
BoM	= Bill of Materials
CFF	= Circular Footprint Formula
CPA	= Classification of Products by Activities
DC	= Distribution Centre
DNM	= Data Needs Matrix
DQR	= Data Quality Rating
EC	= European Commission
EF	= Environmental Footprint
ELCD	= European reference Life Cycle Database
EoL	= End-of-Life
FEVE	= European Container Glass Federation
FU	= Functional unit
GHG	= Greenhouse Gas
GR	= Geographical Representativeness
ha	= hectare
hl	= hectolitre (= 100 litres)
ILCD	= International Reference Life Cycle Data System
ISO	= International Organization for Standardization
LCA	= Life Cycle Assessment
LCDN	= Life Cycle Data Network
LCI	= Life Cycle Inventory
LCIA	= Life Cycle Impact Assessment
LCS	= Life Cycle Stages
MCF	= Methane Correction Factor
NACE	= Statistical classification of economic activities in the European Community
P	= Precision
PCR	= Product Category Rules
PEF	= Product Environmental Footprint
PEFCR	= Product Environmental Footprint Category Rules
PET	= Polyethylene Terephthalate
R1	= Recycled content
R2	= Recycling rate
RP	= Representative Product
SC	= Steering Committee
SKU	= Stock Keeping Unit
TAB	= Technical Advisory Board
TeR	= Technological Representativeness
TiR	= Time Representativeness
TR	= Trip rate for returnable packaging
TS	= Technical Secretariat
UUID	= Universally Unique IDentifier
w/w	= Mass fraction
WWTP	= Waste Water Treatment Plant

Definitions

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

Aggregated dataset - This term is defined as a life cycle inventory of multiple unit processes (e.g. material or energy production) or life cycle stages (cradle-to-gate), but for which the inputs and outputs are provided only at the aggregated level. Aggregated datasets are also called "LCI results", "cumulative inventory" or "system processes" datasets. The aggregated dataset can have been aggregated horizontally and/or vertically. Depending on the specific situation and modelling choices a "unit process" dataset can also be aggregated. See Figure 1[2].

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

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

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

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

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

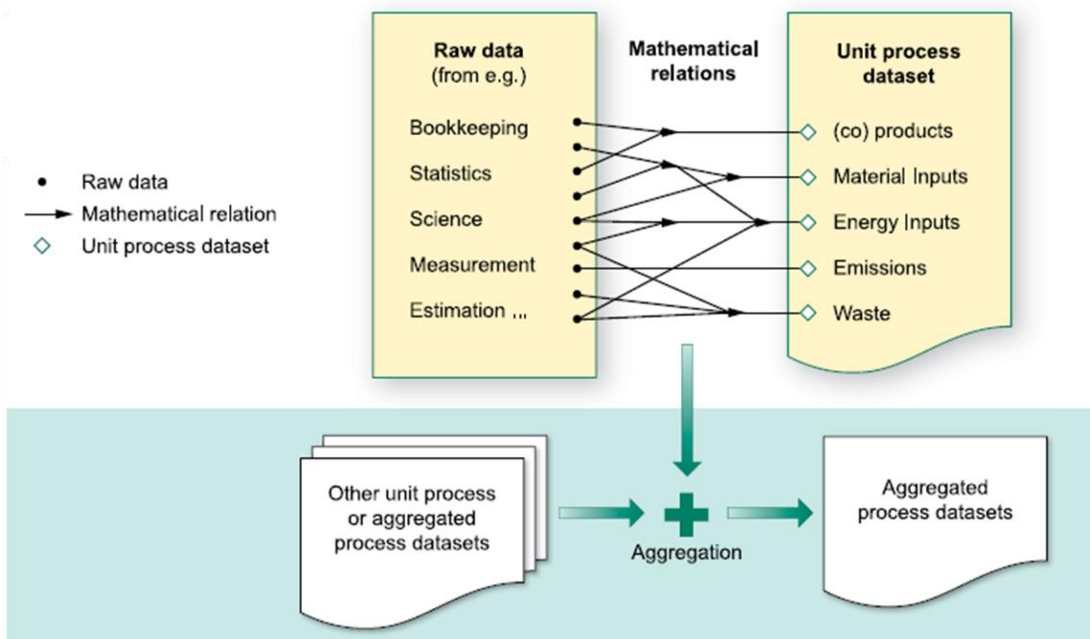


Figure 1: Definition of a unit process dataset and an aggregated process dataset

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

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

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

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

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

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

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

Direct elementary flows (also named elementary flows) – All output emissions and input resource use that arise directly in the context of a process. Examples are emissions from a chemical process, or fugitive emissions from a boiler directly onsite. See Figure 2.

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

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

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

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

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

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

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

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

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

Functional unit - The functional unit defines the qualitative and quantitative aspects of the function(s) and/or service(s) that the Organisation being evaluated provides; the unit of analysis definition answers the questions "what?", "how much?", "how well?", and "for how long?" (European Commission, 2013).

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

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

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

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

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

Life Cycle Assessment (LCA) - Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO, 2006).

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.

Life Cycle Impact Assessment (LCIA) - Stage of life cycle assessment 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 (ISO, 2006).

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

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

Partially disaggregated dataset - A dataset with a LCI that contains elementary flows and activity data, and that only in combination with its complementing underlying datasets yield a complete aggregated LCI data set. We refer to a partially disaggregated dataset at level 1 in case the LCI contains elementary flows and activity data, while all complementing underlaying dataset are in their aggregated form (see an example in Figure 2).

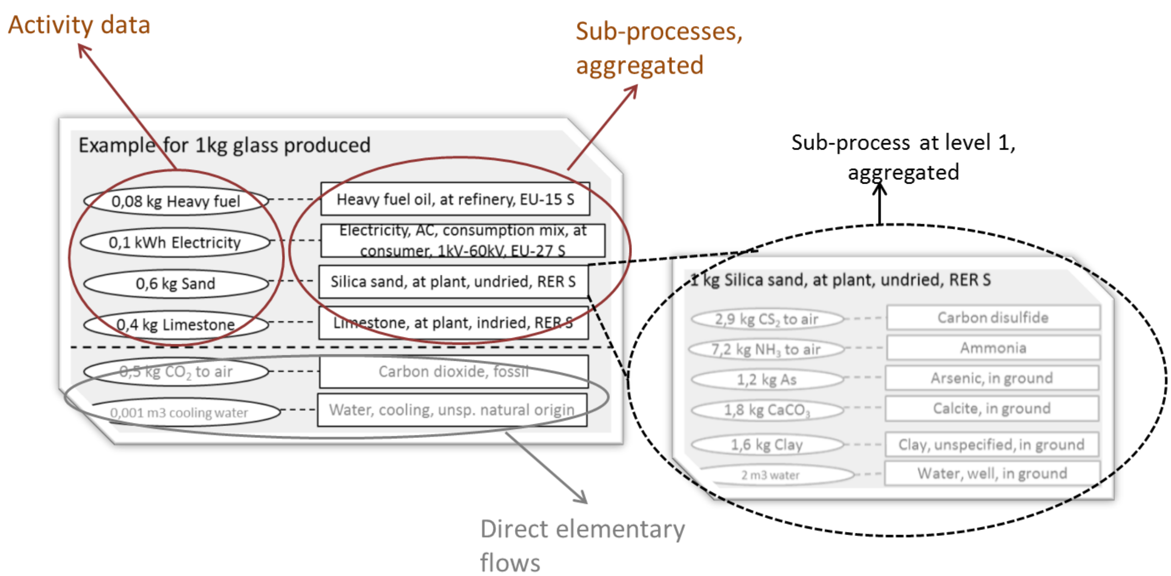


Figure 2: An example of a partially aggregated dataset, at level 1. The activity data and direct elementary flows are to the left, and the complementing sub-processes in their aggregated form are to the right. The grey text indicates elementary flows

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

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

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

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

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

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

Primary packaging - Primary Packaging constitutes the packaging designed to come into direct contact with the product (The Consumer Goods Forum, 2011).

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

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

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

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

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

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

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

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

Secondary packaging - Secondary packaging groups a given number of primary packaging units together into a convenient unit at the point of sale. Secondary packaging typically has one or two roles: it can be a convenient means to replenish the shelves; or it can group primary packaging units into a package for purchase. It can be removed without affecting the product's properties, and generally defines the unit handled by the retailer (The Consumer Goods Forum, 2011).

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

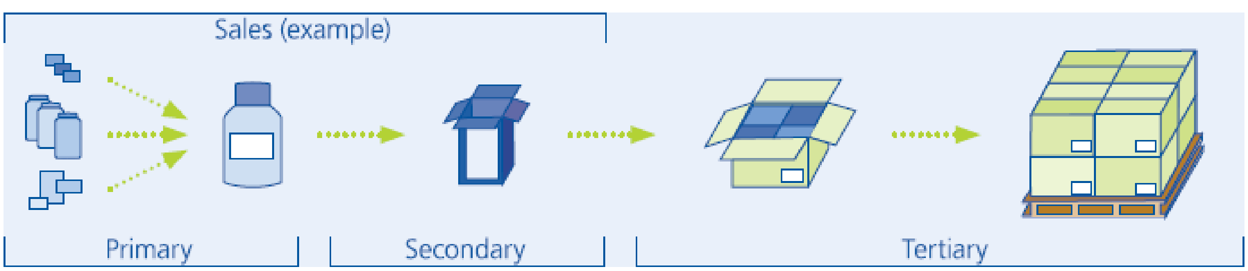
Stock Keeping Unit (SKU) - Warehousing item that is unique because of some characteristic (such as brand, size, colour, model). Every SKU is assigned a unique identification number which is often the same as (or is tied to) the item's EAN or UPC.

Sub-processes - Those processes used to represent the activities of the level 1 processes (=building blocks). Sub-processes can be presented in their (partially) aggregated form (see Figure 2).

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

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

Tertiary packaging - Tertiary Packaging is designed to ensure damage-free handling and transport of a number of SKUs or grouped packages. (The Consumer Goods Forum, 2011).



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

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

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

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

1 Introduction

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

For all requirements not specified in this PEFCR the applicant shall refer to the PEF guidance 6.3.

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

Terminology: shall, should and may

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

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

2 General information about the PEFCR

2.1. Technical secretariat

Table 1 Organizations in the Technical secretariat

Name of the organization	***Type of organization***	***Name of the members***	***Participation since***
The Brewers of Europe info@brewersofeurope.org	Industry Brewing EU association TS coordinator	Anna-Maria De Smet	March 2014
AB-InBev	Industry Brewing Company	Miroslav Halachev	March 2014
Carlsberg Group	Industry Brewing Company	Eskild Andersen	March 2014
HEINEKEN	Industry Brewing Company	Paul Bruijn	March 2014
SABMiller[6]	Industry Brewing Company	David Grant	March 2014
European Aluminium	Industry Aluminium Sector EU association	Christian Leroy & Djibril René	November 2014
The European Container Glass Federation – FEVE	Industry Glass containers EU association	Fabrice Rivet & Romeo Pavanello	November 2014
Beverage Industry Environmental Roundtable – BIER	Industry Beverages International association	Peter Penning	March 2014
Blonk Consultants	Consultant	Jasper Scholten	March 2014
Bocconi University	Consultant	Matteo Donelli	March 2014

[6] The merger between ABInbev and SABMiller closed early October 2016. The merged company had to divest the SABMiller activities in Europe.

2.2. Consultations and stakeholders

This PEFCR has been developed in a transparent manner and the different steps were made available on the dedicated wiki page of the EU pilots' website:
https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/Stakeholder+workspace%3A+PEFCR+pilot+Beer

The Technical Secretariat of the Beer PEF pilot has on several occasions 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 organizations (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.

The first public virtual consultation on the draft scope and representative product was performed from 15 September 2014 to 31 October 2014. The 1st physical consultation was held on 26 September 2014 and resulted in the report "*PEF Pilot Beer; Draft Scope and Representative Product*" (The Brewers of Europe, 2014) which was accepted by the Steering Committee on 16 December 2014.

The screening study and draft PEFCR were part of the 2nd open virtual consultation which was held from 15 September 2015 to 18 October 2015. The draft PEFCR was accepted in the Steering Committee of 19 January 2016. Notwithstanding, the supporting studies could only be started once:

- the draft PEFCR was updated to include the comments and commitments made during the Steering Committee meeting; and
- missing information needed to perform the supporting studies (e.g., the list of all datasets to be used) had been shared with the European Commission.

On 21 March 2016 the European Commission provided the green light to the Beer PEF Pilot to embark on the next step in the process. Based on the updated PEFCR, 8 SKU's in 3 supporting studies were investigated. The supporting studies were finalized in July 2016.

The feedback from these supporting studies is integrated in this draft PEFCR which went to a third (final) public virtual consultation from 2 August 2016 until 15 September 2016.

Table 2 Summary report on consultations towards stakeholders

	1st consultation	*2nd consultation*	*3rd consultation*
Type	Online and physical	Online	Online
Start	15.09.2014	15.09.2015	02.08.2016
End	31.10.2014	18.10.2015	15.09.2016
Number of participating stakeholders (online)	2	7	11
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
Number of comments	14	70	117
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 - 8 UK maltster – 2 UAPME - 3

2.3. Review panel and review requirements

The external review panel for this PEFCR is composed of the following members:

Name of the member	***Affiliation***	***Role***
Sébastien Humbert	Quantis Intl	LCA expert and chair
Stig Irving Olsen	Toxicon v/Stig Olsen	LCA and brewer expert
Jochem Verberne	WWF International	NGO representative

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

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

2.4. Review statement

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

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

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

The review panel would like to emphasize the very positive, constructive and communicative attitude of the TS and her leader in the course of the critical review process.

2.5. Geographic validity

This PEFCR is valid for products in scope consumed in the European Union + EFTA.

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

2.6. Language

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

2.7. Conformance to other documents

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

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

3 PEFCR scope

The 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(s)

The representative product ("weighted average beer recipe" in "average packaging") was developed during the screening phase. The screening study is available upon request to the TS coordinator that has the responsibility of distributing it with an adequate disclaimer about its limitations[7].

The representative product is based on the volumes of beer sold in the EU between 2010 - 2014. Table 3 contains the market shares of different beer types. Data is obtained from the beverage database of Canadean (Canadean, 2015). Table 4 contains the recipes made by Campden BRI of the different beer types included.

Table 3 Determination of the representative product, based on volumes of beer types sold in EU (2010-2014).

Beer types	Market share EU 2010-2014
Lager beer	89.54%
Wheat beer	2.28%
Ale	2.13%
Beer mixes	1.64%
Other top fermented	1.48%
Flavoured beer	0.95%
Stout beer	0.86%
Dark beer	0.64%
Others	0.43%
Seasonal beer	0.06%

[7] info@brewersofeurope.org

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 2010 of the EU27 including Norway, Switzerland and Turkey (The Brewers of Europe, 2012) and the cooling scenarios (cooling mix and energy use) are based on the scenarios from the screening study. Figure 3 provides an overview of the benchmark beer. Please note that the representative product is not on the market, it does not exist.

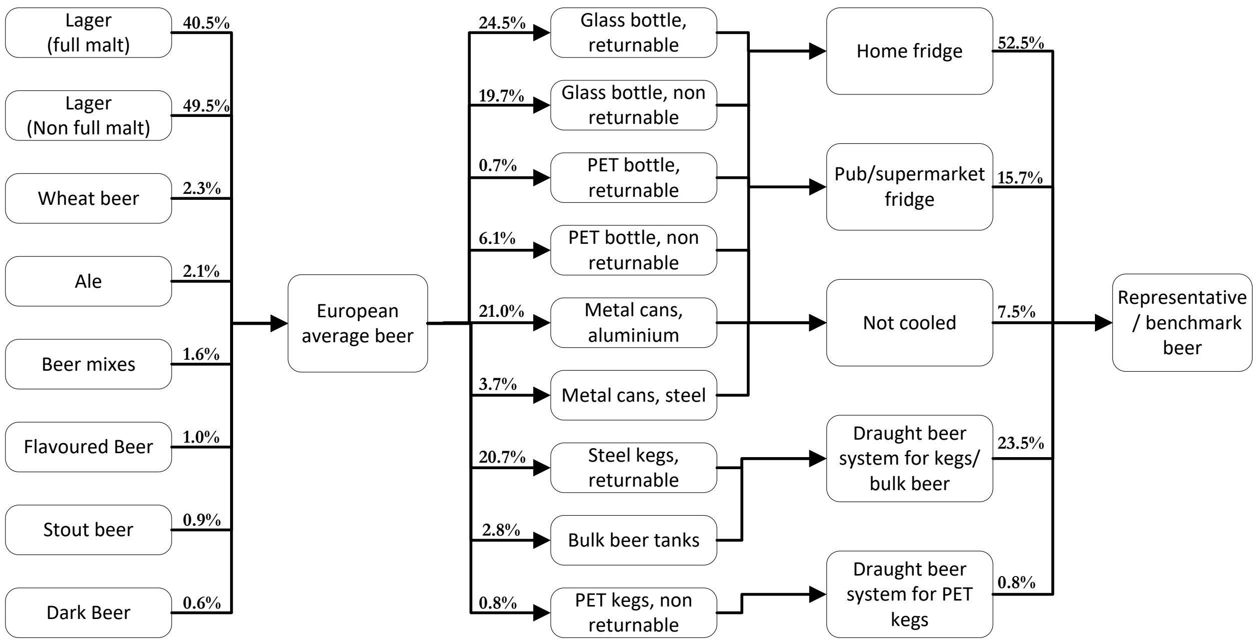


Figure 3 Determination of the representative product, based on volumes of beer types sold in EU (2010-2014).

There is only one representative product for beer, so no subcategories exist.

Table 4 Determination of the representative product, based on volumes of beer types sold in EU (2010-2014).

	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		

	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									

	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									

3.3. Functional unit and reference flow

The FU is 1 hectolitre[8] of beer. Table 5 defines the key aspects used to define the FU.

Table 5 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 6.8), must be increased to 7%.

For communication purposes the results may be translated to stock keeping units (SKUs) or a drinking unit.

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 at the brewery. 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 4 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 6 provides descriptions for each LCS. Due to the harmonisation requirements in LCS naming the LCS as mentioned in the PEF guidance 6.3 is also listed in italic in the first column of Table 6 (See also section 7.4.2 of the PEF guidance 6.3). The TS of beer decided not to use the required LCS naming because to 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.

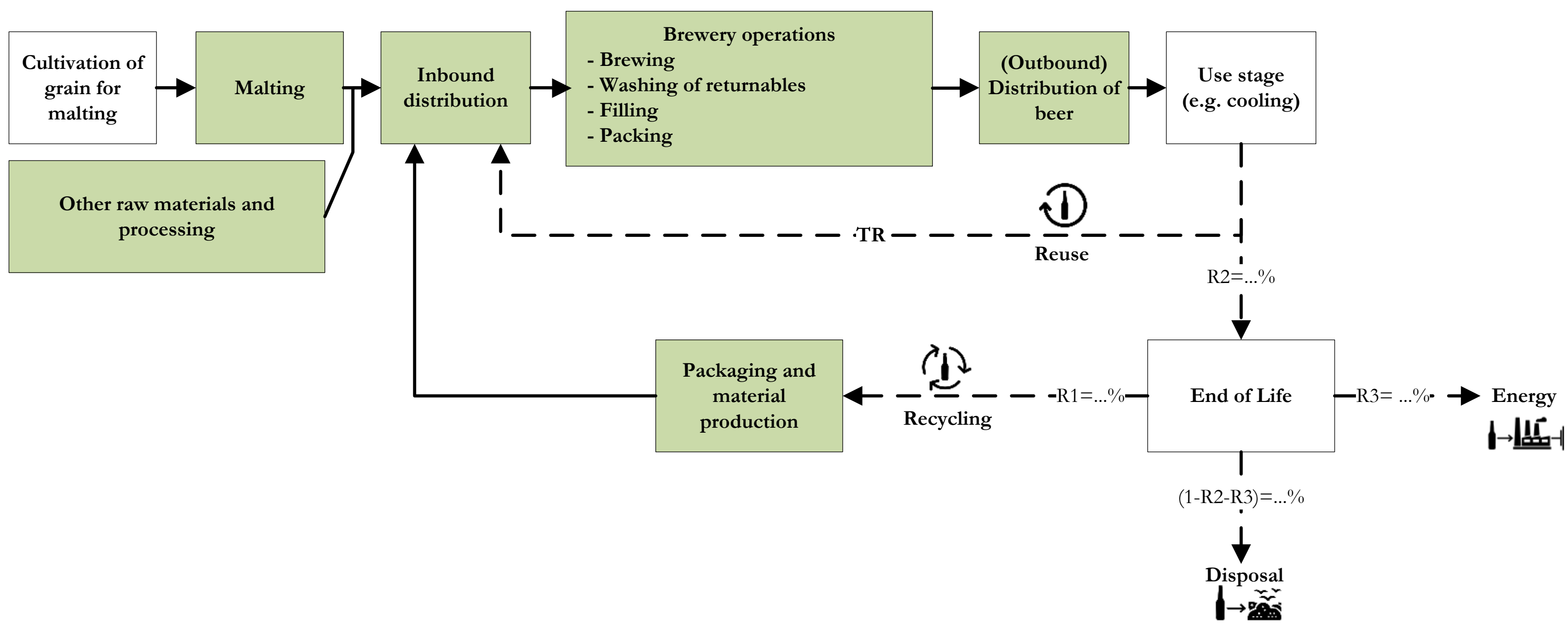


Figure 4 System diagram of beer including all life cycle stages (LCS). The green boxes are LCSs where company-specific data shall be used (see section 4 for more details). Secondary data may be used for the white boxes. Please note that processes within the LCS "Malting", "Processing of other raw materials"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

Table 6 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 4.
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 4
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 4
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 4

Life cycle stage	***Short description of the processes included***
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 4.
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 4.
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).

Life cycle stage	*Short description of the processes included*
End-of-life (continued)	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, the following processes can be excluded based on the cut-off rule: None.

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

3.5. EF impact assessment

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

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

Impact category	*Indicator*	*Unit*	*Recommended default LCIA method*
Climate change *~~– Climate change biogenic~~*[10] *~~– Climate change – land use and land transformation~~*[10]	*Radiative forcing as Global Warming Potential (GWP100)*	*kg $CO_{2\ eq}$*	*Baseline model of 100 years of the IPCC (based on IPCC 2013)*
Ozone depletion	*Ozone Depletion Potential (ODP)*	*kg CFC-11 $_{eq}$*	*Steady-state ODPs 1999 as in WMO assessment*
*Human toxicity, cancer**	*Comparative Toxic Unit for humans (CTU_h)*	*CTUh*	*USEtox model (Rosenbaum et al, 2008)*
*Human toxicity, non-cancer**	*Comparative Toxic Unit for humans (CTU_h)*	*CTUh*	*USEtox model (Rosenbaum et al, 2008)*
Particulate matter	*Impact on human health*	*disease incidence*	*UNEP recommended model (Fantke et al 2016)*
Ionising radiation, human health	*Human exposure efficiency relative to U^{235}*	*kBq $U^{235}{}_{eq}$*	*Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)*
Photochemical ozone formation, human health	*Tropospheric ozone concentration increase*	*kg NMVOC $_{eq}$*	*LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe*

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

Impact category	***Indicator***	***Unit***	***Recommended default LCIA method***
Acidification	*Accumulated Exceedance (AE)*	*mol $H+_{eq}$*	*Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)*
Eutrophication, terrestrial	*Accumulated Exceedance (AE)*	*mol N_{eq}*	*Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)*
Eutrophication, freshwater	*Fraction of nutrients reaching freshwater end compartment (P)*	*kg P_{eq}*	*EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe*
Eutrophication, marine	*Fraction of nutrients reaching marine end compartment (N)*	*kg N_{eq}*	*EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe*
*Ecotoxicity, freshwater**	*Comparative Toxic Unit for ecosystems (CTU_e)*	*CTUe*	*USEtox model, (Rosenbaum et al, 2008)*
Land use	• *Soil quality index[11]* • *Biotic production* • *Erosion resistance* • *Mechanical filtration* • *Groundwater replenishment*	• *Dimensionless (pt)* • *kg biotic production[12]* • *kg soil* • *m^3 water* • *m3 groundwater*	• *Soil quality index based on LANCA (EC-JRC)[13]* • *LANCA (Beck et al. 2010)* • *LANCA (Beck et al. 2010)* • *LANCA (Beck et al. 2010)* • *LANCA (Beck et al. 2010)*
*Water use***	*User deprivation potential (deprivation-weighted water consumption)*	*m^3 world $_{eq}$*	*Available WAter REmaining (AWARE) Boulay et al., 2016*
Resource use, minerals and metals	*Abiotic resource depletion (ADP ultimate reserves[14])*	*kg Sb_{eq}*	*CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.*
Resource use, fossils	*Abiotic resource depletion – fossil fuels (ADP-fossil)*	*MJ*	*CML 2002 (Guinée et al., 2002) and van Oers et al. 2002*

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

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

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

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

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

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

[14] The ADP crustal content/ultimate reserves is considered as an intermediate recommendation in terms of life cycle impact assessment method. The results of this impact category shall be interpreted with caution, because the results of ADP after normalization may be overestimated. The European Commission in cooperation with industry intends to develop a new method moving from depletion to dissipation model to better quantify the potential for conservation of resources.

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

3.6. Limitations

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.

ILCD compliant datasets

The following ILCD compliant datasets (so not EF-compliant datasets) are used in the benchmark including the reasoning:

Table 8 ILCD compliant datasets[15]

Name of non-EF compliant datasets	Reasoning for using a non-EF compliant dataset	Node
Barley grain| technology mix| at farm| {EU-28+3} [OPEN]	EF-compliant dataset on EU level was not available.	Link to node
Barley, malted| from malting| at plant| per kg {EU-28+3} [OPEN]	To be able to split the cultivation LCS from malting. This was not possible with the available EF-compliant datasets.	Link to node
Wheat, malted| from malting| at plant| per kg {EU-28+3} [OPEN]	To be able to split the cultivation LCS from malting. This was not possible with the available EF-compliant datasets.	Link to node
Roast malt| from malting| at plant| per kg {EU-28+3} [OPEN]	To be able to split the cultivation LCS from malting. This was not possible with the available EF-compliant datasets.	Link to node
Oats, malted| from malting| at plant| per kg {EU-28+3} [OPEN]	To be able to split the cultivation LCS from malting. This was not possible with the available EF-compliant datasets.	Link to node
Crystal malt| from malting| at plant| per kg {EU-28+3} [OPEN]	To be able to split the cultivation LCS from malting. This was not possible with the available EF-compliant datasets.	Link to node
Sorghum, malted| from malting| at plant| per kg {EU-28+3} [OPEN]	To be able to split the cultivation LCS from malting. This was not possible with the available EF-compliant datasets.	Link to node
Losses of refrigerants at the brewery	Data specific from PEF screening – shall be replaced by company-specific data.	Link to node

15 The '[OPEN]' datasets are based on aggregated datasets which were too aggregated for the purpose of the benchmark because cultivation of grains is a separate LCS.

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

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

- Climate change
- Particulate matter
- Acidification
- Water use
- Resource use, minerals and metals
- Resource use, fossils.

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

- Cultivation of grain for malting
- Malting
- Other raw materials and processing
- Packaging and material production
- Brewery operations
- Use stage
- End of Life.

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

Table 9 List of the most relevant processes

Most relevant impact category	Most relevant processes	Cultivation of grain for malting	Malting	Other raw materials and processing	Inbound distribution	Packaging	Brewery operations	Distribution of beer	Use stage (e.g. cooling)	End Of Life
Climate change	Electricity grid mix 1kV-60kV		1%						18%	
	Can beverage, body aluminium					11%				
	Container glass, virgin					19%				-11%
	Container glass, ER, Recycled Content 100% (provided by FEVE) - Aggregated					1%				7%
	High fructose corn syrup			7%						
	Thermal energy from natural gas						6%			
	Copy 80%LF				1%			3%		
	Caramel			3%						
	Cans beverage, sanitary end aluminium					3%				
	Solid board box					3%				
	Electricity from hard coal						2%			
	Can beverage, body steel					2%				
	Thermal energy from light fuel oil (LFO)		1%							
	Process steam from natural gas		1%							
	Cap, ECCS steel					1%				
	Wheat grain	1%								
	Thermal energy from heavy fuel oil (HFO)						1%			
	Sodium hydroxide production			1%						
	Barley grain	1%								
	Nitric acid production			1%						
	Testliner (2015)									1%
	Barley grain	1%								
	Barley grain	1%								

	Aluminium ingot mix									-6%
Respiratory inorganics	High fructose corn syrup			13%						
	Electricity grid mix 1kV-60kV								10%	
	Can beverage, body aluminium					7%				
	Container glass, ER, Recycled Content 100% (provided by FEVE) - Aggregated					1%				5%
	Caramel			5%						
	Container glass, virgin					12%				-7%
	Wheat grain	4%								
	Barley grain	3%								
	Barley grain	3%								
	Barley grain	3%								
	Can beverage, body steel					2%				
	Cap, ECCS steel					2%				
	Solid board box					2%				
	Stainless steel cold rolled								2%	
	Cans beverage, sanitary end aluminium					2%				
	Barley grain	1%								
	Oat grain peeled		1%							
	Sodium hydroxide production			1%						
	Phosphoric acid production			1%						
	Copy 80%LF							1%		
	Electricity from hard coal						1%			
	Sorghum production		1%							
	Barley grain	1%								
	Secondary Copper Cathode								1%	
	Barley grain	1%								
	Maize flaked			1%						
	Rice flour			1%						
	Rice middlings			1%						

	Copper cathode								1%	
	Hot rolled coil								1%	
	Rice flaked			1%						
	Kraft paper, uncoated									-1%
	Aluminium ingot mix									-3%
Acidification terrestrial and freshwater	High fructose corn syrup			13%						
	Electricity grid mix 1kV-60kV								8%	
	Container glass, ER, Recycled Content 100% (provided by FEVE) - Aggregated					1%				7%
	Caramel			5%						
	Can beverage, body aluminium					5%				
	Wheat grain	4%								
	Container glass, virgin					9%				-5%
	Barley grain	4%								
	Barley grain	3%								
	Copy 80%LF				1%			3%		
	Barley grain	3%								
	Copper cathode								3%	
	Barley grain	2%								
	Oat grain peeled		2%							
	Solid board box					1%				
	Cans beverage, sanitary end aluminium					1%				
	Barley grain	1%								
	Phosphoric acid production			1%						
	Barley grain	1%								
	Can beverage, body steel					1%				
	Electricity from hard coal						1%			
	Stainless steel cold rolled								1%	
	Sorghum production		1%							
	Cap, ECCS steel					1%				

	Sodium hydroxide production			1%						
	Diesel mix at filling station							1%		
	Maize flaked			1%						
	Roast malt			1%						
	Thermal energy from heavy fuel oil (HFO)						1%			
	Nitric acid production			1%						
	Aluminium ingot mix									-3%
Water scarcity	High fructose corn syrup			30%						
	Tap water		2%				21%			
	Container glass, virgin					32%				-19%
	Oat grain peeled		8%							
	Barley grain	8%								
	Caramel			7%						
	Solid board box					5%				
	Electricity grid mix 1kV-60kV								2%	
	Sugar			2%						
	Container glass, ER, Recycled Content 100% (provided by FEVE) - Aggregated					-3%				-15%
Resource use, energy carriers	Electricity grid mix 1kV-60kV		1%						23%	
	Can beverage, body aluminium					11%				
	Container glass, ER, Recycled Content 100% (provided by FEVE) - Aggregated					2%				8%
	Container glass, virgin					18%				-10%
	Thermal energy from natural gas						7%			
	High fructose corn syrup			5%						
	Diesel mix at filling station				1%			4%		
	Cans beverage, sanitary end aluminium					3%				
	Solid board box					3%				
	Caramel			2%						
	Process steam from natural gas		2%							

	Can beverage, body steel					2%				
	Electricity from hard coal						2%			
	Thermal energy from light fuel oil (LFO)		1%							
	Plastic bag, LDPE					1%				
	PET bottle, transparent					1%				
	Sodium hydroxide production			1%						
	Electricity from nuclear						1%			
	Kraft paper, uncoated									-1%
	Aluminium ingot mix									-6%
Resource use, mineral and metals	Copper cathode								23%	
	Secondary Copper Cathode								21%	
	PET bottle, transparent					19%				
	Stainless steel cold rolled								7%	
	Can beverage, body steel					6%				
	Cap, ECCS steel					6%				

5 Life cycle inventory

All newly created processes shall be EF-compliant.

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% (based on w/w of the BoM from the beer) of the sum of malting and other raw materials and processing;
  - 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;
- At least 60% (based on w/w of the BoM from the beer) of inbound distribution;
- Brewery operations;

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

- (Outbound) Distribution of beer.

Studies which 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 "*Beer PEFCR Final Version June 2018-life cycle inventory.xls*". The activity data request on raw materials for container glass is provided as an example in the below table. In the supporting material are also the DQRs of the EF-compliant datasets embedded.

Table 10 Example of the activity data request from the supporting material (please see the supporting material for an overview of all required activity data)

Bill of Materials (BOM):		Remarks:	Default dataset to be used	Dataset source (i.e. node)	UUID
Glass bottle output (kg)	1000	*All data in the table below per 1000kg of output*			
Total raw material input for glass bottle production (kg)					
Post consumer glass cullets (kg)			glass cullet production	http://lcdn.blonkconsultants.nl/Node/	*2df05e85-d2b3-4036-8e0f-561b718f27af*
Silica sand (kg)			silica sand production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/	573168e4-8f9e-46a3-a684-6187deeea33d
Synthetic soda (kg)			Soda production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/	546d4097-a453-4706-ac17-389325a04b6f
Natural soda (kg)			Soda production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/	546d4097-a453-4706-ac17-389325a04b6f

Bill of Materials (BOM) (continued):		Remarks:	Default dataset to be used	Dataset source (i.e. node)	UUID
Limestone/chalk (kg)			Calcium carbonate production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/	616b719c-0787-4329-a076-318e7adad458
Dolomite (kg)			Dolomite grinding dolomite grinding production mix, at plant 2.90 g/cm3	http://lcdn.thinkstep.com/Node/	ed307a79-72a1-4971-b954-b6c94245ee26
Feldspar (kg)			Feldspar (mining, open pit) feldspar mining, washing, drying production mix, at plant 2.56 g/cm3	http://lcdn.thinkstep.com/Node/	f30a5995-a7dd-4b76-ae27-8aa384c1df7f
Oxygen (kg)			Oxygen production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/	b12a9897-9ebb-41e9-8c3b-18db23ecd99e

5.2. Data gaps

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 7.19.5 of the PEF guidance 6.3, about which datasets to use, shall be applied.
  - For glass, no EF-compliant dataset is available for $E_{recycling}$ with a level 1 point of substitution to be used with company-specific data. As proxy the ILCD data-entry level compliant dataset glass cullet production available at the following node http://lcdn.blonkconsultants.nl/Node/ shall be used.
- 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 7.19.5 of the PEF guidance 6.3, 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 *"Beer PEFCR Final Version June 2018-life cycle inventory.xls"*. One example is "Malt extract (liquid)" for which no EF-compliant dataset is available. The supporting material states that the datasets 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.

5.3. Data quality requirements

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

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

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

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

5.4. Company-specific datasets

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

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

2) Calculate the DQR criteria TeR, TiR, GR and P for each most relevant process and each most relevant direct elementary flow. The values of each criterion shall be assigned based on Table 11*.*

2.a) Each most relevant elementary flow consists of the amount and elementary flow naming (e.g. 40 g carbon dioxide). For each most relevant elementary flow, evaluate the 4 DQR criteria named Te_{R-EF}, Ti_{R-EF}, G_{R-EF}, P_{EF} in Table 11. NOTE: in case the newly developed dataset has most relevant processes filled in by non-EF compliant datasets (and thus without DQR), then these datasets cannot be included in step 4 and 5 of the DQR calculation. (1) The weight of step 3 shall be recalculated for the EF-compliant datasets only. Calculate the environmental contribution of each most-relevant EF compliant process and elementary flow to the total environmental impact of all most-relevant EF compliant processes and elementary flows, in %. Continue with step 4 and 5. (2) The weight of the non-EF compliant dataset (calculated in step 3) shall be used to increase the DQR criteria and total DQR accordingly. For example:

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

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

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

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

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

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

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

$$\boldsymbol{DQR = \frac{\overline{Te_R}+\overline{G_R}+\overline{Ti_R}+\overline{P}}{4}}$$ *[*Equation 2*]*

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

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

Table 11 How to assess the value of the DQR criteria for datasets with company-specific information

	P_{EF} and P_{AD}	Ti_{R-EF} and Ti_{R-AD}	Ti_{R-SD}	Te_{R-EF} and Te_{R-SD}	G_{R-EF} and G_{R-SD}
1	*Measured/calculated and externally verified*	*The data refers to the most recent annual administration period with respect to the EF report publication date*	*The EF report publication date happens within the time validity of the dataset*	*The elementary flows and the secondary dataset reflect exactly the technology of the newly developed dataset*	*The data(set) reflects the exact geography where the process modelled in the newly created dataset takes place*
2	*Measured/calculated and internally verified, plausibility checked by reviewer*	*The data refers to maximum 2 annual administration periods with respect to the EF report publication date*	*The EF report publication date happens not later than 2 years beyond the time validity of the dataset*	*The elementary flows and the secondary dataset is a proxy of the technology of the newly developed dataset*	*The data(set) partly reflects the geography where the process modelled in the newly created dataset takes place*
3	*Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer*	*The data refers to maximum three annual administration periods with respect to the EF report publication date*	*Not applicable*	*Not applicable*	*Not applicable*
4-5	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*

5.5. Data needs matrix (DNM)

All processes required to model the product and outside the list of mandatory company-specific (listed in section 4) shall be evaluated using the Data Needs Matrix (See table 12). The DNM shall be used by the PEFCR applicant to evaluate which data is needed and shall be used within the modelling of its PEF, depending on the level of influence the applicant (company) has on the specific process. The following three cases are found in the DNM and are explained below:

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

Table 12 Data Needs Matrix (DNM)[16]. *Disaggregated datasets shall be used.

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

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

5.6. Processes in situation 1

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

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

Situation 1/Option 1

For all processes run by the company and where the company applying the PEFCR uses company specific data. The DQR of the newly developed dataset shall be evaluated as described in section 5.4.

Situation 1/Option 2

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

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

5.7. Processes in situation 2

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

- *The company applying the PEFCR has access to extensive supplier-specific information and wants to create a new EF-compliant dataset[17] (Option 1);*
- *The company has some supplier-specific information and want to make some minimum changes (Option 2).*
- *The process is not in the list of most relevant processes and the company prefers to use a secondary dataset (option 3).*

Situation 2/Option 1

For all processes run by the company and where the company applying the PEFCR uses company specific data. The DQR of the newly developed dataset shall be evaluated as described in section 5.4.

[17] The review of the newly created dataset is optional.

Situation 2/Option 2

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

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

The applicant of the PEFCR shall make the DQR values of the dataset used context-specific by re-evaluating Te_R and $Ti_{R,}$ using the table(s) provided Table 13. The criteria G_R shall be lowered by 30%[18] and the criteria P shall keep the original value.

Situation 2/Option 3

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

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

Table 13 How to assess the value of the DQR criteria when secondary datasets are used.

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

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

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

5.8. Processes in situation 3

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

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

Situation 3/Option 1

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

Situation 3/Option 2

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

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

5.9. Which datasets to use?

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

- *Use an EF-compliant dataset available on one of the following nodes:*
  - *http://eplca.jrc.ec.europa.eu/EF-node*
  - *http://lcdn.blonkconsultants.nl*
  - *http://ecoinvent.lca-data.com*
  - *http://lcdn-cepe.org*
  - *https://lcdn.quantis-software.com/PEF/*
  - *http://lcdn.thinkstep.com/Node*
- *Use an EF-compliant dataset available in a free or commercial source;*
- *Use another EF-compliant dataset considered to be a good proxy. In such case this information shall be included in the "limitation" section of the PEF report.*

- *Use an ILCD-entry level-compliant dataset that has been modelled according to the modelling requirements included in the Guidance version 6.3. In such case this information shall be included in the "limitations" section of the PEF report.*
- *Use an ILCD-entry level-compliant dataset. In such case this information shall be included in the "data gap" section of the PEF report.*

5.10. How to calculate the average DQR of the study

In order to calculate the average DQR of the EF study, the applicant shall calculate separately the TeR, TiR, GR and P for the EF study as the weighted average of all most relevant processes, based on their relative environmental contribution to the total single score (excluding the 3 toxicity-related ones). The calculation rules explained in chapter 5.3 and 5.5 shall be used.

5.11. Allocation rules

The following allocation rules shall be used by PEF studies:

Table 14 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 of the feed PEFCR when no company-specific data is applied.
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[19]. 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.

[19] 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).

Process	Allocation rule	Modelling instructions
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[20]. See also the sensitivity analysis in Annex 3. Use the Circular Footprint Formula in all other cases. (e.g. discharged to a pond, landfilling).

5.12. Electricity modelling

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

The following electricity mix shall be used in hierarchical order:

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

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

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

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

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.*

[20] 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).

Set of minimal criteria to ensure contractual instruments from suppliers:

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

A contractual instrument used for electricity modelling shall:

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

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

Datasets for residual grid mix, per energy type, per country and per voltage have been purchased by the European Commission and are available in the dedicated node (http://lcdn.thinkstep.com/Node/). In case the necessary dataset is not available, an alternative dataset shall be chosen according to the procedure described in section 0. If no dataset is available, the following approach may be used:

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

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

  These data can be found in the publications of the International Energy Agency (IEA).

- *Available LCI datasets per fuel technologies in the node. The LCI datasets available are generally specific to a country or a region in terms of:*
    - *Fuel supply (share of resources used, by import and / or domestic supply),*
    - *Energy carrier properties (e.g. element and energy contents)*
    - *Technology standards of power plants regarding efficiency, firing technology, flue-gas desulphurisation, NOx removal and de-dusting.*

Allocation rules:

Table 15 Allocation rules for electricity

Process	***Physical relationship***	***Modelling instructions***
The same allocation rules shall be applied for electricity as mentioned in section 0 and Table 14.	*The same allocation rules shall be applied for electricity as mentioned in section 0 and Table 14.*	*The same allocation rules shall be applied for electricity as mentioned in section 0 and Table 14.*

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 can be allocated to one specific product in the following conditions:

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

On-site electricity generation:

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

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

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

- *If possible, apply subdivision.*
- *Subdivision applies both to separate electricity productions or to a common electricity production where you can allocate based on electricity amounts the upstream and direct emissions to your own consumption and to the share you sell out of your company (e.g. if a company has a wind mill on its production site and export 30% of the produced electricity, emissions related to 70% of produced electricity should be accounted in the PEF study.*
- *If not possible, direct substitution shall be used. The country-specific residual consumption electricity mix shall be used as substitution[21].*
- *Subdivision is considered as not possible when upstream impacts or direct emissions are closely related to the product itself.*

5.13. Climate change modelling

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

1. *Climate change – fossil: This sub-category includes emissions from peat and calcination/carbonation of limestone. The emission flows ending with '(fossil)' (e.g., 'carbon dioxide (fossil)'' and 'methane (fossil)') shall be used if available.*
2. *Climate change – biogenic: This sub-category covers carbon emissions to air (CO_2, CO and CH_4) originating from the oxidation and/or reduction of biomass by means of its transformation or degradation (e.g. combustion, digestion, composting, landfilling) and CO_2 uptake from the atmosphere through photosynthesis during biomass growth – i.e. corresponding to the carbon content of products, biofuels or aboveground plant residues such as litter and dead wood. Carbon exchanges from native forests[22] shall be modelled under sub-category 3 (incl. connected soil emissions, derived products, residues). The emission flows ending with '(biogenic)' shall be used.*
   A simplified modelling approach shall be used when modelling the foreground emissions: Yes

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

   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.

[21] For some countries, this option is a best case rather than a worst case.
[22] Native forests – represents native or long-term, non-degraded forests. Definition adapted from table 8 in Annex V C(2010)3751 to Directive 2009/28/EC.

3. C*limate change – land use and land transformation: This sub-category accounts for carbon uptakes and emissions (CO_2, CO and CH_4) originating from carbon stock changes caused by land use change and land use. This sub-category includes biogenic carbon exchanges from deforestation, road construction or other soil activities (incl. soil carbon emissions). For native forests, all related CO_2 emissions are included and modelled under this sub-category (including connected soil emissions, products derived from native forest*[23] *and residues), while their CO_2 uptake is excluded. The emission flows ending with '(land use change)' shall be used.*

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

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

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

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

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

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

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

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

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

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

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

The sub-category 'Climate change-biogenic' shall be reported separately: No[24].

The sub-category 'Climate change-land use and land transformation' shall be reported separately: No[25].

5.14. Modelling of wastes and recycled content

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

[24] See footnote 10.
[25] Se footnote 10.

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

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

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

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

With the following parameters:

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

***B:** allocation factor of energy recovery processes: it applies both to burdens and credits. It 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 pre-processing of virgin material.*

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

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

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

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

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

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

6 Life cycle stages

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

6.1. 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.

6.2. 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 5 provides the overall simplified process flow of processing beer ingredients.

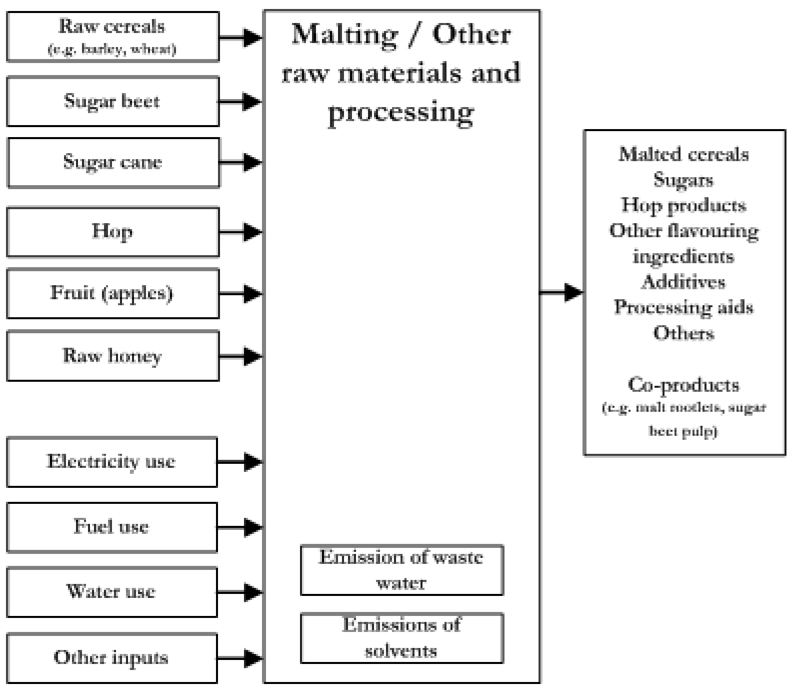


Figure 5: Simplified process flow of malting / Other raw materials and processing

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 4 on data requirements). The activity data as in the associated supporting material file 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 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 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 = 938d5ba6-17e4-4f0d-bef0-481608681f57).

If certain emissions (e.g. NO_x, 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.

6.3. 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 6: Primary, secondary and tertiary packaging material(The Consumer Goods Forum, 2011).

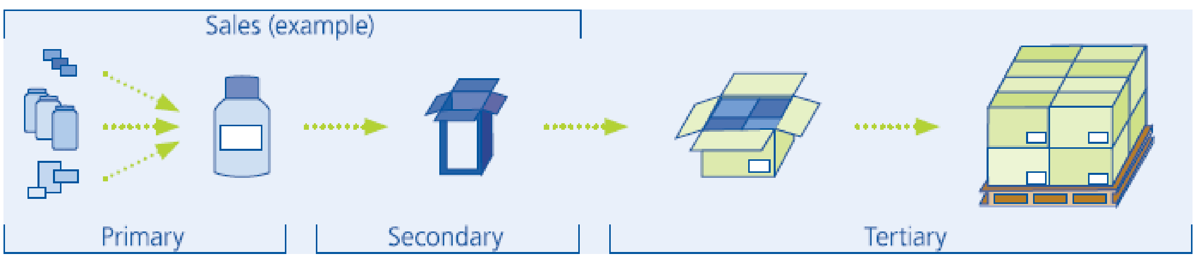


Figure 6: Primary, secondary and tertiary packaging material

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 4. 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 "*Beer PEFCR Final Version June 2018-life cycle inventory.xls*".

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 = 938d5ba6-17e4-4f0d-bef0-481608681f57).

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. NO_x, 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.

Guidance on how to model the production of glass bottles

The point of substitution is at level 1 when glass is modelled based on company specific data. This means that E_v 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 $E_v = E^*_v$. Erecyced is the collection, sorting and transportation of glass cullets to the glass factory and $E_{recyced} = E_{recyclingEoL}$.

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 CO_2-eq. / kg soda
- Dolomite: 0.415 kg CO_2-eq. / kg dolomite
- Limestone/Chalk: 0.440 kg CO_2-eq. / kg limestone/chalk

Model guidance of aluminium can bodies, steel can bodies and aluminium can ends

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: 21e4ff8c-4949-40f3-a800-d48bdfbe4294
- Can beverage, body steel Steel production, can forming, cleaning, drying, printing and varnishing, baking production mix, at plant body steel
  - UUID: 215151a2-e33c-4b59-a9d2-9b3fe569a07c
- Can beverage, sanitary end aluminium Aluminium production, can forming, cleaning, drying, printing and varnishing, baking production mix, at plant aluminium, 2.7 g/cm3
  - 2feefb75-f4c4-44b7-8c49-46150b0cee6c

Please see sections 7.18.7.2 and 7.18.7.4 (option 2) of the PEF guidance version 6.3 for more guidance on how to model the pre-consumer scrap.

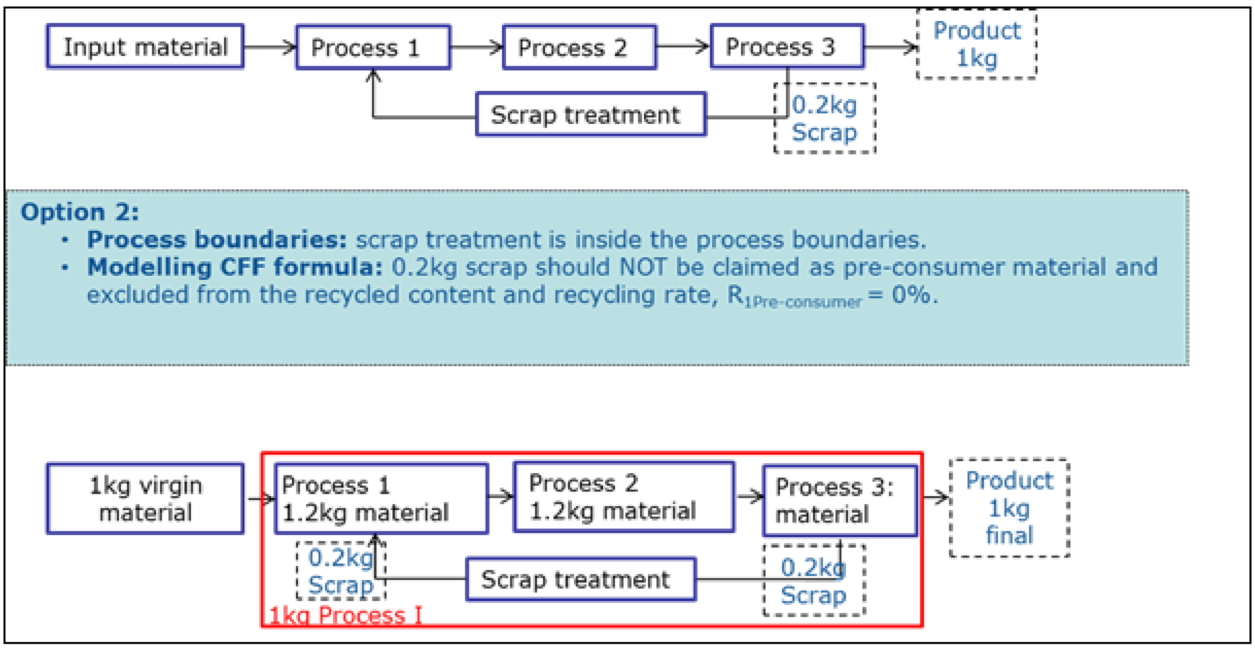


Figure 7: Modelling option when pre-consumer scrap is not claimed as pre-consumer recycled content (option 2 taken from section 7.18.7.4 of the PEF guidance version 6.3).

Table 16 provides a default list of EF-compliant datasets which may be used in PEF studies when no company-specific data is required.

Table 16 Default list of EF-compliant datasets which may be used 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	ef4e440e-05b3-4dd7-afbc-f24b4e625634
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	Cans 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

Guidance on how to model steel beer tanks

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

6.3.1. 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. For example: a reuse rate of 80% equals 5 reuses. Equation 3 describes the conversion:

$$\textbf{\textit{Number of reuse}} = \frac{\mathbf{1}}{\mathbf{100}\% - \%\ \boldsymbol{reuse\ rate}} \qquad \text{[Equation 3]}$$

The number of reuse 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 organized by the company owning the packaging material (company owned pools) or can be organized 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:** The use of supply-chain-specific data, based on accumulated experience over the lifetime of the previous glass bottle pool. This is the most accurate way to calculate the reuse rate of bottles for the previous bottle pool and can be a proper estimate for the current bottle pool. The following supply-chain-specific data is collected (see wiki page 'Access to documents of common interest' https://webgate.ec.europa.eu/fpfis/wikis/display/ EUENVFP/):*

- *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)*

$$\textit{Reuse rate of the bottle pool} = \frac{\#\, F_i}{\#B} \qquad \text{[Equation 4]}$$

$$\textit{The net glass use (kg glass/l beverage)} = \frac{\#\boldsymbol{B} \times (\boldsymbol{kg\ glass}/\boldsymbol{bottle})}{\#\boldsymbol{F_i}} \qquad \text{[Equation 5]}$$

This calculation option shall be used:

i. *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.*
ii. *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: *When 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)*

$$\text{Reuse rate of the bottle pool} = \frac{LT}{(LT \times \%Los) + \left(\frac{1}{\#Rot}\right)} \quad \text{[Equation 6]}$$

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 by an external verification, including the reasoning of this method choice.

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*[26]*, 5 trips for wine*[27]
- *Plastic crates for bottles: 30 trips*[28]
- *Plastic pallets: 50 trips (Nederlands Instituut voor Bouwbiologie en Ecologie, 2014)*[29]

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[26] 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).

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

[28] 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.

[29] The less conservative number is used.

- *Wooden pallets: 25 trips (Nederlands Instituut voor Bouwbiologie en Ecologie, 2014)*[30]

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:

$$(1-R_1)E_V + R_1 \times \left(AE_{recycled} + (1-A)E_V \times \frac{Q_{Sin}}{Q_p}\right) \qquad \text{[Equation 7]}$$

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.*

6.4. Agricultural modelling

Handling multi-functional processes: The rules described in the LEAP Guideline shall be followed: 'Environmental performance of animal feeds supply chains (pages 36-43), FAO 2015, available at http://www.fao.org/partnerships/leap/publications/en/'.

Use of crop type specific and country-region-or-climate specific data for yield, water and land use, land use change, fertiliser (artificial and organic) amount (N, P amount) and pesticide amount (per active ingredient), per hectare per year, if available.

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

Cultivation data shall be collected over a period of time sufficient to provide an average assessment of the life cycle inventory associated with the inputs and outputs of cultivation that will offset fluctuations due to seasonal differences:

- *For annual crops, an assessment period of at least three years shall be used (to level out differences in crop yields related to fluctuations in growing conditions over the years such as climate, pests and diseases, et cetera). Where data covering a three-year period is not available i.e. due to starting up a new production system (e.g. new greenhouse, newly cleared land, shift to other crop), the assessment may be conducted over a shorter period, but shall be not less than 1 year. Crops/plants grown in greenhouses shall be considered as annual crops/plants, unless the cultivation cycle is significantly shorter than a year and another crop is cultivated consecutively within that year. Tomatoes, peppers and other crops which are cultivated and harvested over a longer period through the year are considered as annual crops.*
- *For perennial plants (including entire plants and edible portions of perennial plants) a steady state situation (i.e. where all development stages are proportionally represented in the studied time period) shall be assumed and a three-year period shall be used to estimate the inputs and outputs[31].*
- *Where the different stages in the cultivation cycle are known to be disproportional, a correction shall be made by adjusting the crop areas allocated to different development stages in proportion to the crop areas expected in a theoretical steady state. The application of such correction shall be justified and recorded. The life cycle inventory of perennial plants and crops shall not be undertaken until the production system actually yields output.*
- *For crops that are grown and harvested in less than one year (e.g. lettuce produced in 2 to 4 months) data shall be gathered in relation to the specific time period for production of a single crop, from at least three recent consecutive cycles. Averaging over three years can best be done by first gathering annual data and calculating the life cycle inventory per year and then determine the three years average.*

Pesticide emissions shall be modelled as specific active ingredients. As default approach, the pesticides applied on the field shall be modelled as 90% emitted to the agricultural soil compartment, 9% emitted to air and 1% emitted to water.

Fertiliser (and manure) emissions shall be differentiated per fertilizer type and cover as a minimum:

- *NH_3, to air (from N-fertiliser application)*
- *N_2O, to air (direct and indirect) (from N-fertiliser application)*
- *CO_2, to air (from lime, urea and urea-compounds application)*
- *NO_3, to water unspecified (leaching from N-fertiliser application)*

[31] The underlying assumption in the cradle to gate life cycle inventory assessment of horticultural products is that the inputs and outputs of the cultivation are in a 'steady state', which means that all development stages of perennial crops (with different quantities of inputs and outputs) shall be proportionally represented in the time period of cultivation that is studied. This approach gives the advantage that inputs and outputs of a relatively short period can be used for the calculation of the cradle-to-gate life cycle inventory from the perennial crop product. Studying all development stages of a horticultural perennial crop can have a lifespan of 30 years and more (e.g. in case of fruit and nut trees).

- *PO_4, to water unspecified or freshwater (leaching and run-off of soluble phosphate from P-fertiliser application)*
- *P, to water unspecified or freshwater (soil particles containing phosphorous, from P-fertiliser application).*

The LCI for P emissions should be modelled as the amount of P emitted to water after run-off and the emission compartment 'water' shall be used. When this amount is not available, the LCI may be modelled as the amount of P applied on the agricultural field (through manure or fertilisers) and the emission compartment 'soil' shall be used. In this case, the run-off from soil to water is part of the impact assessment method.

The LCI for N emissions shall be modelled as the amount of emissions ending up in the different emission compartments per amount of fertilisers applied. The nitrogen emissions shall be calculated from Nitrogen applications of the farmer on the field and excluding external sources (e.g. rain deposition).

For nitrogen-based fertilisers the Tier 1 emissions factors of IPCC 2006 should be used.

Table 17 Parameters to be used when modelling nitrogen emission in soil

Emission	***Compartment***	***Value to be applied***
N_2O (synthetic fertiliser and manure; direct and indirect)	*Air*	*0.022 kg N_2O/ kg N fertilizer applied*
NH_3 (synthetic fertiliser)	*Air*	*kg NH_3= kg N * FracGASF= 1*0.1* (17/14)= 0.12 kg NH_3/ kg N fertilizer applied*
NH_3 (manure)	*Air*	*kg NH_3= kg N*FracGASF= 1*0.2* (17/14)= 0.24 kg NH_3/ kg N manure applied*
NO_3^- (synthetic fertiliser and manure)	*Water*	*kg NO_3^-= kg N*FracLEACH = 1*0.3*(62/14) = 1.33 kg NO_3^-/ kg N applied*
P based fertilisers	*Water*	*0.05 kg P/ kg P applied*

Heavy metal emissions from field inputs shall be modelled as emission to soil and/or leaching or erosion to water. The inventory to water shall specify the oxidation state of the metal (e.g., Cr+3, Cr+6). As crops assimilate part of the heavy metal emissions during their cultivation clarification is needed on how to model crops that act as a sink. The following modelling approach shall be used:

- *The final fate (emission compartment) of the heavy metal elementary flows is considered within the system boundary: the inventory does account for the final emissions (release) of the heavy metals in the environment and therefore shall also account for the uptake of heavy metals by the crop. For example, heavy metals in agricultural crops cultivated for feed will mainly end up in the animal digestion and used as manure back on the field where the metals are released in the environment and their impacts are captured by the impact assessment methods. Therefore, the inventory of the* *agricultural stage shall account for the uptake of heavy metals by the crop. A limited amount ends up in the animal (= sink), which may be neglected for simplification.*

Methane emissions from rice cultivation shall be included on basis of IPCC 2006 calculation rules.

Drained peat soils shall include carbon dioxide emissions on the basis of a model that relates the drainage levels to annual carbon oxidation.

The following activities shall be included:

- *Input of seed material (kg/ha)*
- *Input of peat to soil (kg/ha + C/N ratio)*
- *Input of lime (kg $CaCO_3$/ha, type)*
- *Machine use (hours, type) (to be included if there is high level of mechanisation)*
- *Input N from crop residues that stay on the field or are burned (kg residue + N content/ha)*
- *Crop yield (kg/ha)*
- *Drying and storage of products*
- *Field operations through total fuel consumption or through inputs of sub-farm units (specific machinery, transport to and from field, energy for irrigation, etc).*

6.5. 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.

6.6. Brewery operations / Manufacturing

Figure 8 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 which shall be used are listed in the associated supplementary information named "*Beer PEFCR Final Version June 2018-life cycle inventory.xls*".

The company-specific data shall be specific for the brewery where the beer is produced (so no average of multiple production locations). The input of beer ingredients and packaging materials shall be beer specific. The other input/output may be yearly averages of the brewery.

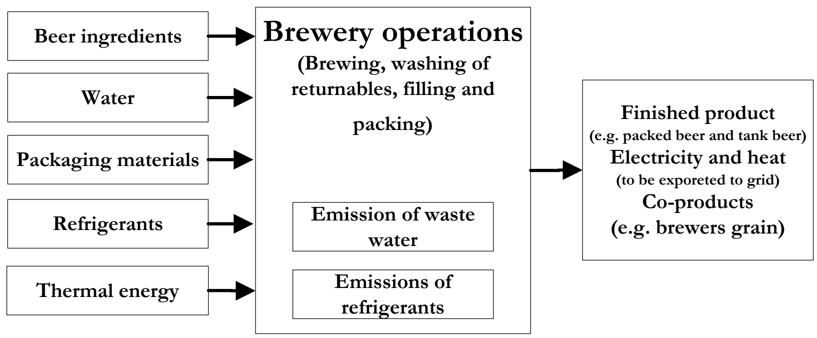

Figure 8 Simplified process flow of brewery operations

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.

If certain emissions (e.g. NO_x, 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.

On-site and third-party waste water treatment plant

Biogenic methane and N_2O 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 CH_4 producing capacity (B_0): 0.25 kg CH_4/kg COD
- Methane Correction Factor (MCF): 0.1
- Emission factor for N_2O emissions from discharged to wastewater ($EF_{EFFLUENT}$): 0.005 kg N_2O-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[32]

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 waste of products used during the manufacturing shall be included in the modelling. The reference flow shall be 1 hl of beer sold (so excluding losses).

6.7. Distribution stage

The transport from factory to final client (including consumer transport) shall be modelled within this life cycle stage. The final client is defined as the person who will consume/drink the beer.

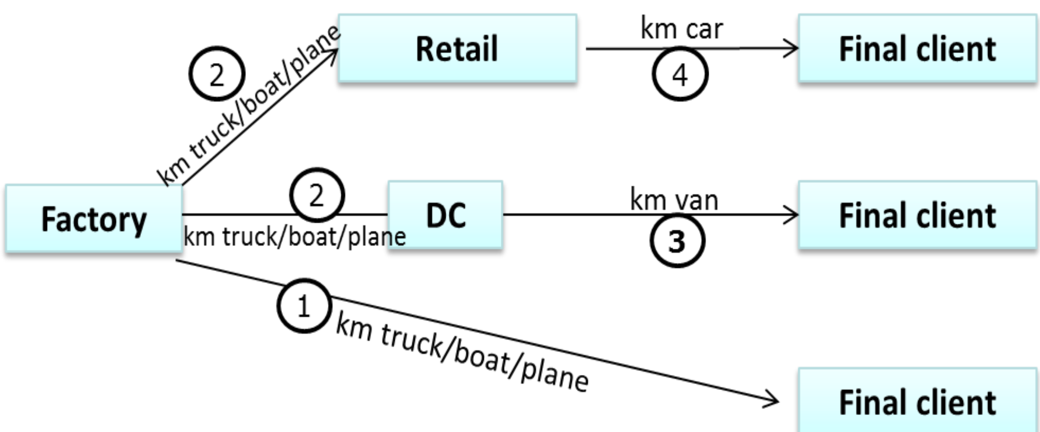

Figure 9 Distribution scenarios

For the distribution of the final product to retail, DC and/or the final client (route 1, 2 and 3 in Figure 9) a weighted average distance from brewery to the point of sales should be calculated taking into account yearly data of sold product.

[32] 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.

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 PEF guidance 6.3):

(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 3, utilisation ratio of 20%; UUID aea613ae-573b-443a-aba2-6a69900ca2ff)

(4) 60%[33] 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 3 with utilisation ratio of 20%[6]; UUID aea613ae-573b-443a-aba2-6a69900ca2ff)
- 33%: no impact modelled

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.

[33] 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%).

6.8. Use stage

Figure 10 provides the overall simplified process flow of the use stage.

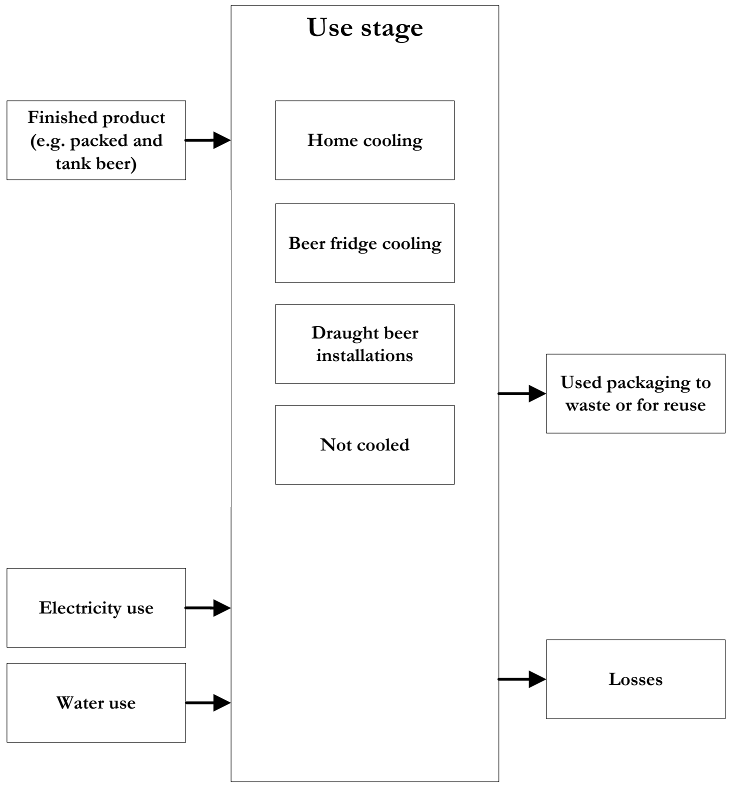

Figure 10 Simplified process flow of the use stage

The cooling of beer shall be modelled with the same secondary data as the benchmark. Table 18 provides cooling scenarios related to primary packaging types.

Table 18: 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**

Losses

The waste of products during the use stage shall be included in the modelling.

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%

Please note that losses are accounted at the end of the life cycle: i.e. after the beer is cooled. So, losses include for instance beer losses, packaging losses and wasted energy for cooling the beer.

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

The applicant shall report the DQR for all the datasets used.

6.9. End of life

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

Please note that this LCS only includes the waste of packaging. Beer losses are included in the previous LCSs.

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 19 and the parameters as listed in Table 20. 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 19 and Table 20.

Table 19 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)	$E_{recyclingEoL}$	glass cullet production	2df05e85-d2b3-4036-8e0f-561b718f27af				
Glass bottle	Material (EoL)	E^*_v	E*v = Ev (see section 6.3)	*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	Steel cold rolled coil| blast furnace route| single route	3e5ff637-ffc2-4920-9051-11055b1d2d18	2	3	2	2

Packaging material	CFF part	CFF parameter	Simple UUID name	UUID	Default DQR			
					P	*Ti_R*	*G_R*	*Te_R*
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 | primary production	dd93261c-d6da-44ec-a842-78b4a42c2884	PM	PM	PM	PM
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	60dd82e4-46d0-4735-a8ad-94e708a2b92a	PM	PM	PM	PM
PET bottle or keg	Material (EoL)	E^*_v	PET granulates, bottle grade via purified terephthalic acid (PTA) and ethylene glycol	41655123-771d-4b8e-b56e-9aeac7e1170a	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
PET bottle or keg	Disposal	E_d	Landfill of plastic waste	f2bea0f5-e4b7-4a2c-9f34-4eb32495cbc6	2	2	2	2
Paper products	Material (EoL)	$E_{recyclingEoL}$	Testliner (2015) | technology mix, thermal energy sold/used externally	a0c91472-04d8-4293-acf5-0ec97a514bfd	PM	PM	PM	PM
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 20 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[34]	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

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

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

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

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[35].

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

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

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

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 end of life. The amount of packaging treated at end of life shall be calculated by dividing the actual weight of the packaging by the number of times this packaging was reused.

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

7 PEF results

7.1. Benchmark values

Table 21 Characterised benchmark values for the benchmark beer for 1 hl consumed beer

Impact category	Unit	Life cycle excl. use stage	Use stage
Climate change	kg CO2 eq	55.1	17.5
Ozone depletion	kg CFC11 eq	1.47E-06	4.80E-06
Ionising radiation, human health	kBq U-235 eq	5.0	5.8
Photochemical ozone formation, human health	kg NMVOC eq	0.150	0.033
Particulate matter	disease inc.	3.38E-06	7.59E-07
Acidification	mol H+ eq	0.41	0.07
Eutrophication, freshwater	kg P eq	4.67E-03	2.53E-03
Eutrophication, marine	kg N eq	2.49E-01	1.21E-02
Eutrophication, terrestrial	mol N eq	1.53E+00	1.24E-01
Land use	Pt	5155.1	163.2
Water use	m3 depriv.	75.0	3.2
Resource use, fossils	MJ	699.9	277.7
Resource use, minerals and metals	kg Sb eq	1.45E-04	3.00E-04

Table 22 Normalised benchmark values for the benchmark beer for 1 hl consumed beer

Impact category	Life cycle excl. use stage	Use stage
Climate change	7.10E-03	2.25E-03
Ozone depletion	6.29E-05	2.06E-04
Ionising radiation, HH	1.18E-03	1.36E-03
Photochemical ozone formation, HH	3.69E-03	8.11E-04
Particulate matter	5.31E-03	1.19E-03
Acidification	7.30E-03	1.24E-03
Eutrophication freshwater	1.83E-03	9.93E-04
Eutrophication marine	8.81E-03	4.28E-04
Eutrophication terrestrial	8.66E-03	6.99E-04
Land use	3.86E-03	1.22E-04
Water scarcity	6.53E-03	2.81E-04
Resource use, energy carriers	1.07E-02	4.26E-03
Resource use, mineral and metals	2.51E-03	5.18E-03

Table 23 Weighted benchmark values for the benchmark beer for 1 hl consumed beer

Impact category	Life cycle excl. use stage	Use stage
Climate change	1.58E-03	5.00E-04
Ozone depletion	4.25E-06	1.39E-05
Ionising radiation, HH	6.35E-05	7.33E-05
Photochemical ozone formation, HH	1.88E-04	4.13E-05
Particulate matter	5.07E-04	1.14E-04
Acidification	4.85E-04	8.24E-05
Eutrophication freshwater	5.40E-05	2.93E-05
Eutrophication marine	2.75E-04	1.33E-05
Eutrophication terrestrial	3.38E-04	2.73E-05
Land use	3.25E-04	1.03E-05
Water scarcity	5.90E-04	2.54E-05
Resource use, energy carriers	9.56E-04	3.80E-04
Resource use, mineral and metals	2.03E-04	4.19E-04

7.2. PEF profile

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

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

Together with the PEF report, the applicant shall provide a weblink to the EF-compliant dataset (downloadable for free without registration). The disaggregated version may stay confidential.

7.3. 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.

7.4. 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.

The following 6 impact categories are relevant for biodiversity: Climate change, Eutrophication aquatic freshwater, Eutrophication aquatic marine, Acidification, Water use, Land use. Three of these 6 impact categories are 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.

8 Verification

The verification of an EF study/report carried out in compliance with this PEFCR shall be done according to all the general requirements included in Section 8 of the PEFCR Guidance version 6.3 and the requirements listed below.

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

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

- *the verifier shall check if the correct version of all impact assessment methods was used. For each of the most relevant impact categories, at least 50% of the characterisation factors (for each of the most relevant EF impact categories) shall be verified, while all normalisation and weighting factors of all ICs shall be verified. In particular, the verifier shall check that the characterisation factors correspond to those included in the EF impact assessment method the study declares compliance with[36];*
- *all the newly created datasets shall be checked on their EF compliancy (for the meaning of EF compliant datasets refer to Annex H of the Guidance). All their underlying data (elementary flows, activity data and sub processes) shall be validated;*
- *the aggregated EF-compliant dataset of the product in scope (meaning, the EF study) is available on the EF node (http://eplca.jrc.ec.europa.eu/EF-node).*
- *for at least 70% of the most relevant processes in situation 2 option 2 of the DNM, 70% of the underlying data shall be validated. The 70% data shall include all energy and transport sub processes for those in situation 2 option 2;*
- *for at least 60% of the most relevant processes in situation 3 of the DNM, 60% of the underlying data shall be validated;*
- *for at least 50% of the other processes in situation 1, 2 and 3 of the DNM, 50% of the underlying data shall be validated.*
- The verifier shall check newly developed supporting materials if all relevant information is included in this material (see also section 6.2).

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

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

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

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

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

9 References

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10 Annex

10.1. 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 and provided in below table.

The three classification levels are based on the ILCD handbook “Recommendations for Life Cycle Impact Assessment in the European context” (JRC-IES & European Commision, 2011) and according to their quality:

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

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

Impact category	Unit	Normalisa-tion factor	Normalisa-tion factor per person	Impact assess-ment robustness	Inventory coverage completeness	Inventory robustness	Comment
Climate change	kg $CO_{2\ eq}$	5.35E+13	7.76E+03	I	II	I	
Ozone depletion	kg CFC-11 $_{eq}$	1.61E+08	2.34E-02	I	III	II	
Human toxicity, cancer	CTUh	2.66E+05	3.85E-05	II/III	III	III	
Human toxicity, non-cancer	CTUh	3.27E+06	4.75E-04	II/III	III	III	
Particulate matter	disease incidence	4.39E+06	6.37E-04	I	I/II	I /II	NF calculation takes into account the emission height both in the emission inventory and in the impact assessment.
Ionising radiation, human health	kBq U^{235}_{eq}	2.91E+13	4.22E+03	II	II	III	

Impact category	Unit	Normalisation factor	Normalisation factor per person	Impact assessment robustness	Inventory coverage completeness	Inventory robustness	Comment
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	2.80E+11	4.06E+01	II	III	I/II	
Acidification	mol H+ $_{eq}$	3.83E+11	5.55E+01	II	II	I/II	
Eutrophication, terrestrial	mol N $_{eq}$	1.22E+12	1.77E+02	II	II	I/II	
Eutrophication, freshwater	kg P $_{eq}$	1.76E+10	2.55E+00	II	II	III	
Eutrophication, marine	kg N $_{eq}$	1.95E+11	2.83E+01	II	II	II/III	
Land use	pt	9.20E+15	1.33E+06	III	II	I I	The NF is built by means of regionalised CFs.
Ecotoxicity, freshwater	CTUe	8.15E+13	1.18E+04	II/III	III	III	
Water use	m^3 world $_{eq}$	7.91E+13	1.15E+04	III	I	II	The NF is built by means of regionalised CFs.
Resource use, fossils	MJ	4.50E+14	6.53E+04	III	I	II	
Resource use, minerals and metals	kg Sb $_{eq}$	3.99E+08	5.79E-02	III			

The European weighting factors that shall be applied are listed in below table.

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

10.2. ANNEX 2 - Check-list for PEF study

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

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

ITEM	***Included in the study (Y/N)***	***Section***	***Page***
DQR calculation of each dataset used for the most relevant processes and the new ones created.			
DQR (of each criteria and total) of the study			

10.3. ANNEX 3 - Critical review report

Included as separate xls attachment.

10.4. 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 "*Beer PEFCR Final Version June 2018-life cycle inventory.xls*". This file shall be available where also this PEFCR is available.

ANNEX 4.2 – Sensitivity analysis to allocation choices at brewery for brewers' grain

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)
Date:	1-3-2016
Subject:	Sensitivity analysis to allocation choices at the 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' grain 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' grain 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 grain (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 24.

Table 24: Sensitivity to allocation choices for the impact of the brewery specifically, per hl of beer.

Impact category	Unit/hl	Current: No allocation to brewers' grain	Economic allocation: 99% to beer	Mass allocation (dm): 99% to brewers' grain	System expansion: 1.7 kg dm brewers' grain 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 25.

Table 25: 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' grain	Economic allocation: 99% to beer	Mass allocation (dm): 99% to brewers' grain	System expansion: 1.7 kg dm brewers' grain 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 11.

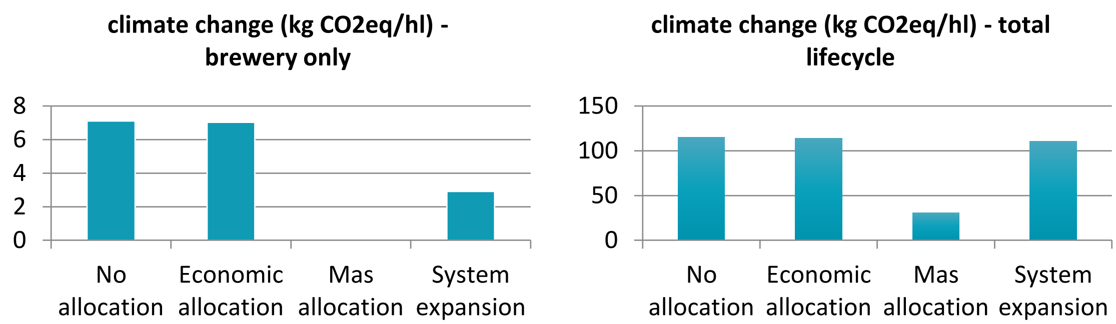

Figure 11: Sensitivity to allocation choices for the impact on climate change, for the brewery only and the total lifecycle.

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 26**.

Table 26: Environmental impact of brewers' grains compared to malted barley.

Impact category	Unit/hl	Impact of 1kg brewers' grain 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 find 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.