Product Environmental Footprint

Product Environmental Footprint Category Rules (PEFCRs) for thermal insulation

Thermal insulation products in buildings:

- **Cellulose insulation applied in pitched roofs with massive timber rafters**
- **EPS, PU and Cellular Glass insulation applied in non-accessible flat roofs with concrete structure**

- **Version number**: 5.0
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Table of contents

List of Figures

List of Tables

List of Acronyms

AF	Allocation Factor
AR	Allocation Ratio
B2B	Business to Business
B2C	Business to Consumer
BoC	Bill of Components
BoM	Bill of Materials
BP	Bonne Pratique
CEN	European Committee for Normalisation
CF	Characterization Factor
CFF	Circular Footprint Formula
CFF-M	Circular Footprint Formula – Modular form
CML	Centre for Environmental Sciences in Leiden
CMWG	Cattle Model Working Group
CPA	Classification of Products by Activity
DC	Distribution Centre
DG	Directorate General
DIN	German institute for standardisation
DMI	Dry Matter Intake
DNM	Data Needs Matrix
DQR	Data Quality Rating
EA	Economic Allocation
EC	European Commission
EEA	European Economic Area
EF	Environmental Footprint
EI	Environmental Impact
ELCD	European Life Cycle Database
EN	European Norm
EoL	End-of-Life
EPD	Environmental Product Declaration
EPS	Expanded Polystyrene
ETA	European Technical Approval
ETICS	External Thermal Insulation Composite System
FDIS	Final Draft International Standard (ISO)
FU	Functional Unit
GE	Gross Energy intake
GR	Geographical Representativeness
GHG	Greenhouse Gas
GWP	Global Warming Potential
HD	Helpdesk
ILCD	International Reference Life Cycle Data System
IPCC	Intergovernmental Panel on Climate Change

ISO	International Organisation for Standardisation
JRC	Joint Research Centre
LCDN	Life Cycle Data Network
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LCT	Life Cycle Thinking
LT	Lifetime
NACE	Statistical classification of economic activities in the European Community
NDA	Non-Disclosure Agreement
NF	French norm
NGO	Non-Governmental Organisation
NMVOC	Non-methane volatile compounds
OSB	Oriented Standard Board
P	Precision
PCR	Product Category Rules
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PIR	Polyisocyanurate
PU	Polyurethane
RF	Reference Flow
RP	Representative Product
RSL	Reference Service Life
SB	System Boundary
SC	Steering Committee
SMRS	Sustainability Measurement & Reporting System
SS	Supporting study
TAB	Technical Advisory Board
TC	Technical Committee
TeR	Technological Representativeness
TiR	Time Representativeness
TS	Technical Secretariat
UNEP	United Nations Environment
UUID	Universally Unique Identifier
XPS	Extruded Polystyrene Foam

I. List of definitions

For all terms used in this Guidance and not defined below, please refer to the most updated version of the Product Environmental Footprint (PEF) Guide, ISO 14025:2006, ISO 14040-44:2006, and the ENVIFOOD Protocol.

Activity data - This term refers to information which is associated with processes while modelling Life Cycle Inventories (LCI). In the PEF Guide it is also called “non-elementary flows”. The aggregated LCI results of the process chains that represent the activities of a process, are each multiplied by the corresponding activity data[1] and then combined to derive the environmental footprint associated with a process (See Figure 1). 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].

Ancillary material – Additional materials necessary for running the production lines.

Ancillary product – Additional product necessary in the build-up of a specific application, like (non-exhaustive list) mechanical fixing, adhesive, water proofing layer and vapour barrier.

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.

Applicant - Company/Organisation implementing this PEFCR.

Assessed product - The assessed product is the thermal insulation product for which the PEF study is done.

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, 2004).

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

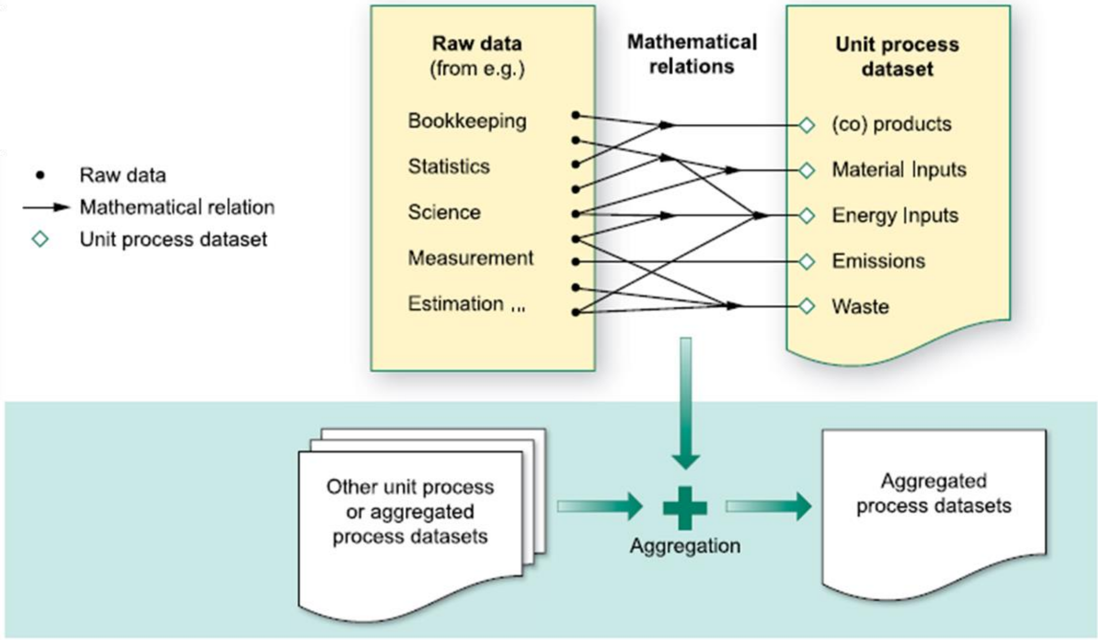

Figure 1: Definition of a unit process dataset and an aggregated process dataset

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 EF Guide, EF Guidance and the relevant PEFCR, if available (definition adapted from ISO 14071/2014, point 3.4).

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

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

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

Conventional roof - In flat roofs with conventional build-up, the thermal insulation is placed above the structural deck but below the water-proofing membrane.

Design life span - Service life intended by the designer [ISO 15686-1:2000]

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Inverted roof - Inverted roofs have their water proofing layer beneath the insulation instead of above it as in conventional forms of roofing.

Insulation material - The substance(s) from which the thermal insulation product is made.

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

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

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

[3] https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/e-track_ii_guarantees_of_origin_in_europe.pdf

https://ec.europa.eu/energy/intelligent/projects/en/projects/e-track#results

https://ec.europa.eu/energy/intelligent/projects/en/projects/e-track-ii life cycle inventory. A LCI dataset could be a unit process dataset, partially aggregated or an aggregated dataset.

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

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

Partially disaggregated dataset - A dataset with an LCI that contains elementary flows and activity data, and that only in combination with the complementing aggregated datasets that represent the activities yields a complete aggregated LCI data set. We refer to a partially disaggregated dataset at level 1 in case the LCI contains elementary flows and activity data, while at least some of the complementing sub-processes are in their aggregated form (see an example in Figure 2). The underlying sub-processes should be based on EF-compliant secondary datasets (if available).

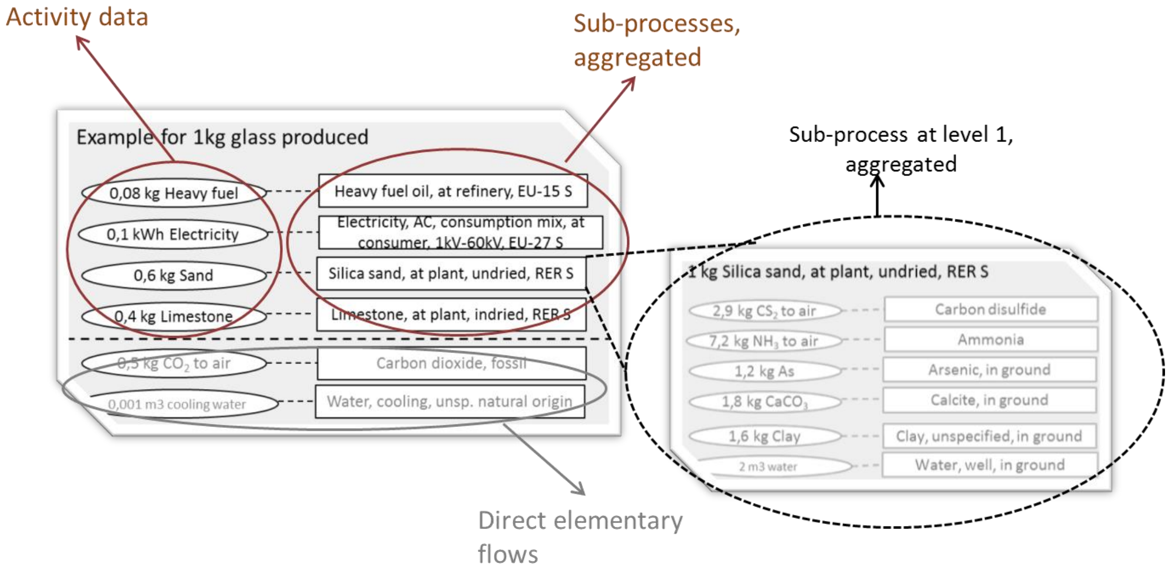

Figure 2: An example of a partially aggregated dataset, at level 1.

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 EF Guide, EF Guidance and the relevant PEFCR if available. The practitioner of the EF study can belong to the same organisation as the commissioner of the EF study (adapted from ISO 14071/2014, point 3.6).

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

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

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

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

Reference service life (RSL) - Service life of a construction product which is known to be expected under a particular set, i.e., a reference set, of in-use conditions and which form the basis of estimating the service life under other in-use conditions [ISO 21930:2007]

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

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

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

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

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

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

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

data. Primary data that go through a horizontal aggregation step are considered as secondary data.

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

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

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

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

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

Thermal insulation product - A thermal insulation product is a construction product used to reduce heat transfer through the building element against which, or in which, it is installed. ISO 9229 defines thermal insulation products [3] for buildings as: “factory made products in the form of rolls, bats, boards or slabs, with or without facings, or 'in-situ' applied materials, which have a primary function to reduce heat transfer through the structure against which, or in which, it is installed. Products covered by this definition may also be used in prefabricated thermal insulation systems and composite panels”.

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

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

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

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

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

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

II. Disclaimer

For a good understanding of the scope and limitations of this PEFCR, it is important to carefully read the limitations of this PEFCR in section 3.6.

1 Introduction

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

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

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

A Product Environmental Footprint Category Rule provides guidance and rules for calculating and reporting the environmental footprint (i.e. life cycle environmental impact) of a product in a specific product group. This document has been drafted in the context of the Environmental Footprint (EF) pilot phase organised by the Commission in the period 2013-2018.

This PEFCR includes two sets of rules, defined as follows (see Figure 3):

Horizontal rules: these are rules valid for all thermal insulation products in scope of this PEFCR, independently from the specific application.

Vertical rules: these are rules that apply to all thermal insulation products in the scope of this PEFCR in the context of a specific application.

In case of conflicts between a vertical and a horizontal rule, the latter prevails over the former.

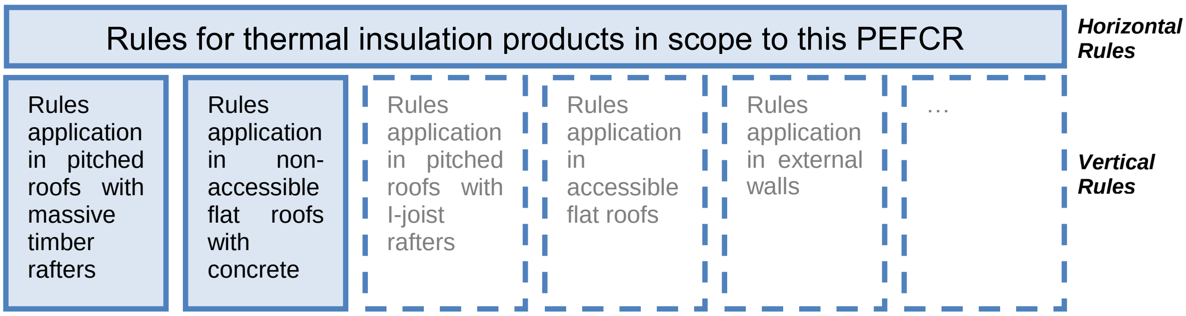

Figure 3 Structure of the PEFCR for thermal insulation products in buildings in specific applications (only the full blue boxes are part of this PEFCR)

The vertical rules defined in this PEFCR refer to the following two applications**:**

- Thermal insulation products in scope of this PEFCR applied in a pitched roof where the insulation is put between and/or under massive timber rafters;
- Thermal insulation products in scope of this PEFCR applied in a non-accessible flat roof with a loadbearing concrete structure: conventional roof.

The horizontal rules shall be followed whenever new vertical rules in this PEFCR are developed.

The horizontal rules should be considered when developing new PEFCRs for thermal insulation products and/or applications not intended to be included in the scope of this PEFCR and it should be examined if these new PEFCRs can be integrated as new vertical rules in this PEFCR.

Depending on the goal of the PEF study, this PEFCR shall be followed:

- in all cases when there is a comparison/comparative assertion, being it with reference to a benchmark value or another thermal insulation product;
- in all cases when a claim related to the environmental performance of a thermal insulation product is declared to be in compliance with the PEF method and/or this PEFCR.

The use of this PEFCR is also recommended for other applications intended to calculate the life cycle environmental performance of a thermal insulation product.

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

COORDINATOR

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MEMBERS OF TECHNICAL SECRETARIAT PEF PILOT THERMAL INSULATION

Organisation			Logo
DHUP/CSTB	Governmental organisation	France	Ministère de l'Écologie, du Développement Durable et de l'Énergie
ECIA	Cellulose	Europe	ECIA
EUMEPS	EPS	Europe	EUMEPS
PITTSBURGH CORNING Europe	Cellular Glass	Belgium	FOAMGLAS
IBO	Expert LCA	Europe	IBO Österreichisches Institut für Baubiologie und -ökologie
KULeuven	Expert LCA	Belgium	KU LEUVEN
WeLOOP	Expert LCA	France	WeLoop
Plastics Europe	Plastics	Europe	PlasticsEurope Association of Plastics Manufacturers
PU EUROPE	PUR/PIR	Europe	PU EUROPE EXCELLENCE IN INSULATION

CAPEM/Agrodome	CAPEM	Netherlands	Agrodome
CAPEM/NGS	CAPEM	UK	NGS
CAPEM/Renuables	CAPEM	UK	Renuables LCA // MATERIALS // ENERGY
CAPEM/VIBE	CAPEM	Belgium	VIBE

The members of the Technical Secretariat (TS) of the PEF pilot on thermal insulation in buildings that commonly developed the PEFCR are:

- CSTB / Ministry of Ecology, Sustainable Development and Energy: Pierre Ravel
- ECIA: Lucia Gross, Pasi Typpö
- EUMEPS: Edmar Meuwissen
- Pittsburgh Corning Europe: Piet Vitse
- IBO: Philipp Boogman
- KU Leuven: Karen Allacker
- WeLOOP: Naeem Adibi
- Plastics Europe: Quentin de Hults, Guy Castelan
- PU Europe: Oliver Loebel, Arnaud Duvielguerbigny, Shpresa Kotaji
- CAPEM/Agrodome: Fred van der Burgh
- CAPEM/VIBE: Els Van de moortel

2.2 Consultation and stakeholders

The process of developing this PEFCR was open and transparent and included therefore an open consultative format with stakeholders. One public physical consultation meeting was organised, and two virtual consultations took place.

The **first physical consultation meeting on the scope and representative product** of the pilot took place on the **15th of October 2014** in Brussels.

The **draft PEFCR and screening have been open for a first virtual stakeholder consultation** in the period **9th of November 2015 – 4th of December 2015**. Nine unique stakeholders commented during the first consultation phase for a total number of 80 comments (AFIPEB, Covestro, CSTB, EuGeos Limited (Chris Foster), European Steel Association, Federal Public Service of Health and Environment – Belgium, ROCKWOOL and VIPA).

The **final draft of the PEFCR has been open for a second virtual stakeholder consultation** in the period **12th of September 2016 – 10th of October 2016**. Nine unique stakeholders commented during the second consultation phase for a total number of 90 comments (AFELMA Federal Public Service of Health and Environment - Belgium, CEMBUREAU, DG ENV EC, Eco-platform, FILMM, Georg Schoener, IBU and Metal sheets pilot).

More information about the consultation process and the comments received are available at: https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/Stakeholder+workspace%3A+PEFCR+pilot+Thermal+insulation+materials

2.3 Review panel and review requirements

Name of the member	Affiliation	Role
Guido Sonnemann	University of Bordeaux, France	President
Johannes Kreissig	Sustainable Building Council, Germany	Member
Angela Schindler	Independent LCA expert, Germany	Member

The reviewers have verified the fulfilment of the following requirements:

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

The review statement is provided in section 2.4 and the detailed review report is provided in the Annex 3.

2.4 Review statement

This PEFCR has been developed following version 6.3 of the PEFCR Guidance and the PEF Guide adopted by the Commission on 9 April 2013. A tremendous amount of work and excellent comprehensive thinking have gone into the Product Environmental Footprint Category Rules (PEFCRs) for thermal insulation.

The horizontal rules are mostly applied in compliance with PEFCR Guidance v6.3.

The disclaimer and the related chapter with limitations explain the applicability of the PEFCR to a limited range of materials and their specific building elements. This means, that the benchmarking process supported by this PEFCR bears the risk to distort competition, due to tight constructional and fictive frame conditions, due to system rather than product benchmarking and due to a very limited number of available vertical rules. In the case of cellulose insulation applied in pitched roofs with massive timber rafters, the vertical rules have been applied to a single material. In the case of the three materials for the non-accessible flat roofs with concrete structure, the review panel received the confirmation of the European Commission that the requirements of representativeness are fulfilled.

Overall, some further improvements, enabling a biunique implementation in a PEF study with a reliable methodological approach, are recommended in the review report so that 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:

- Guido Sonnemann, University of Bordeaux, France, President of the Review Panel
- Johannes Kreissig, DGNB, German Sustainable Building Council, Germany
- Angela Schindler, Independent LCA expert, Germany

2.5 Geographic validity

This PEFCR is valid for products in scope sold/installed 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/installed 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(s) of PEFCR

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

2.7 Conformance to other documents

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

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

At the time of writing, no European product standards were in place for the environmental impact assessment of thermal insulation products in buildings. CEN is currently working on a draft PCR (TC88 PCR prEN16783[8]) based on EN 15804 as the standard for thermal insulation products in buildings.

The draft PCR (TC88 PCR prEN16783 [8]) was studied and considered in the development of this PEFCR.

3 PEFCR scope

The primary purpose of this PEFCR is to provide a common set of rules to calculate the PEF-profile of thermal insulation products in their application.

The thermal insulation products listed in Table 1 are included in the scope of this PEFCR.

Table 1. Thermal insulation products in scope of this PEFCR

Product	Reference
Loose fill cellulose	ETA – EN 15101*
Unfaced cellular glass board	EN 13167: 2015
Unfaced EPS grey board	EN 13163: 2015
Faced PU board	EN 13165: 2015

* pending citation in European official journal

3.1 Product classification

There is no single CPA code covering all thermal insulation products. Code F.41.2 – Construction of residential and non-residential buildings (C – Manufacturing) covers a much wider product group than the products in the scope of this PEFCR.

3.2 Representative product(s)

The description of the representative products is included in Table 2.

Table 2. Thermal insulation products included in horizontal rules and definition of representative products

Application	Product	Reference	*Definition of representative product*
Pitched roof with massive timber rafters	Cellulose	ETA – EN 15101: pending citation in European official journal	***Virtual Product,*** *but very similar to existing products in the market*
Non-accessible flat roofs with concrete structure	Cellular glass	EN 13167: 2015	***Virtual Product,*** *but very similar to existing products in the market*
	EPS	EN 13163: 2015	***Real product,*** *Grey EPS (density 15 kg/m3)*
	PU	EN 13165: 2015	***Virtual Product,*** *Factory-made PU boards with a mix of the two most representative facings and average of lambda values available in the market*

The market share for the products in the scope of PEFCR is based on expert judgment. The representativeness of products included in the scope has been checked by European Commission

Figure 4 and Figure 5 show how the representative products for the two applications have been modelled.

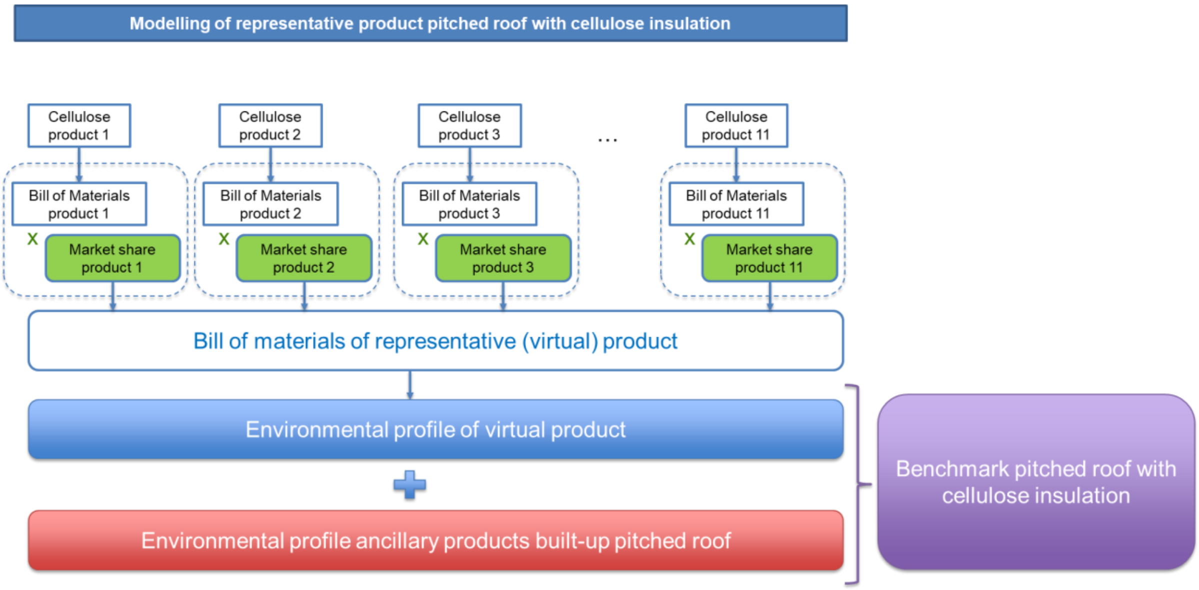

Figure 4: pitched roof representative product.

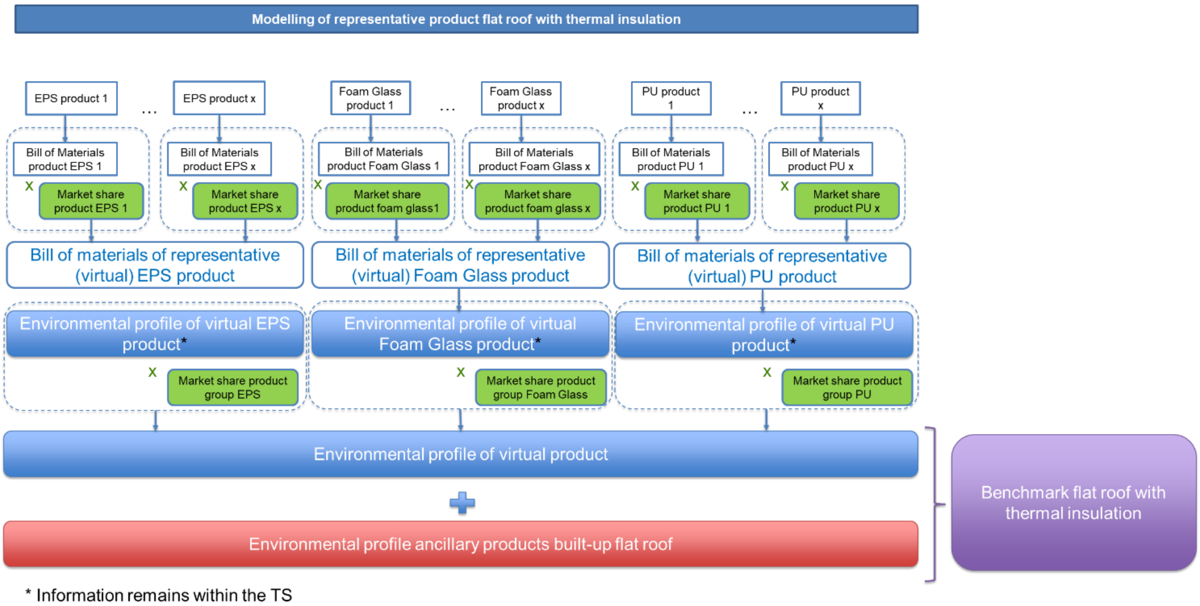

Figure 5: Flat roof representative product.

The modelling of the two representative products provides the following results:

- Characterised environmental impacts, calculated based on the life cycle inventory for the 16 PEF environmental impact categories for each application,
- Most relevant impact categories, life cycle stages and processes, meaning those contributing cumulatively to more than 80% to any impact category.

The characterised environmental impacts from different product(s) are aggregated at application level via weighted averaging using European sales data (for product(s) included in the scope of the application). This provides a more accurate overall indication of the impacts related to thermal insulation for each application.

The most relevant impact categories, life cycle stages, and processes and elementary flows and the environmental hotspots are applied directly to the relevant representative product at application level, as they present important issues that should not be neglected (which could happen through a weighted average).

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

3.3 Functional unit and reference flow

The functional unit for thermal insulation products in scope of this PEFCR is defined as follows:

"Thermal insulation of X m² of a building element, with an insulation thickness that gives a thermal transmittance Uc of the element as defined in the vertical rules, with a design life span of 50 years". The value of X shall be defined in the vertical rules.

The declared unit for thermal insulation products in scope of this PEFCR is defined as follows: *"Thermal insulation of 1m² of a building element, with an insulation thickness that gives a thermal transmittance Uc of the element as defined in the vertical rules, with a design life span of 50 years".*

The calculation of the thermal transmittance (Uc) of the element shall be in line with the European standard EN ISO 6946:2007. For the calculation of the thermal transmittance the design lambda value (three digits after the comma shall be considered) of the insulation materials shall be used.

3.3.1 The reference service life of the product

The reference service life (RSL) of the insulation product shall be provided by the manufacturer and defined and justified based on technical reports or standards or official documents and should be based on ISO 15686/1. The RSL shall refer to the declared technical and functional performance of the product within a building.

The properties of the product and reference in-use conditions shall be declared together with the RSL and it shall be stated that the RSL applies for the reference conditions.

<u>Tables summing up the key aspects of the functional unit and the reference flow are included in the vertical rules.</u>

3.4 System boundary – life-cycle stages and processes

A PEF study compliant with this PEFCR shall be based on a “cradle-to-grave” assessment including all life cycle stages (see Figure 6).

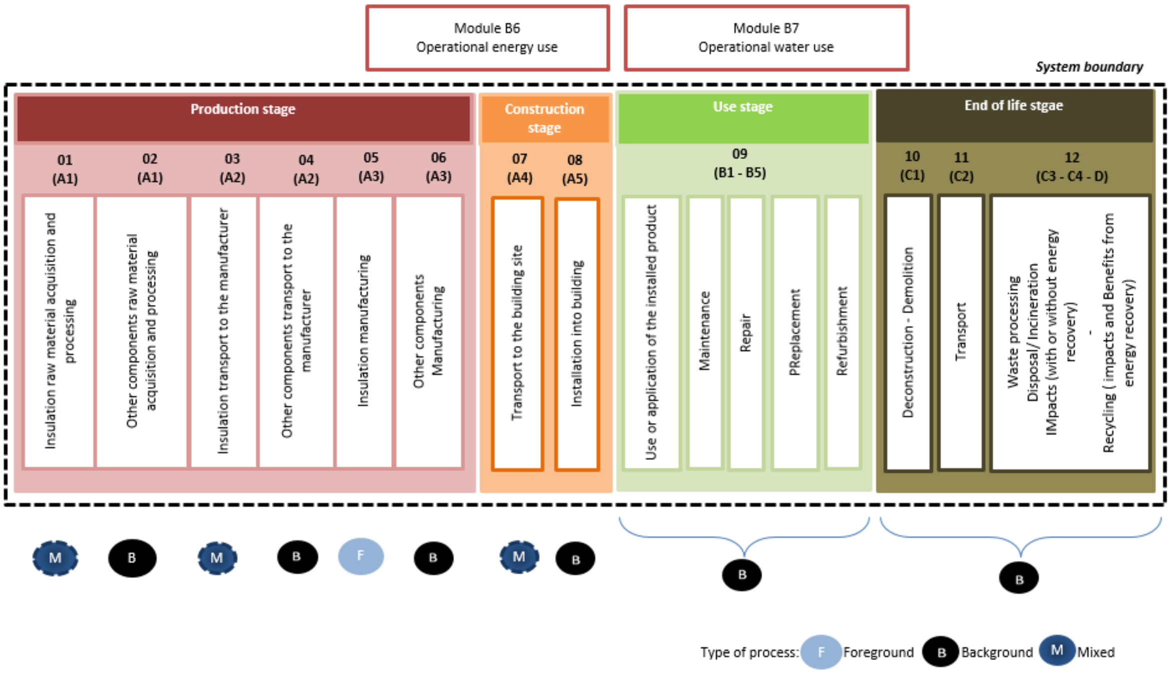

Figure 6: System boundary for thermal insulation products

The inventory shall be structured in a way to facilitate a possible future alignment with the requirements of the EN 15804. Therefore, the life cycle stages and processes shall be structured in a modular system (Modules A-D) as follows:

- **Module A 1-3 = production stage**: covers raw material supply (A1), transport of raw materials (A2) and manufacturing (A3),
- **Module A 4-5 = construction stage**: covers transport to the construction site (A4) and construction/installation processes (A5),
- **Module B 1-7 = use stage**: covers use (B1), maintenance (B2), repair (B3), replacement (B4), refurbishment (B5),
- **Module C 1-4 = end of life**: covers de-construction/demolition (C1), transport (C2), waste processing (C3) and disposal (C4),
- **Module D = recycling and benefits from energy recovery.**

As shown in Figure 6, the system boundary and the related modular structure shall differentiate between processes related to the thermal insulation product and those related to ancillary products.

Thermal insulation products do not use water or energy during the use phase of the building. Both operational energy use (module B6) and operational water use (module B7), as indicated in Figure 6, are therefore excluded from the system boundaries. Thermal insulation products however reduce the energy consumption of buildings. The environmental benefits of energy savings and how to consider these in a PEF study in line with this PEFCR are explained in section 4.3.1.When implementing this PEFCR the applicant shall declare which processes among those listed in Table 3 are under its operational control (Situation 1 of the Data Need Matrix, see Table 6).

As a minimum the following processes shall be under the operational control of the company implementing this PEFCR:

- The manufacturing process of the thermal insulation product or of the thermal insulation material used in situ[6]. This refers to the production stage 5 (A3) as indicated in Figure 6 and additionally, to the construction stage 8 (A5) for in-situ produced thermal insulation materials.

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

Table 3. Life Cycle Stages and processes that shall be included

Life Cycle Stage	Processes which shall be included
Upstream	
1. Raw materials acquisition for the insulation products*	• Extraction and processing of raw materials (virgin and recycled) for the insulation products, including their packaging; Infrastructure of the factories.
2. Raw materials acquisition for ancillary products	• Extraction and processing of raw materials (virgin and recycled) for the additional products in the build-up, such as mechanical fixing, adhesive, water proofing layer and vapour barrier, including their packaging. Infrastructure of the factories.
3. Transport of the raw materials for the insulation products	• All transport of raw materials of the insulation product to the production site.
4. Transport of the raw materials for the ancillary products	• All transport of raw materials of the ancillary products in the build-up to their production site(s).
5a. Manufacturing of the insulation product (gate to gate)	• Production process of the insulation product, including the ancillary materials (lubricated oils, etc.); • Infrastructure of the factories.
5b. Packaging for the final product (cradle to gate)	• Extraction and processing of raw materials, production process and transport of the packaging products to the insulation factory.
6. Manufacturing of the ancillary products in the build up	• Production process of all ancillary products in the build-up, including mechanical fixing, adhesives, water proofing layer and vapour barrier.
Downstream	
7. Transport from production site to building	• Transport of insulation products from production site to building site; • Transport of all ancillary products in the build-up from production site to the building site.

[6] For thermal insulation products with an in-situ production (loose fill, spray foam, etc) the materials become a product during the installation.

Life Cycle Stage	Processes which shall be included
8. Installation in building	• Processes used for the installation of the thermal insulation product(s) including all ancillary products; • EoL of the packaging materials (Including avoided virgin production/energy production in case of recycling/incineration with heat recovery respectively); • All processes related to any losses during this installation stage (i.e. production, transport, and waste processing and disposal of the lost products).
9. Use, maintenance and refurbishment	• All processes related to maintenance and refurbishment.
10. Demolishing or dismantling	• All processes related to demolition and dismantling.
11. Transport to End of Life (EoL)	• Transport to the EoL treatment (recycling, incineration and/or disposal).
12. End of life (EoL)	• Sorting of all materials going to the EoL treatment; • Incineration and disposal processes (including benefits); • Recycling process (including benefits).

Each PEF study done in accordance with this PEFCR shall provide in the PEF study a diagram indicating the organisational boundary. This is needed to highlight those activities under the control of the organisation (situation 1) and those falling into situation 2 and 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 4 below.

Table 4. List of the impact categories to be used to calculate the PEF profile

Impact category	Indicator	Unit	Recommended default LCIA method
Climate change	Radiative forcing as Global Warming Potential (GWP100)	kg CO_{2eq}	Baseline model of 100 years of the IPCC (based on IPCC 2013)
- Climate change-biogenic			
- Climate change – land use and land transformation			
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11_{eq}	Steady-state ODPs 1999 as in WMO assessment
Human toxicity, cancer effects*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al, 2008)
Human toxicity, non- cancer effects*	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)

Impact category	Indicator	Unit	Recommended default LCIA method
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq U^{235}_{eq}	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg $NMVOC_{eq}$	LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe
Acidification	Accumulated Exceedance (AE)	mol $H+_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N_{eq}	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P_{eq}	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N_{eq}	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Ecotoxicity, freshwater)	Comparative Toxic Unit for ecosystems (CTU_e)	CTUe	USEtox model, (Rosenbaum et al, 2008)
Land use	• Soil quality index[7] • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Dimensionless (pt) • kg biotic production[8] • kg soil • m^3 water • m3 groundwater	• Soil quality index based on LANCA (EC-JRC)[9] • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010)
Water use**	User deprivation potential (deprivation-weighted water consumption)	m^3 $world_{eq}$	Available WAter REmaining (AWARE) Boulay et al., 2016
Resource use, minerals and metals***	Abiotic resource depletion (ADP ultimate reserves)	kg Sb_{eq}	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002

* Long-term emissions (occurring beyond 100 years) shall be excluded from the impact assessment. If included by the applicant in the LCI modelling, the sub-compartment 'unspecified (long-term)' shall be used. Toxicity emissions to this sub-compartment are not included and have a characterisation factor 0.

** 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 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 EU 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.

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

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

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

The full list of normalisation and weighting factors are available in Annex 1. The full list of characterisation factors (EC-JRC, 2017a) is available at this link: http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml

3.6 Limitations

For a good understanding of the scope and limitations of this PEFCR, it is important to note the complexity of construction products. Construction products are used and combined to obtain several performances in the final end product of the building. The aim of this PEFCR is, amongst others, to enable the comparison and benchmarking of thermal insulation products. For this goal, it was decided to calculate the environmental information at the level of the application at building element level (i.e. specific pitched roof and flat roof). This allows to make comparisons at this level, but has some important limitations. First, a predefined build-up had to be defined for Europe and does not represent the exact build-up in several EU Member States. The build-up defined should hence be seen as a (fictive) reference for comparison, rather than an exact representation of the real situation. Second, this approach allows only to compare systems rather than products, meaning that the environmental information does not refer to the impact of a single insulation product, but includes the impact of one or more insulation product(s) in combination with other construction products to achieve a predefined performance. The fixing of a specific thermal performance in order to allow for comparisons limits the range of products that may be benchmarked. The PEFCR does not allow to use part of the system in different build-ups.

The approach chosen, i.e. horizontal rules for insulation products for any application in any building, and vertical rules for each specific application, was needed to allow for benchmarking at application level. Such narrow scope was necessary to allow for comparisons and in consequence requires the development of vertical PEFCRs and the definition/quantification of a representative product for any other application.

It is not clear how many vertical PEFCRS will be necessary in future to cover ‘all’ applications. Whilst this is independent from the technical validity of this PEFCR, the approach chosen might have significant impact on the implementability of the PEF method to the sector of thermal insulation for buildings.

4 Horizontal rules

All the requirements listed in this section are valid also for the vertical rules unless differently foreseen. In case of conflict between the horizontal rules listed in this section and the corresponding ones in the vertical rules (section 0 and 0), the former prevails over the latter.

The specific datasets to be used to model each life cycle stage are listed in the sections related to the vertical rules for each specific application. Most relevant impact categories, life cycle stages and processes are identified in the vertical rules.

Note: See product-specific requirements in the vertical rules, where specific requirements are provided in the vertical rules.

4.1 Life cycle inventory

All newly created processes shall be EF-compliant.

4.1.1 List of mandatory company-specific data

See section 5.10.1 in the vertical rules.

4.1.2 List of processes expected to be run by the company

See section 5.10.2 in the vertical rules.

4.1.3 Data gaps

The following data gaps have been identified due to lacking EF compliant datasets and due to lacking of alternative datasets:

- Handling in sorting plant, except for plastics
- Infrastructure of sorting plant
- Infrastructure for insulation factory: conveyor belt
- Copper used in infrastructure
- Additives for PU insulation
- Additives in the glue for the fixing of the PU insulation

The above processes shall be excluded from PEF studies carried out in compliance with this PEFCR.

4.1.4 Data quality requirements

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

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

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

Table 5 provides the criteria to be used for the semi-quantitative assessment of each parameter. 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.

4.1.4.1 Company-specific datasets

The score of P may not be higher than 3 while the score for TiR, TeR, and GR may not 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 mandatory processes 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 B.5.

> 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 TeR-EF, TiR-EF, GR-EF, PEF in Table 5. How to assess the value of the DQR parameter for the processes for which company specific values are used. 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) TiR and P shall be evaluated at the level of the activity data (named TiR-AD, PAD) and (ii) TeR, TiR and GR shall be evaluated at the level of the secondary dataset used (named TeR-SD , TiR-SD and GR-SD). As TiR is evaluated twice, the mathematical average of TiR-AD and TiR-SD represents the TiR 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 TeR, TiR, GR 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).

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

NOTE: in case the newly developed dataset has most relevant processes filled in by non-EF compliant datasets (and thus without DQR), then these datasets may not 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 $\overline{Te_R}, \overline{G_R}, \overline{T\iota_R}, \bar{P}$ and the total DQR shall be multiplied with 1.375.

Table 5. How to assess the value of the DQR parameter for the processes for which company specific values are used.

	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 <u>and</u> 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

4.1.4.2 Data needs matrix (DNM)

All processes required to model the product and outside the list of mandatory company-specific shall be evaluated using the Data Needs Matrix (see Table 6).

For each process listed in the vertical rules (both most relevant and other processes), the applicant shall declare the level of operational control, meaning if it falls under situation 1, 2 or 3 (see Figure 7).

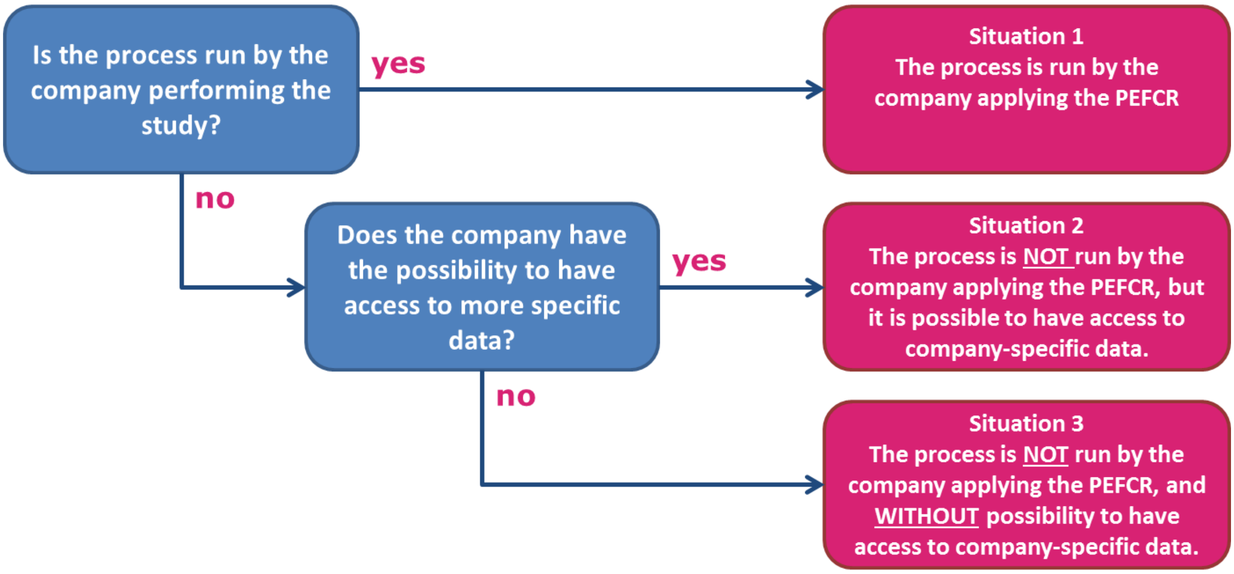

Figure 7: The level of influence by company

		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

Table 6. Data Needs Matrix (DNM)[10]

4.1.4.3 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);

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

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

Situation 1/Option 1

The applicant shall provide company-specific activity data and use them to create a specific new dataset. The required level of aggregation for the Bill of Material shall be determined in the vertical rules for each application.

An example of what should be included in a dataset disaggregated at level-1 is reported in Figure 8.

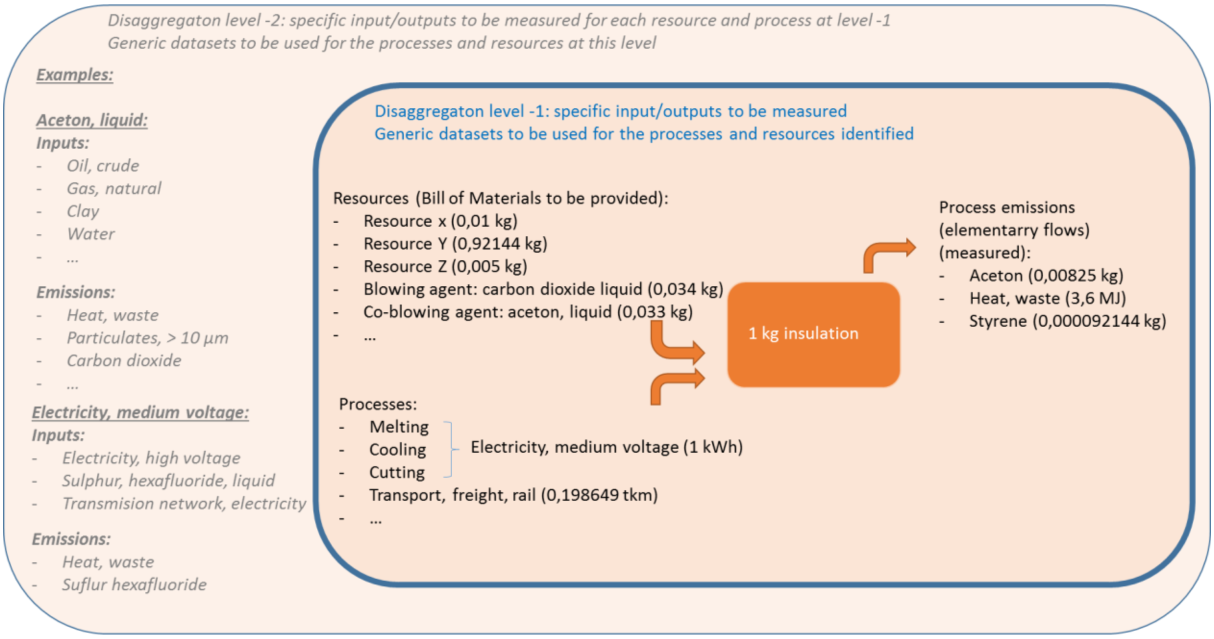

Figure 8: Flow diagram for a typical production process – illustration of disaggregated dataset

All company-specific datasets produced when implementing this PEFCR shall be EF-compliant. They shall be made available for free through a dedicated node in the Life Cycle Data Network. In case the primary datasets include confidential information, they will be made available with access restriction to EC only.

When a company-specific dataset is created, the DQR of the newly developed dataset shall be calculated by the applicant of this PEFCR as described in section 4.1.4.1.

Situation 1/Option 2

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

If the default dataset to be used for the process is not listed in the PEFCR, the applicant of the PEFCR shall identify a suitable alternative (according to procedure explained in section 4.1.4.6) and use the DQR values from the metadata in the original dataset.

4.1.4.4 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 three possible options:

- The company applying the PEFCR has access to extensive supplier-specific information and wants to create a new EF-compliant dataset[11] (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

The same procedure as in Situation 1/Option1 shall be applied.

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. When the process is in situation2/option2 the disaggregated version of the dataset is required.

The applicant of the PEFCR shall make the DQR values of the dataset used context-specific by re-evaluating Te_R and Ti_R, using the table(s) provided. The criteria G_R shall be lowered by 30%[12] 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 identify a suitable alternative (according to procedure explained in section 4.1.4.6) and use the DQR available in the metadata of the selected dataset.

Table 7. How to assign the values to parameters in the DQR formula 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

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

[12] 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
2	The EF report publication date happens not later than 2 years beyond the time validity of the dataset	The technologies used in the EF study is included in the mix of technologies in scope of the dataset	The process modelled in the EF study takes place in the geographical region (e.g. Europe) the dataset is valid for
3	The EF report publication date happens not later than 4 years beyond the time validity of the dataset	The technologies used in the EF study are only partly included in the scope of the dataset	The process modelled in the EF study takes place in one of the geographical regions the dataset is valid for
4	The EF report publication date happens not later than 6 years beyond the time validity of the dataset	The technologies used in the EF study are similar to those included in the scope of the dataset	The process modelled in the EF study takes place in a country that is not included in the geographical region(s) the dataset is valid for, but sufficient similarities are estimated based on expert judgement.
5	The EF report publication date happens later than 6 after the time validity of the dataset	The technologies used in the EF study are different from those included in the scope of the dataset	The process modelled in the EF study takes place in a different country than the one the dataset is valid for

4.1.4.5 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 parameters listed.

If the default dataset to be used for the process is not listed in the PEFCR, the applicant of the PEFCR shall identify a suitable alternative (according to procedure explained in section 4.1.4.6) and use the DQR available in the metadata of the selected dataset.

4.1.4.6 Which datasets to use?

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

- Use an EF-compliant dataset available on one of the following nodes:
  - http://eplca.jrc.ec.europa.eu/EF-node
  - http://lcdn.blonkconsultants.nl
  - http://ecoinvent.lca-data.com
  - http://lcdn-cepe.org
  - https://lcdn.quantis-software.com/PEF/

- ○ http://lcdn.thinkstep.com/Node
- Use an EF-compliant dataset available in a free or commercial source;
- Use another EF-compliant dataset considered to be a good proxy. In such case this information shall be included in the "limitations" 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.

4.1.4.7 How to calculate the average DQR of the study

In order to calculate the average DQR of the EF study, the applicant shall calculate separately the TeR, TiR, GR and P for the EF study as the weighted average of all most relevant processes, based on their relative environmental contribution to the total single score (excluding the 3 toxicity-related ones).
The total DQR of the study shall be calculated using Equation [2], where $\overline{Te_R}, \overline{G_R}, \overline{Ti_R}, \overline{P}$ are the parameter weighted averages.
For example, the most-relevant processes account for 82.5% of the total environmental impact (single score). The 82.5% is rescaled to 100% together with the weights for the processes. These are the weights used to calculate the weighted average the DQR parameters for the most relevant processes.

4.1.5 Allocation rules

In case multiple products are produced during the production process, then the applicant shall use mass-based allocation.

4.1.6 Electricity modelling

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

The following electricity mix shall be used in hierarchical order:

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

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

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

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

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

Set of minimal criteria to ensure contractual instruments from suppliers:

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

A contractual instrument used for electricity modelling shall:

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

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

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

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

Datasets for residual grid mix, per energy type, per country and per voltage have been purchased by the European Commission and are available in the dedicated node (http://lcdn.thinkstep.com/Node/). In case the necessary dataset is not available, an alternative dataset shall be chosen according to the procedure described in section 4.1.4.6. If no dataset is available, the following approach may be used:

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

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

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

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

Allocation rules:

In case allocation rules are necessary (i) to subdivide the electricity consumption among multiple products for each process (e.g. mass, number of pieces, volume…) or (ii) to reflect the ratios of production/ratios of sales between EU countries/regions when a product is produced in different locations or sold in different countries, then the applicant shall use mass-based allocation (depending on what is more appropriate for the product produced).

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

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

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

In case a product is produced in different locations or sold in different countries, the electricity mix shall reflect the ratios of production or ratios of sales between EU countries/regions. To determine the ratio a physical unit shall be used (e.g. kg of product). For PEF studies, where such data are not available, the average EU residual consumption mix (EU-28 +EFTA), or region representative residual mix, shall be used. The same general guidelines mentioned above shall be applied.

For the use stage the consumption grid mix shall be used. The electricity mix shall reflect the ratios of sales between EU countries/regions. To determine the ratio a physical unit shall be used (e.g. number of pieces or kg of product). Where such data are not available, the average EU consumption mix (EU-28 +EFTA), or region representative consumption mix, shall be used.

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 may 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 may allocate based on electricity amounts the upstream and direct emissions to your own consumption and to the share you sell out of your company (e.g. if a company has a 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[13].
- Subdivision is considered as not possible when upstream impacts or direct emissions are closely related to the product itself.

4.1.7 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[14] shall be modelled under sub-category 3 (incl. connected soil emissions, derived products, residues). The emission flows ending with '(biogenic)' shall be used.

   A simplified modelling approach shall be used when modelling the foreground emissions. Only the emission 'methane (biogenic)' shall be modelled, while no further biogenic emissions and uptakes from atmosphere are included. When methane emissions may 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 hasn’t a carbon storage beyond 100 years and therefore no credits from biogenic carbon storage shall be modelled.
3. Climate change – land use and land transformation. This sub-category accounts for carbon uptakes and emissions (CO_2, CO and CH_4) originating from carbon stock changes caused by land use change and land use. This sub-category includes biogenic carbon exchanges from deforestation, road construction or other soil activities (incl. soil carbon emissions). For native forests, all related CO_2 emissions are included and modelled under this sub-category (including connected soil emissions, products

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

[14] 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.

derived from native forest[15] 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 may 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 may 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 may not be demonstrated to be more than 20 years, or a single harvest period, prior to making the assessment (whichever is the longer), it shall be assumed that the land use change occurred on 1 January of either:

- the earliest year in which it may 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 may be found in PAS 2050-1:2012);

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

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 may 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 may 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 may be used. Countries in which a crop is grown may be determined from import statistics, and a cut-off threshold of not less than 90% of the weight of imports may be applied. Data sources, location and timing of land use change associated with inputs to products shall be reported.

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

Soil carbon stock: soil carbon emissions shall be included and modelled under this sub-category (e.g., from rice fields). Soil carbon emissions derived from aboveground residues (except from native forest) shall be modelled under sub-category 2, such as the application of non-native forest residues or straw. Soil carbon uptake (accumulation) shall be excluded from the footprint results as it is highly questionable how the long term uptakes (beyond 100 years) may be guaranteed in practice. For example, from grasslands or improved land management through tilling techniques or other management actions taken in relation to agricultural land. Soil carbon storage may be included in the PEFCR as additional environmental information when proof is provided. For example, when legislation has different modelling requirements for the sector, such as the EU greenhouse gas accounting directive from 2013 (Decision 529/2013/EU) which indicate carbon stock accounting.

The sum of the three sub-categories shall be reported. Moreover, the sub-category 'Climate change-biogenic' and Climate change-land use and land transformation' shall be reported separately.

4.1.7.1 Characterisation factors of methane, carbon dioxide and carbon monoxide

Within the current PEF method, the global warming potentials of the third assessment report of IPCC (2007) are applied. The GWPs shall be updated using the fifth assessment report of IPCC (2013), including climate-change carbon feedbacks for both CO_2 and non-CO_2 substances (following the UNEP/SETAC recommendations of the Pellston Workshop, January 2016). The values with feedbacks are applied to ensure consistency, as feedbacks are already included for CO_2. The GWPs of well-mixed GHGs may be found in chapter 8 of the Scientific basis report, Tables 8.7 and 8.SM.16. The GWPs for near term GHGs are not recommended for use due to their complexity and high uncertainty. Near term GHGs refer to substances that are not well-mixed once emitted to the atmosphere because of their very rapid decay (black carbon, organic carbon, nitrogen oxides, sulphur oxides, volatile organic compounds, and carbon monoxide).

The third assessment IPCC report (2007) estimated the global warming potential for methane at 25 for a time period of 100 years. This value factors in the indirect climate effects of methane emissions (such as the positive feedback on the methane lifetime and on the concentrations of ozone and stratospheric water vapour) but excludes the oxidation of methane into carbon dioxide. The Fifth assessment report of IPCC (2013) reports a global warming potential for methane at 34, still with the exclusion of methane oxidation into carbon dioxide and which is valid for biogenic methane only (IPCC 2013, Table 8.7). IPCC (2013) refers to Boucher et al. (2009) to add the methane oxidation for fossil methane, resulting in a GWP of 36. The added value of +2 includes only a partial oxidation of methane into CO_2. Boucher et al. (2009), calculated an upper limit of +2.5 when considering that all methane is converted into CO_2 and up to +2.75 with a longer time horizon. Within the context of the environmental footprint a simple stoichiometric calculation may be used to compensate the avoided CO_2 uptake within the released methane (+2.75). It may be discussed which correction factor should be applied, (i) +2 following IPCC, (ii) +2.5 following the upper margin of Boucher et al. (2009) for a time horizon of 100 years or (iii) +2.75 using the stoichiometric balance (all emissions happen "now"). The last approach is chosen, as a GWP of 36.75 reassures the same outcome between a detailed modelling (modelling all carbon uptakes and releases) and a simplified modelling approach (only modelling the CH_4 release). Within the EF context, the same result between a detailed modelling approach or the EF proposed simplified modelling approach is considered to be essential. This means that for fossil methane a GWP of 36.75 shall be used.

For biogenic carbon modelling the list of ILCD elementary flows and CFs as provided in the PEFCR Guidance v. 6.3 shall be applied.

4.1.8 Modelling of wastes and recycled content

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

The Circular Footprint Formula is used to model the End-of-Life of products as well as the recycled content:

Production burdens	$(1 - R_1)E_V + R_1 \times E_{recycled}$	**Cradle-to-gate**
Burdens and benefits related to secondary materials input	$-(1 - A)R_1 \times \left(E_{recycled} - E_V \times \frac{Q_{Sin}}{Q_P}\right)$	**Additional information from the EoL stage**
Burdens and benefits related to secondary materials output	$(1 - A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P}\right)$	
Energy recovery	$(1 - B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$	
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.

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 nit) 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.

4.1.9 Sampling

Sampling is not allowed.

4.2 Life cycle stages

4.2.1 Raw materials acquisition for the thermal insulation products

This life cycle stage (or module using EN15804 terminology) shall include raw material extraction and processing, and processing of secondary material input (e.g. recycling processes).

Packaging of the raw materials shall be included based on the same packaging modelling of the insulation. For the amounts of the packaging of raw materials, the following default values shall be assumed if specific data are lacking.

- Packaging for solid chemical raw materials - transported in big bags with pallets (1000 kg of raw material packed in a big bag over a pallet):
    - Pallets: 0.025 kg per kg of raw material transported
    - PP plastics: 0.003 kg per kg of raw material transported

    - If the density of the transported raw material is low, then the amount of packaging shall be adjusted based on real density and transport conditions.
- Packaging for liquid chemical raw materials:
    - In most cases raw materials are transported in tankers and IBC (bulk container) that is delivered at the production plant and after the use of the content, it is returned to the provider of the raw materials[16]. If the raw materials are transported in tankers and IBC, no packaging shall be accounted for.
- In case the raw material and additives don't require any packaging, justification shall be provided.

The end of life of the packaging shall not be included in this life cycle stage. The end of life of the packaging shall be modelled in the overall waste flows generated during the manufacturing of the insulation material. The transport of the packaging of the raw materials for the thermal insulation shall be excluded (cut-off).

4.2.2 Raw materials acquisition for ancillary products in the build-up

In the corresponding vertical rules section there is a list of all the additional products in the build-up that shall be included in this module.

4.2.3 Manufacturing of the insulation product (gate to gate)

The bill of material and its level of aggregation shall be specified at the level of the vertical rules.

Inputs and outputs (emissions, waste, co-products) related to the production process of the insulation product, including the ancillary materials (lubricated oils, etc.) shall be provided in this module.

Infrastructure shall be included for the manufacturing stage according to requirements in section 4.2.11.

In case of any co-products, the allocation hierarchy of the PEF Guide shall be followed, with the following additional rule:

- Allocation shall be based on physical properties (i.e. mass) when the difference in revenue from the co-products is low (i.e. lower than or equal to 25%):
- In all other cases, allocation shall be based on economic values (i.e. difference in revenue from the coproducts of more than 25%).

4.2.4 Manufacturing of the ancillary products in the build up

In the corresponding vertical rules section there is a list of all the ancillary product in the build-up that shall be included in this module. The packaging of the ancillary products shall be included.

4.2.5 Logistics

All transportation processes across the products supply chain shall be modelled using EF-compliant datasets. In particular, for road transports, depending on the amount of product

[16] The IBC is considered as a particular type of bulk transport, where the "container" from the truck is just kept on site until the content is emptied.

transported, one of the following types of trucks shall be used (the truck type Euro 0 to 5 and the European mix are available separately):

- **Type 1:** Articulated lorry transport, Total weight >32 t; diesel driven, Euro 0 - 5 or mix, cargo; consumption mix, to consumer; more than 32t gross weight / 24,7t payload capacity
- **Type 2:** Articulated lorry transport, Total weight 28-32 t; diesel driven, Euro 0 - 5 or mix, cargo; consumption mix, to consumer; 28 - 32t gross weight / 22t payload capacity
- **Type 3:** Articulated lorry transport, Total weight 20-26 t; diesel driven, Euro 0 - 5 or mix, cargo; consumption mix, to consumer; 20 - 26t gross weight / 17,3t payload capacity
- **Type 4:** Articulated lorry transport, Total weight 14-20 t; diesel driven, Euro 0 - 5 or mix, cargo; consumption mix, to consumer; 14 - 20t gross weight / 11.4t payload capacity
- **Type 5:** Articulated lorry transport, Total weight 12-14 t; diesel driven, Euro 0 - 5 or mix, cargo; consumption mix, to consumer; 12 - 14t gross weight / 9.3t payload capacity
- **Type 6:** Articulated lorry transport, Total weight 7.5-12 t; diesel driven, Euro 0 - 5 mix, cargo; consumption mix, to consumer; 7,5 - 12t gross weight / 5t payload capacity
- **Type 7:** Articulated lorry transport, Total weight <7.5 t; diesel driven, Euro 0 - 5 mix, cargo; consumption mix, to consumer; up to 7,5t gross weight / 3t payload capacity

The secondary datasets available in the EF-node (and indicated in the respective tables) **do not** include the use of fuel. The applicant shall always model it by adding the corresponding fuel (usually it is the dataset diesel mix at filling station, UUID: e5c14d1c-9e2e-49eb-82b4-566e5265b18e).

It shall be assumed that no waste is generated during transport (including storage and distribution).

The transport payload (= maximum mass allowed) is indicated in the transportation datasets to be used (see vertical rules). For example, a truck of 28-32t has a payload of 22t. When the mass of a full freight is lower than the load capacity of the truck (e.g., 10t), the transport of the product may be considered volume limited. Within the EF-compliant transport datasets available at http://lcdn.thinkstep.com/Node/, the transport payload is modelled in a parameterised way through the **utilisation ratio**.

Real **payload rates** of the trucks shall be used for all products according to the primary data from the transporter. The utilisation ratio shall be calculated at a precision level of four digits after the comma. If the **load of the truck is mass limited**: a default utilisation ratio of 64% shall be used if the real load rate is unknown. This utilisation ratio includes empty return trips. Therefore, empty returns shall not be modelled separately. This shall be modelled by changing the parameter 'utilisation ratio' to 0.64. If a specific load rate is used based on primary data, the empty returns shall be accounted for. If information about the empty returns is lacking, a default value of 30% shall be assumed.

For light products as insulation the payload rate of the truck is often limited by the volume of the truck. This real payload shall be calculated as follows and adjusted in the dataset. To determine the real payload, the following calculation rules shall be used:

- Firstly, the density of the insulation shall be determined based on the compressed insulation that is being transported (e.g. 45 kg/m³).
- Secondly, the maximum volume of the truck shall be defined by the insulation company or associated transport company (e.g. 100 m³). If information on the volume of the truck is lacking, the following values shall be used:
  - small truck: 40 m³
  - medium truck: 60 m³
  - large truck: 100 m³
- Thirdly, the maximum volume of the truck shall be assumed 85% filled and hence the maximum volume is recalculated as 85% x maximum volume

- Fourthly, the real payload equals: compressed density (kg/m³) x 85% x maximum volume (m³) / 1000 (kg/tonnes).

For the modelling of the volume based truck transport, **empty returns** shall be fixed at 30%. The modelling of the real payload and the 30% empty returns, shall be done by changing the parameter 'utilisation ratio' as follows:

Utilisation rate = real payload / 1.3 / maximum payload

With real payload = compressed density [kg/m³] x 85% x maximum volume [m³] / 1000 [kg/tonnes].

Example: compressed density of 45 kg/m³ with a maximum truck volume of 100 m³ (maximum payload: 24.7 tonnes) leads to a real payload of 4.5 tonnes, as follows: 45 kg/m³ x 100 m³ x 85%= 3825 kg, or hence 3.825 tonnes. The utilisation rate equals 3.825 / 1.3 / 24.7= 0.119.

As insulation has a low density, the transport for insulation shall be volume based. A compression factor of the product during transportation shall be considered if applicable. Mass based transport may be considered for some cases (for example, some in-situ insulation products) but shall be justified.

4.2.5.1 Transport of the raw materials for the thermal insulation product

This process shall be based on primary data. In particular the applicant shall collect the following information:

- Transport mean and truck type (e.g. Euro 0, 1, 2, 3, 4, 5 or mix of these)
- Distance (in km)
- Load rate (%)
- Empty returns (%)

The load rate and empty returns shall be used to calculate the utilisation ratio in line with equations 1 and 2 in section 4.2.5.
In case specific values for the load rate and empty returns are not available, a default utilisation ratio of 64% shall be used.

4.2.5.2 Transport of (the raw materials for) the ancillary products in the build-up

This process shall be based on the scenario provided in Table 8.

Table 8. Default parameters for transport of (raw materials for) ancillary products

Transport of (raw materials for) ancillary products to the building site	Truck type[17]	Transport distance	Utilisation ratio
Ballast (from extraction to building site)	1	50 km	64%
Raw materials for ancillary products, except ballast (from extraction to manufacturing site)	1	500 km	64%
Ancillary products except ballast (from manufacturing to building site)	1	500 km	64%

In case the applicant wants to use primary data, then the same requirements as in 4.2.5.1 apply.

[17] See Section 4.2.11

4.2.5.3 Transport of the packaging to be used for the thermal insulation product

For the transport from the packaging production facility to the thermal insulation factory, the process shall be based on the scenario provided in Table 9.

Table 9. Default parameters for transport of packaging

Transport of packaging	Vehicle type	Dataset source (i.e. node)	Dataset UUID	Transport distance	Utilisation rate*
Truck	Type 1 (> 32 t, EURO 4)	http://lcdn.thinkstep.com/Node/	938d5ba6-17e4-4f0d-bef0-481608681f57	230 km	64%
Train	Average freight train	http://lcdn.thinkstep.com/Node/	02e87631-6d70-48ce-affd-1975dc36f5be	280 km	
Ship	Barge; technology mix, diesel driven, cargo; consumption mix, to consumer; 1500 t payload capacity	http://lcdn.thinkstep.com/Node/	4cfacea0-cce4-4b4d-bd2b-223c8d4c90ae	360 km	

Note: In case of packaging re-use, the reuse rate affects the quantity of transport that is needed per functional unit. The transport impact shall be calculated by dividing the one-way trip impact by the number of times this packaging is reused. For the calculation of the number of re-use cycles the guidelines of the Guidance document version 6.3 shall be used (i.e. paragraph 7.16.2). Option ‘a’ of the Guidance document shall be used. If data are lacking, option ‘b’ shall be used. Additional transport (both transport to go and return transport) shall be counted in the PEF study according to the guidelines in the Guidance document v6.3 – paragraph 7.16.2.

* The utilisation rate includes the empty returns.

In case the applicant wants to use primary data, then the same requirements as in 4.2.5.1 apply.

4.2.5.4 Transport from production site to construction site

The transport distance of the insulation product from production site to retailer, from retailer to the building and/or directly from production site to building site shall be based on the scenario provided in Table 10.

Table 10. Default parameters for transport of the thermal insulation product

Transport of thermal insulation product	Truck type	Transport distance	Utilisation rate
From the production site to the building	Type 1 (> 32 t, EURO 4)	1000 km	64%

In case primary data is available it may be used if the average transport distance covers at least 12 consecutive month data (not older than the three years before the assessment date) of sales delivered.
Where detailed primary data is available regarding a part of the transport, this share may be deducted from the default scenario provided. For example, if detailed records are available for the transport of 30% of the production volume and the transport distance of this 30% equals 660 km, these may be deducted as follows:

70% x 1000 km = 700 km
30% x 660 km = 220 km
Final distance = 700 + 220 = 920 km, instead of 1000 km

In case the available part of transport data is the insulation product transport from production site to retailer, in the example above, then a share of 70% (100%-30%) may be deducted and replaced. For example, if detailed records are available for the transport from production site to retailer of the overall production volume (m^3, kg, etc.), these may be deducted as follows:

1000 km x 70% = 700 km > substituted by real data e.g. 500 km
Final distance = 500 + 300 = 800 km, instead of 1000 km

In case primary data are used, the modelling of the transport activity itself shall follow the requirements listed in 4.2.5.1.
When a producer may justify that a production site is only supplying a specific geographic area (e.g. production site in Belgium only supplying Belgium) the longest distance of transport (from the production site) in the same country may be considered instead of the default transport distance.
As insulation has a low density, the transport shall be volume based. A compression factor of the product during transportation shall be considered if applicable. Mass based transport may be considered for some cases (for example, some in-situ insulation products) but shall be justified.

4.2.5.5 Transport to the End of Life

These processes shall be based on the scenario provided in Table 11.

Table 11. Assumptions for End of Life transport

Transport of all materials in the build-up + packaging	Truck type	Transport distance	Utilisation rate
From the building site to end of life	2	• 50 km for landfill and composting • 100 km for incineration with and without energy recovery • 150 km for recycling and re-use	64%

Landfilling and incineration EF datasets are aggregated with EoL transport scenario. However, in this PEFCR a separate modelling of End of Life transport and End of Life treatment are needed. To avoid double counting and to be able to use the available datasets, the impact of transport shall be subtracted from the EF End of Life treatment datasets when needed. The following steps shall be applied:

1. For the corresponding EoL treatment check if the processes named converter are used.
2. If the two converter processes are passenger car and transport converter then the following transport shall be subtracted:

Process included in EoL Treatment	Dataset for subtraction	Dataset source (i.e. node)	Dataset UUID	Amount to be subtracted
Transport Converter Car (kg/km)	Passenger car, average| technology mix, gasoline and diesel driven, Euro 3-5, passenger car| consumption mix, to consumer| engine size from 1,4l up to >2l {GLO} [LCI result]	http://lcdn.thinkstep.com/Node/	1ead35dd-fc71-4b0c-9410-7e39da95c7dc	50 m
Transport Converter	Articulated lorry transport, Euro 4, Total weight 20-26 t (without fuel)| diesel driven, Euro 4, cargo| consumption mix, to consumer| 20 - 26t gross weight / 17,3t payload capacity {EU-28+3} [Unit process, single operation]	http://lcdn.thinkstep.com/Node/	ee313a8a-6aea-4ff7-a4ee-0224c2e038f4	30 kgkm

3. If the converter processes indicated in the list of complementing processes are different, then applicant should search for the respective converter processes and see which distance is applied to be subtracted.

Additional information regarding the modelling parameters of the transportation of the packaging insulation to EoL is provided in the Excel file “PEFCR thermal insulation_life cycle stages” available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm.

In case the applicant wants to use primary data, then the requirements defined in section 4.2.5.1 apply.

4.2.6 Packaging of the final product (cradle to gate)

See specific requirements in vertical rules.

4.2.7 Installation

All input/output flows related to the equipment and tools (including the energy consumption) used during the installation phase for both in-situ and factory made insulation shall be included in the PEF study.
Any losses during the installation shall be considered during this stage. The production, transport, and waste processing and disposal of the lost products and materials shall be taken into account.
A default waste percentage of 2% shall be applied for thermal insulation products at installation stage if no primary data is available. The same End of Life (EoL) scenario as applied for the thermal insulation product shall be applied for the EoL scenario of the 2% waste. If a different scenario is applied justifications shall be provided.
For electricity use during installation, the rules in section 4.1.6 shall be followed.

4.2.8 Use, maintenance and refurbishment

Use, maintenance and refurbishment shall be defined at vertical level and if relevant these shall be in line with the vertical rules defined. If justified, use, maintenance and refurbishment may be excluded at vertical level.
The environmental benefits related to energy savings during the use phase shall be separately provided in the PEF study and shall not be merged with the other life cycle stages.
It shall be assumed that the insulation products are applied correctly and in standard conditions.
Maintenance includes preventative and regular maintenance activity and the planned servicing, replacement or mending of worn, damaged or degraded parts.

Maintenance shall include:

- production and transportation of any component and ancillary products used for maintenance,
- use of related energy and water,
- transportation of any waste from maintenance processes or from maintenance related transportation,
- end-of-life processes of any waste from transportation and the maintenance process, including any part of the component and ancillary materials removed.

Refurbishment covers the combination of all technical and associated administrative actions during the service life of the product to a condition in which it may perform its required functions. Refurbishment covers a concerted programme of maintenance, repair and/or replacement activity.
Refurbishment shall include:

- production of the components and ancillary materials used for refurbishment,
- refurbishment process and related water and energy use including production aspects and impacts of any waste of materials used during the refurbishment process,
- transportation of the component and ancillary materials used for refurbishment, including production aspects and impacts of any losses during transportation,
- end-of-life processes of any losses suffered during transportation and the refurbishment process, including the components and ancillary materials removed.

For electricity use during the use phase of the building, the rules in section 4.1.6 shall be followed.

4.2.8.1 Calculation of the number or replacements

The number of replacements of a construction product shall be defined by dividing the design life span of the building element (i.e. 50 years) by the RSL of the construction product minus one. If this result leads to an integer, then the integer shall represent the number of replacements. If this number is not an integer, the obtained number shall be rounded up to an integer.

Example: a thermal insulation product with an RSL of 30 years is installed in a building element with a design life span of 50 years. The number of replacements = 50/30 = 1.67. 1.67 – 1 = 0.67 replacements. This is not an integer and hence, this number is rounded up = 1 replacement.

When any replacement is needed, each replacement shall include demolition or dismantling of the part that is being replaced, production and installation of the new part, all related transport, and end-of life of the part that is being replaced. Maintenance shall be accounted for the full design life span of the building element.

4.2.9 Demolishing or dismantling

The processes to be used when modelling this life cycle stage are listed in the sections about vertical rules. The demolition processes mainly use energy for mechanical operations.

For all products included in the scope, the assumptions to model this stage are based on Debacker et al., 2012 [12]).

In case a verifiable specific demolition scenario or primary verifiable data for the demolition processes are available they shall be used instead of the default scenario.

If dismantling instead of demolition is assumed, the applicant shall prove that dismantling is happening for the specific product and the assumptions shall be verified.

4.2.10 End of Life stage

4.2.10.1 Sorting

Where no specific scenario or primary data is available for the sorting of material going to any of the EoL scenarios, the scenario in Table 12 shall be applied. The sorting shall be applied for each material to the total quantity of that material at the EoL, even if a small share of the material is recycled at the end of life. For example, for a product weighing 2 kg, with a recycling rate of 10%, the sorted mass at the end of life is 2 kg, while 0.2 kg are actually recycled. As this rule is applied for each material: it is hence assumed that the sorting of one material does not imply sorting of the other materials.

Table 12. Assumptions for sorting of material going to any EoL scenario [12]

Name	Amount per kg	Unit	Data record	Source
INPUT				
Handling in sorting plant	1/density*	m^3	No EF compliant dataset available. Process is considered as data gap.	-
Electricity for mechanical sorting processes	7,92E-03	MJ	Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, at consumer| 1kV - 60kV {EU-28+3} [LCI result] {34960d4d-af62-43a0-aa76-adc5fcf57246}	EF dataset
Infrastructure sorting plant	1E-10	piece	No EF compliant dataset available. Process is considered as data gap.	-
OUTPUT				
Emission in sorting plant	0,00792	MJ	Heat, waste	

* The handling in the sorting plant refers to the diesel for loading and unloading of the sorted waste. The amount depends on the density of the sorted material. For the thermal insulation products, the specific density shall be used. For the ancillary products the densities as defined in the vertical rules shall be used.

If no information is available on the sorting site, it shall be assumed that sorting takes place either at the building site or at the recycling site. No additional transport is then needed and section 4.2.5.5 refers to the overall end-of-life transport.

4.2.10.2 End of Life scenarios for thermal insulation products

Depending on the available information about the market where a thermal insulation product is sold four options are possible for the EoL scenarios:

Option 1: if the thermal insulation product is sold all over Europe, then the EU EoL scenario provided in Table 13 shall be applied;

Option 2: if the non-mineral thermal insulation product is sold in several European countries, then the applicant may choose to either use the option 1 or to calculate the EoL scenario based on the weighted average of the scenario applying in each of the EU countries where the thermal insulation product is sold. The weighted average shall be based on volume of product(s) sold and the country specific data available in Table 14. For any lacking country in Table 14, the values shall be justified;

Option 3: if the non-mineral thermal insulation product is sold in a single European country, then the applicant shall use the EoL scenario applicable for that country based on the data available in Table 14;

Option 4: the applicant may use a specific scenario for the EoL provided that this is applied to its company and is functioning, and the scenario and the assumptions it is based upon have been verified by an independent external third party[18].

Table 13. EU EoL scenario for thermal insulation products[19]

	Recycling %	Energy recovery %	Landfill %
Non-mineral products	0%	45%	55%
Mineral products	0%	0%	100%

Table 14. EoL scenario for non-mineral thermal insulation products in each Member State and neighbouring countries[20]

Country	Energy recovery %	Landfill %
Austria	100%	0%
Belgium	100%	0%
Bulgaria	7%	93%
Croatia	5%	95%
Cyprus	0%	100%
Czech Republic	28%	72%
Denmark	100%	0%
Estonia	65%	35%
Finland	77%	23%
France	54%	46%

[18] A company might only have specific data on the recycling (part the company takes back) and not on what happens with the percentage that goes to energy recovery/landfill. In that case it is allowed to take into account the specific data for the recycling and use the same procedure (option 1-4) described in section 4.2.10.2 for the remaining part.

[19] PEF thermal insulation technical secretariat expert judgment.

[20] Data based on expert judgement.

Germany	100%	0%
Greece	0%	100%
Hungary	27%	73%
Ireland	72%	28%
Italy	45%	55%
Latvia	6%	94%
Liechtenstein	To be approximated by scenario for Switzerland	
Lithuania	33%	67%
Luxembourg	100%	0%
Malta	0%	100%
Netherlands	100%	0%
Norway	94%	6%
Poland	25%	75%
Portugal	41%	59%
Romania	20%	80%
Slovakia	36%	64%
Slovenia	53%	47%
Spain	24%	76%
Sweden	100%	0%
Switzerland	100%	0%
UK	43%	57%

4.2.10.3 End of Life scenarios for packaging materials

The End of Life of all packaging materials is accounted for in this stage. The EoL scenarios for packaging materials provided in Table 15 shall be applied. Additional information is provided in the Excel file "PEFCR thermal insulation_life cycle stages" (sheets Packaging and EoL packaging) available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm.

Table 15. EoL scenarios for packaging materials

	Recycled content %	Recycling %	Energy recovery %	Landfill %
Plastic - PET and PP packaging, PE film packaging – source Eurostat	0%	28.84%	32.20%	38.96%
Board and Paper (Corrugated board) - source Eurostat	88%	74.61%	11.49%	13.90%
Wood - source Eurostat	0%	30%	31.68%	38.32%
Metals – source metal sheet pilot	0%	73.60%	11.95%	14.45%

4.2.10.4 End of Life scenarios for ancillary materials

The End of Life scenarios for ancillary materials in the build-up shall be based on Table 16. All assumptions follow the same logic as for the insulation products.

The default scenario provided may be adjusted in the vertical rules or may include more materials and products.

It is to be noted that the default scenarios might not reflect the legal framework in all EU member states.

Table 16. EoL scenarios for ancillary materials

	Recycled Content %	Recycling %	Energy recovery %	Landfill %
Plastic (Water proofing layer, vapour barrier)	0%	0%	45.25%	54.75%
Wood (rafter extensions)	0%	38.00%	28.06%	33.94%
Metals (hangers, extensions)	10.70%	95.00%	2.26%	2.74%

Additional information is provided in the Excel file “PEFCR thermal insulation_life cycle stages” available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm.

4.2.10.5 End-of-life assumptions

The baseline Circular Footprint Formula (CFF) as presented below shall be applied when dealing with the EoL modelling. Table 17 lists the meaning of each parameter and the default value that shall be used unless differently foreseen in the vertical rules.

	Material acquisition	Recycling	Energy recovery	Disposal
PEF	$(1-R_1)\times E_v + R_1 \times E_{recycled}$	$-(1-A)R_1 \times \left(E_{Recycled} - E_v \times \left(\frac{Q_{Sin}}{Q_p}\right)\right)$ $+(1-A)R_2 \times \left(E_{RecyclingEoL} - E_v^* \left(\frac{Q_{Sout}}{Q_p}\right)\right)$	$(1-B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat}$ $-LHV \times X_{ER,elec} \times E_{SE,elec})$	$(1-R_2-R_3)E_D$

Table 17. EoL modelling parameters

Parameters	Description	Default value
A	Allocation factor of burdens and credits between supplier and user of recycled materials	- metals: 0.2 - packaging - paper based: 0.2 - packaging - plastic based: 0.5 - packaging - wood pallet: 0.8 - HDPE delta U separation layer: 0.5 - - Timber rafters: 0.8 - Insulation: ▪ cellulose: 0.5 ▪ cellular glass: 0.5 ▪ EPS: 0.5 ▪ PU: 0.5
B	Allocation factor of energy recovery processes: it applies to burdens and credits	0
R_1 ($0=<R_1<=1$)	"recycled (or reused) content of material", is the proportion of material in the input to the production that has been recycled from a previous system ($0=<R_1<=1$).	
R_2 ($0=<R_2<=1$)	"recycling (or reuse) fraction of material", is the proportion of the material in the product that will be recycled (or reused) in a subsequent system. R_2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R_2 shall be measured at the output of the recycling plant ($0=<R_2=<1$).	

R_3 (0=<R_3<=1)	The proportion of material in the product that is used for energy recovery (e.g. incineration with energy recovery) at EoL (0=<R_3 =<1).	
E_v	Specific emissions and resources consumed (per unit of analysis) arising from the acquisition and pre-processing of virgin material.	See excel file "PEFCR thermal insulation_life cycle stages" – EoL sheets for the secondary dataset to be used for each specific material, available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm
E_v^*	Specific emissions and resources consumed (per unit of analysis) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials: in case of closed loop E*V = EV in case of open-loop recycling: E_v^*= E_v^ξ represents the input of virgin material that refers to the actual virgin material substituted through open-loop recycling.	
$E_{recycled}$	Specific emissions and resources consumed (per unit of analysis) arising from the recycling process of the recycled (or reused) material, including collection, sorting and transportation processes.	
$E_{RecyclingEoL}$	Specific emissions and resources consumed (per unit of analysis) arising from the recycling process at the end-of-life, including collection, sorting and transportation processes. in case of closed loop Erecycled = ErecyclingEoL.	
E_D	Specific emissions and resources consumed (per unit of analysis) arising from disposal of waste material at the EoL of the analysed product (e.g. landfilling, incineration, pyrolysis), without energy recovery.	
E_{ER}	Specific emissions and resources consumed (per unit of analysis) arising from the energy recovery process.	
$E_{SE,heat}$ $E_{SE,elec}$	Specific emissions and resources consumed (per unit of analysis) that would have arisen from the specific substituted energy source, heat and electricity respectively.	
LHV	Lower Heating Value [e.g. MJ/kg] of the material in the product that is used for energy recovery.	Paper 14.12 MJ/kg Cardboard 15.92 MJ/kg PE 42.47 MJ/kg PET 22.95 MJ/kg Mixed plastics 30.79 MJ/kg Steel 0 MJ/kg

		Aluminium 31.6 MJ/kg * oxyrate[21] Glass 0 MJ/kg Wood 14 MJ/kg
$X_{ER,heat}$ $X_{ER,elec}$	The efficiency of the energy recovery process (0<X_{ER}<1) for both heat and electricity, i.e. the ratio between the energy content of output (e.g. output of heat or electricity) and the energy content of the material in the product that is used for energy recovery. X_{ER} shall therefore take into account the inefficiencies of the energy recovery process (0=<X_{ER}<1).	$X_{ER,heat}$ = 31 % $X_{ER,elec}$ = 10.1 %
Q_{Sin}	Quality of the ingoing secondary material, i.e. the quality of the recycled or reused material at the point of substitution	
Q_{Sout}	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. the quality of the virgin material.	
Q_{Sin}/Q_p = Q_{Sout}/Q_p	Quality ratio[22]	Glass 1 Steel 1 Aluminium 1 Other metals 1 Paper and cardboard 0.85 or 1* PET 0.9 or 1** PP 0.9 HDPE 0.9 LDPE film 0.75 Insulation 1 Wood 1

* 0.85 shall be used when the recycling process doesn't consider fibre losses and 1 shall be used when the recycling process considers fibre losses.

** 1 shall be used for PET – SSP recycling and 0.9 shall be used for PET mechanical recycling.

[21] Thick section aluminium packaging 90-900 micron (beverage cans, closures and aerosols): use **15%** as oxyrate. Small pieces (aluminium trays) 50-90 micron: use **20%** as oxyrate. Thin alufoil and foil laminates, laminated plastic wrappers with alufoil and pouches with alufoil with a thickness of 6-50 micron: use **55%** as oxyrate.

[22] Any different assumption on the value of the Q_s/Q_p ratio shall be based on expert judgment and documented.

The recycling scenario shall be based on existing technologies. All elements for recycling should be considered (e.g. deconstruction (if needed), organisation of logistics, technology, management of additives during the recycling, etc.).

4.2.11 Infrastructure

The infrastructure shall be included for the insulation factory. A default scenario for the factory where the thermal insulation product(s) are produced is provided in Table 18.

Table 18. Default scenario for insulation factory[23]

Name	Default dataset to be used	Dataset source (i.e. node)	Amount for 1 kg of insulation	Correction factor	Final amount	Unit	Dataset UUID
From technosphere (materials/fuel)							
Building, hall	Building, reinforced concrete frame construction (1 m³ gross volume = 242 kg) | reinforced concrete frame production | single route, at plant | material quantities adjustable {GLO} [Unit process, single operation]	http://lcdn.thinkstep.com/Node/	4.74E-05 *4*242	1.2	5.68E-05 *4*242	kg	36a74991-0d96-46b5-b75b-3a96dcfc5a03
Building, multi-storey	Building, administration type (1 m³ gross volume = 432 kg) | building construction | single route, at plant | material quantities adjustable {GLO} [Unit process, single operation]	http://lcdn.thinkstep.com/Node/	7.35E-05 *432	1.2	8.82E-05*432	kg	d7cfc448-6eca-418a-8c14-7b496e375e3f
Concrete, sole plate and foundation	Building, reinforced concrete frame construction (1 m³ gross volume = 242 kg) | reinforced concrete frame production | single route, at plant | material quantities adjustable {GLO} [Unit process, single operation]	http://lcdn.thinkstep.com/Node/	1.23E-06*242	1.2	1.48E-06*242	kg	36a74991-0d96-46b5-b75b-3a96dcfc5a03
Conveyor belt[24]	Data gap (Dummy conveyor belt)						Data gap
Industrial machine, heavy, unspecified	Steel hot dip galvanised| steel sheet hot dip galvanization| single route, at plant| 1.5 mm sheet thickness, 0.02 mm zinc thickness {EU-28+EFTA} [LCI result]	http://lcdn.thinkstep.com/Node/	2.06E-03	1.2	2.47E-03	kg	efdf5d68-090e-4753-bd59-674ec282c4e2
Sheet rolling, steel	Steel sheet stamping and bending| stamping and bending| single route, at plant| 5% loss {GLO} [LCI result]	http://lcdn.thinkstep.com/Node/	2.71E-03	1.2	3.26E-03	kg	c269b02a-b742-46eb-8adb-6baf0a49fa1b

[23] The default scenario is an average of the available data from insulation factories in Ecoinvent, including a 20% correction factor on all inputs and outputs. A life span of 50 years is considered for the plant. The part of the plant allocated to 1 kg of insulation product is 1.55E-09 of the factory. Factories are: Wood pellet factory (for Cellulose), *Stone* wool plant (for both glass and stone wool), Tube insulation factory (for EPS, XPS and PU), Foam glass plant (for the cellular glass), Wooden board factory (for wood insulation). The assessment is based on market share for different insulation products based on TS expert judgment.

[24] The original scenario was based on an Ecoinvent dataset, including a conveyor belt (amount: 4.46E-06 x 1.2 = 5.35E-06 m). However, this has been excluded from the insulation factory scenario to be used in this PEFCR as no EF compliant dataset is available.

Steel, low-alloyed, hot rolled	Hot rolled coil| hot rolling| production mix, at plant| carbon steel {EU-28+EFTA} [LCI result]	http://lcdn.thinkstep.com/Node/	2.71E-03	1.2	3.26E-03	kg	2a164e49-95ee-43f7-b6c1-fb1bbb8cb9c5
From nature (resources)							
Transformation, to industrial area			1.51E-04	1.2	1.81E-04	m²	Elementary flow
Transformation, from unknown			1.68E-04	1.2	2.02E-04	m²	Elementary flow
Occupation, industrial area			6.78E-03	1.2	8.14E-03	m²a	Elementary flow
Transformation, to traffic area, road network			1.74E-05	1.2	2.08E-05	m²	Elementary flow
Waste and emissions to treatment							
Landfill of ferro metals	Landfill of inert (ferro metals)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site| {EU-28+EFTA} [LCI result]	http://lcdn.thinkstep.com/Node/	2.71E-03	1.2	8.98E-03	kg	d1b67ec3-daf6-4978-ac86-c30bc6cd88c3

In case the applicant prefers to use primary data, then the infrastructure data shall be collected based on the template provided in Table 19. When specific data are used, the yearly production rate and reference service life of the building shall be verified. The yearly production rate shall be based on the average yearly production of the previous three years. In case primary data are used, these shall be collected for the complete infrastructure and shall not be mixed with the default values provided in Table 18.

Table 19. Table to collect data for the insulation factory

	Name	Amount	Unit
Inputs	From technosphere (materials/fuel)		
	Building, hall	___	m²
	Building, multi-story	___	m³
	Concrete, sole plate and foundation	___	m³
	Industrial machine, heavy, unspecified	___	kg
	Sheet rolling, steel	___	kg
	Steel, low-alloyed, hot rolled	___	kg
	etc.		
	From nature (resources)		
	Transformation, to industrial area	___	m²
	Transformation, from unknown	___	m²
	Occupation, industrial area	___	m²a
	Transformation, to traffic area, road network	___	m²

<table>
<tr><td></td><td>etc.</td><td></td><td></td></tr>
<tr><td>Outputs</td><td>Waste and emissions to treatment</td><td></td><td></td></tr>
<tr><td></td><td>Waste reinforced concrete {GLO}| market</td><td>____</td><td>kg</td></tr>
<tr><td></td><td>All additional waste flows[25]</td><td></td><td></td></tr>
<tr><td></td><td>etc</td><td></td><td></td></tr>
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4.3 Additional environmental information

4.3.1 Reduced heat demand

The main function of thermal insulation is its heat resistance, reducing the need for heating a building and hence reducing the energy consumption while maintaining the required thermal indoor comfort level. Thermal insulation hence indirectly leads to environmental benefits compared to a non-insulated building.

As the reduced heat demand is an indirect environmental benefit, it shall not be included in the product environmental footprint of the thermal insulation, but should be reported separately as additional environmental information.

As the energy savings and hence the environmental benefits depend on many aspects (e.g. climatic context, indoor air temperature, etc.), clear rules are needed on how to calculate the reduced heat demand and related environmental benefits. These rules are described in Annex 6. These relate to the climatic context and indoor conditions to be considered (equivalent heating degree days), the basis for comparison (i.e. non-insulated roof with a predefined Uc-value), the energy efficiency of the heating system, the calculation rules and the EU final energy consumption mix combined with the datasets to be used.

The energy savings shall be calculated based on the Uc value of the specific build-up the calculation is referring to and it shall be compared to the heating energy use for the non-insulated build-up as defined in the vertical rules. The energy savings and related environmental benefits shall be calculated according to the methodology described in Annex 6.

4.3.2 Temporary effects of carbon storage and delayed emissions

Temporary effects of carbon storage and delayed emissions shall not be included in the PEF profile and shall not be included as additional environmental information (in line with the PEFCR Guidance v. 6.3).

4.3.3 Biodiversity

This PEFCR covers a divers set of raw materials which potentially have a direct and/or indirect impact on biodiversity, raw oil drilling and exploitation, impacts of transport through disconnection of biotopes and land occupation of transport infrastructure, forest management, etc. Currently, suitable and robust methods are however lacking to assess biodiversity. The thermal insulation pilot couldn't propose a suitable approach to assess biodiversity and hence it shall not be reported.

[25] Note: Some of the generic datasets used to model the infrastructure include waste processing in the datasets. These shall not be accounted separately in the waste outputs to avoid double counting.

5 Vertical rules for the application in a pitched roof with massive timber rafters

The vertical rules shall be used when performing a PEF study on an application (and thermal insulation product) claimed to be in compliance with this PEFCR. Whenever the vertical rules conflict the horizontal rules, the latter prevail over the former.

5.1 Scope

The vertical rules for pitched roofs with massive timber rafters are valid for the following thermal insulation products:

Product	Reference
Loose fill cellulose	ETA – EN 15101*

* *pending citation in European official journal*

Thermal insulation products that already incorporate common elements, or the installation of which does not require certain common elements are excluded from the scope.

5.2 Product classification (NACE/CPA)

See section 3.1.

5.3 Representative product

5.3.1 Build-up system assumptions

The way the thermal insulation product is installed in the roof (i.e. under the rafters, between the rafters, or a combination of these) shall be defined based on expert judgment.

Due to various possible practices, a default build-up is defined for the various insulation positions (between and/or under the rafters) and is presented in Figure 9[26].

[26] Based on the insulation position (between and/or under the rafters), structural elements (e.g. rafters and/or perlings) may potentially influence the final Uc-value of the roof.

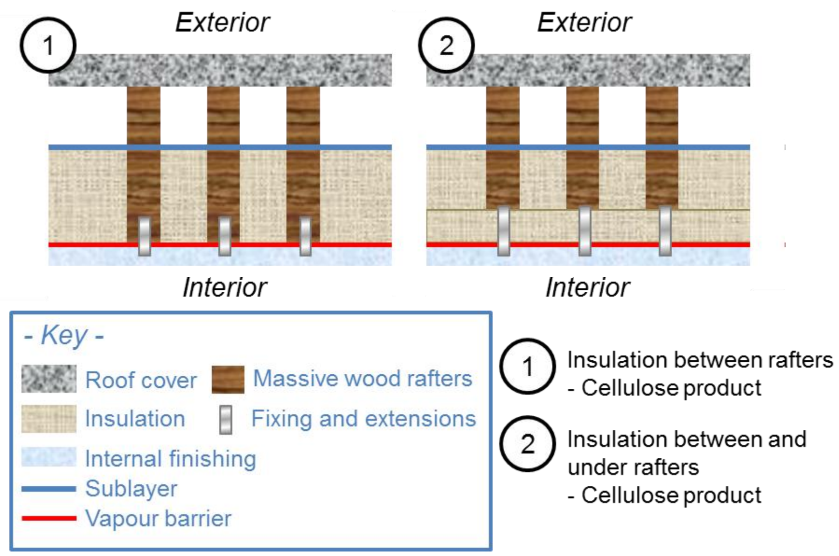

Figure 9: Default cross section of pitched roof with massive timber rafters (to be used for comparisons/comparative assertions and for all insulation products within the scope of the PEFCR)

The build-up shall be described according to the information requested in Table 20. The calculation of the inventory flows specific to the build-up shall be calculated according to the corresponding horizontal rules available in sections 4.2.2, 4.2.4 and, 4.2.5.2.

Table 20. Specific Build-up assumptions for pitched roof

Build-up products or processes	Default value	Unit
Vapour barrier for blown-in insulation (PE/PP)	0.125	kg/m²
Insulation	Depends on the insulation thickness	kg/m²
If needed:		
Sublayer (PP)	0.365	kg/m²
Fixing of the sublayer (staples – galvanised steel)	0.005	kg/m²
Fixing of the vapour barrier (staples – galvanised steel)	0.005	kg/m²
OSB III board as extensions (Oriented standard board)	Depends on the insulation thickness*	kg/m²
Fixing of the wooden board extensions (galvanised steel screws or glue)	Depends on the insulation thickness**	kg/m²
Blowing of insulation (electricity)***	Depends on the insulation thickness	MJ/m²
Tape to close holes in vapour barrier for blown-in insulation (PE/PP)	0.005	kg/m²

* A minimum number[27] of 1.867 OSB III board extensions with a thickness of 1 cm, length of 1 m and width equal to the insulation thickness below the rafters, with a density of the OSB boards of 730 kg/m³ shall be included for 1m² of roof.

[27] The number of OSB boards per m² roof has been calculated as follows: an average roof width of 500 cm is assumed. As the distance (axes to axes) between the rafters equals 60 cm, (500/60 +1) rafters are needed for

** A minimum of two screws per OSB III board with a weight of 0.0017 kg per screw shall be included.
*** The blowing of insulation shall be modelled in the life cycle stage ‘Installation’ (see section 5.14.8).

The following parts shall be included in the scope of the pitched roof application:

- Thermal insulation product(s) including packaging,
- Necessary fixings for the installation of the thermal insulation,
- Additional extensions of the rafters to allow for insulation thicknesses larger than the height of the rafters (14 cm) if the insulation is put between the rafters (if needed),
- Vapour barrier, including fixing,
- Sublayer (wind/water proofing) (if needed), including fixing.

The following parts shall be excluded from the scope, as they are not influenced by the insulation layer (i.e. are used regardless of the type of insulation products):

- Timber rafters[28],
- Bracing of the roof structure,
- Exterior finishing (everything placed outside of the sublayer),
- Interior finishing (everything placed at the inner side of the vapour barrier).

Figure 10 shows the common part in dark colour and the agreed dimensions to be used for comparisons/comparative assertions. The common part (dark colour) is excluded from the scope.

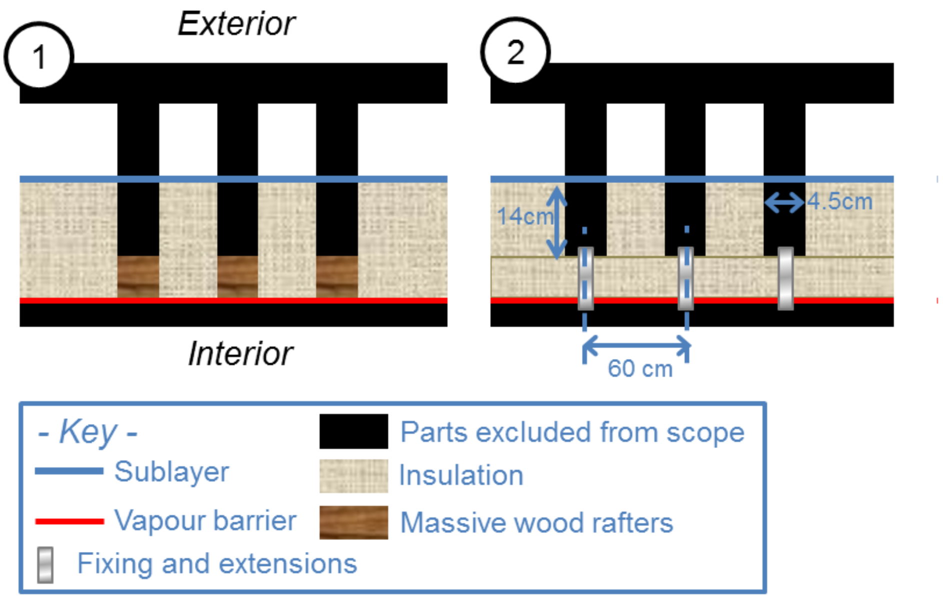

Figure 10: Default scope of the PEFCR for the pitched roof (only build-up 2 to be used for comparisons/ comparative assertions)

the roof structure. To calculate the number of rafters for 1 m of roof width, this number is divided by 5 m, resulting in: (500/60 + 1)/5 = 1.867. Under each rafter, an OSB board needs to be fixed, resulting in 1.867 OSB boards per m² roof.

[28] Although the timber rafters are not included in the environmental calculations, their dimensions and spacing have been defined as they are included in the calculation of the Uc-value of the roof.

If the results of a PEF study carried out in compliance with this PEFCR are used **to make comparisons/comparative assertions** (being them against the benchmark or against other thermal insulation products), then the following specific build-up assumptions shall be used and shall not be changed: 4.5 cm x 14 cm massive timber rafters with an inter-distance (axe to axe) of 60 cm[29], with a lambda value of the timber of 0.130 W/m·K and in line with the specific build-up assumptions of Table 20. Specific Build-up assumptions for pitched roof. The sublayer and vapour barrier shall be those listed in the attached Excel file (sheet raw material acquisition other) available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm. The material for the extensions (if needed) shall be Oriented Standard Board III (OSB III).

For comparative assertions, the fixings and extensions needed for placing the thermal insulation between or under the rafters, shall be assumed as defined in the build-up (Table 20 and Figure 10).

If the results of a PEF study carried out in compliance with this PEFCR are used to calculate and communicate the PEF-profile of a thermal insulation product used in a pitched roof **without comparison/comparative assertions**, then the baseline build-up shall be used, but the dimensions (including inter-distance) of the rafters may be adapted. In this case, the adapted build-up assumptions (and changes compared to the basic build-up) shall be clearly defined and shall be verifiable. In case the baseline build-up is changed (i.e. dimensions of the rafters or the inter-distance is changed), the impact of the timber rafters shall be included.

The following requirements shall be fulfilled:

- The parts of the build-up that are excluded from the scope when taking into consideration the baseline build-up shall remain excluded except for the rafters.
- The thermal transmittance (Uc-value) shall be calculated for the pitched roof (considering all thermal bridges). The Uc-value does not relate solely to the insulation material, but refers to the complete build-up (including the common parts outside the scope).

The final thermal performance of the building element shall be in the range of the variation as defined in the functional unit (see 5.4). The exact performance shall be calculated using the real thickness of the insulation product in the building element (using EN ISO 6946), and this value shall be used throughout the PEF study.

5.4 Functional unit

The functional unit for a thermal insulation product in a pitched roof with massive timber rafters is defined as:

> *"The thermal insulation of 1m² of a pitched roof with massive timber rafters, with an insulation thickness that gives a thermal transmittance Uc of the pitched roof between 0.33 and 0.10 W/m²K, with a design life span of 50 years".*

In case of benchmarking, the value for the thermal transmittance Uc of the pitched roof mentioned in the functional unit shall be at least and as close as possible to 0.14 W/m²K.

The function(s)/service(s) provided:	A thermal insulation product applied in a pitched roof build-up as defined in section 5.3. The product may be applied between and/or below the rafters.

[29] The rafter dimensions and their inter-distance differ across the 28 Member States. The values used in this PEFCR are based on a compromise between the different members of the Technical Secretariat. This does not mean that the values are equal to the dimensions of the common practice in any specific Member State.

The extent of the function or service:	The amount of product needed to insulate 1 m² of the defined pitched roof, including all other components required for fixing, extension of rafters (if needed), air-tightness, vapour barrier, sublayer if not included in the thermal insulation product.
The expected level of performance:	An insulation thickness that gives a thermal transmittance Uc of the pitched roof between 0.33 and 0.10 $W/(m^2.K)$ during its application over the service life of the roof.
The Reference Service Life (RSL) of the product:	50 years based on the expected average design life of the building [8] - [11].

5.4.1 The reference service life of the product

See section 3.3.1.

5.5 System boundary – life-cycle stages and processes

See section 3.4.

5.6 EF impact assessment

See section 3.5.

5.7 Most relevant impact categories

The most relevant impact categories for pitched roof are the following:

- Climate change (38.9% of the total weighted impact, excluding toxicity);
- Land use (13.2% of the total weighted impact, excluding toxicity);
- Particulate matter (12.7% of the total weighted impact, excluding toxicity);
- Resource use, fossils (8.8% of the total weighted impact, excluding toxicity);
- Resource use, minerals and metals (7.2% of the total weighted impact, excluding toxicity).

As the contribution of biogenic carbon is higher than 5% to the total climate change indicator, the latter shall be reported in its three components, that is:

- Climate change – fossil
- Climate change – biogenic
- Climate change – land use and transformation.

5.8 Most relevant life cycle stages

The most relevant life cycle stages for pitched roof are the following:

- Raw material acquisition for the insulation product;
- Raw material acquisition for the ancillary products;
- Manufacturing of the insulation product;
- Transport from production site to the construction site;
- End-of-life treatment of the thermal insulation product.

Table 21 shows the link between the most relevant impact categories and the life cycle stages where they happen.

Table 21. Contribution of the different life cycle stages to the most relevant impact categories for pitched roof (characterised results).

Impact category	Raw material acquisition for insulation product	Raw material acquisition for ancillary products	Manufacturing of the insulation product	Packaging of the insulation product	Transport from production site to the construction site	End-of-life treatment
Climate Change	8.78%	11.12%			3.17%	58.93%
Land use	94.63%					
Particulate matter	59.31%	19.52%	2.59%			
Resource use (fossils)	13.85%	27.60%	3.49%	4.35%	6.98%	24.12%
Resource use (minerals and metals)	44.30%	19.76%	18.06%			

* the percentages are referred to the characterised results.

5.9 Most relevant processes for pitched roof.

Table 22 lists the processes identified as "most relevant" for thermal insulation product(s) used for a pitched roof with massive timber rafters. If a process is not included in Table 22 it means that it shall be considered as "other process" in the DNM matrix (see Table 6). The applicant shall declare which of these processes are under its operational control (Situation 1 of the Data Need Matrix, see Table 6).

Table 22. Most relevant processes for pitched roofs with massive timber rafters

Life cycle stage	**Most relevant processes**	**Impact categories affected**				
		Climate change	Land use	Particulate matter	Resource use (fossils)	Resource use (minerals and metals)
Raw materials acquisition for the insulation products	Production of unbleached kraft pulp, softwood	6.58%	94.63%	46.55%	9.29%	13.76%
	Production of boric acid	2.19%		9.40%	4.55%	24.25%
	Aluminium sulphate powder production					6.29%

	Production of magnesium sulphate			3.36%		
Raw materials acquisition for ancillary products	Production of medium density fibreboard	11.12%		19.52%	22.61%	14.31%
	Production of PP fibres				2.04%	
	Production of HDPE granulates				2.95%	
	Steel production					5.44%
Manufacturing of the insulation product	Electricity grid mix 1kV-60kV				3.49%	
	Thermal energy from natural gas					
	Infrastructure (insulation factory)			2.59%		18.06%
Packaging of the insulation product	Plastic bag, PE				2.26%	
	Plastic film, PE				2.09%	
Transport from production site to construction site	Articulated lorry transport, Euro 4, Total weight >32 t	3.17%				
	Diesel mix at filling station				6.98%	
End of life treatment	Waste incineration of plastics				2.48%	
	Waste incineration of untreated wood	2.53%			4.27%	
	Waste incineration of paper and board	7.33%			17.37%	
	Landfill of paper and board	39.95%				
	Landfill of untreated wood	9.11%				

* the contributions shown in % refer to the characterised results per impact category

5.10 Life cycle inventory

All newly created processes shall be EF-compliant.

5.10.1 List of mandatory company-specific data

The following process shall be under the operational control of the company implementing this PEFCR:

- The production process of the thermal insulation product.

This means that no PEF study compliant with this PEFCR may be carried out without providing the company specific data listed in the Tables below.

Data collection requirements for loose fill cellulose production process

	Requirements for data collection purposes			Requirements for modelling purposes								Remarks
	Activity data to be collected	*Specific requirements (e.g. frequency, measurement standard, etc)*	*Unit of measure*	*Default dataset to be used*	*Dataset source (i.e. node)*	*UUID*	*TiR*	*GR*	*TeR*	*P*	*DQR*	
Loose fill cellulose insulation	**Inputs**											
	Yearly tap water use	Average year	kg water/year	*Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result]*	https://lcdn.quantis-software.com/PEF/	212b8494-a769-4c2e-8d82-9a6ef61baad7	2.42	2.025	2.038	2.02	2.126	
	Yearly diesel consumption	Average year	kg	*Diesel mix at filling station| from crude oil and bio components| consumption mix, at filling station| 7.23 wt.% bio components {EU-27} [LCI result]*	http://lcdn.thinkstep.com/Node/	e5c14d1c-9e2e-49eb-82b4-566e5265b18e	Not evaluated					proxy for Diesel, burned in building machine, conversion factor : 46,5 GJ/tonne
		Average year	kg	*Diesel combustion in construction machine | diesel driven | {GLO} [Unit process, single operation]*	http://lcdn.thinkstep.com/Node/	dae81b4f-688f-44cd-906b-9435d3843e65	2	2	3	2		
	Yearly natural gas use	Average year	MJ	*Thermal energy from natural gas| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]*	http://lcdn.thinkstep.com/Node/	81675341-f1af-44b0-81d3-d108caef5c28	1	1	1	2	1	Natural gas and proxy for propane
	Yearly light fuel oil use	Average year	MJ	*Thermal energy from light fuel oil (LFO)| technology mix regarding firing and flue gas cleaning| production mix, at*	http://lcdn.thinkstep.com/Node/	e7510ad9-4bfa-4113-94b0-426e5f430c98	1	1	1	2	1	

				heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]								
	Yearly electricity use	Average year	kWh/year	*Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, to consumer| 1kV - 60kV {Country specific} [LCI result]*	http://lcdn.thinkstep.com/Node/	34960d4d-af62-43a0-aa76-adc5fcf57246	1	1	1	2	1	
	Outputs											
	Yearly waste generation		kg	*Waste incineration of municipal solid waste| waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment| production mix, at consumer| municipal solid waste {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	2f07be1f-d11a-46ac-b4f0-49c5f28b5b93	1	1	2	2	1	Municipal solid waste to incineration
			kg	*Waste incineration of paper and board| waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment| production mix, at consumer| paper waste {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	b6ce954d-deb4-4c16-907a-c67b71e1e862	1	1	2	2	1	EOL for non-mineral product as for PEFCR (waste graphical paper)
			kg	*Landfill of inert (ferro metals)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix*	http://lcdn.thinkstep.com/Node/	d1b67ec3-daf6-4978-ac86-c30bc6cd88c3	2	2	2	2	2	Waste scrap

				(region specific sites), at landfill site| {EU-28+EFTA} [LCI result]								
			kg	*Treatment of residential wastewater, large plant| waste water treatment including sludge treatment| production mix, at plant| 1m3 of waste water treated {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	f5ec4a19-70da-406d-be31-a7eeef2f8372	2	2	2	2	2	
	Waste packaging materials		kg	*Waste packaging materials*	-							See section 4.2.10.3

	Process name	Unit of measurement (output)	Default				UUID	Default DQR				
			R_1	Amount per kg	Dataset	Dataset source		P	TiR	GR	TeR	Total
2Loose fill cellulose insulation	*Waste newspaper| virgin and recycled content| consumption mix| {EU-28+3} [Unit process, single operation]*	*kg*	*Erecycled - Cellulose is 100 % based on recycled newspaper, R1=1.*	*primary data*	*Sorting paper| | consumption mix| {EU-28+3} [Unit process, single operation]*	*data gap*	*data gap*					
	Waste newspaper| virgin and recycled content| consumption mix| {EU-28+3} [Unit process, single operation]	*kg*	*Ev - as per PEFCR Cellulose is 100 % based on recycled newspaper. In reality Ev does not exist. But in order to model based on PEF end of life formula Unbleached kraft pulp as Ev, R1=1 shall be used*	*primary data*	*Unbleached kraft pulp, softwood| production mix| at plant| per kg pulp {EU-28+3} [LCI result]*	https://lcdn.quantis-software.com/PEF/	*c0b0db5b-8e01-4aa5-890a-ec01730dc32e*	*1.2*	*1.6*	*2.7*	*2.0*	*1.894*

	Calcium carbonate	*kg*	*Not relevant, R1=0*	*primary data*	*Calcium carbonate production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*616b719c-0787-4329-a076-318e7adad458*	*1*	*2*	*2*	*2*	*1*
	Proxy for Monoammonium dihydrogen phosphat	*kg*	*Not relevant, R1=0*	*primary data*	*Monoammonium phosphate| at plant| per kg {EU-28+3} [LCI result]*	https://lcdn.quantis-software.com/PEF/	*e3b700fe-e5a8-456e-b23f-77e31a96efe2*	*2.1*	*2.4*	*2.5*	*2.6*	*2.392*
	Proxy for Sulphated aluminium oxide	*kg*	*Not relevant, R1=0*	*primary data*	*Aluminium sulphate powder production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*ab02995c-cbd5-4d04-8968-461f7d3310c0*	*2*	*1*	*2*	*2*	*2*
	Boric acid	*kg*	*Not relevant, R1=0*	*primary data*	*Boric acid, powder production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*91ec3218-7221-454a-8904-d8112ff78d3a*	*2*	*2*	*1*	*2*	*2*
	Magnesium Sulphate	*kg*	*Not relevant, R1=0*	*primary data*	*Magnesium sulfate| at plant| per kg {EU-28+3} [LCI result]*	https://lcdn.quantis-software.com/PEF/	*bb83a61d-11a6-4385-8084-04324725ff85*	*2.1*	*2.5*	*2.4*	*2.6*	*2.392*
	proxy for linseed oil	*kg*	*Not relevant, R1=0*	*primary data*	*Linseed production| technology mix, production mix| at farm| {EU+28} [LCI result]*	http://lcdn.blonkconsultants.nl	*a9cf33ea-26e0-45c3-b8da-7129cd353a97*	*2*	*1*	*1*	*2*	*1.88*
	proxy for Triphosphates	*kg*	*Not relevant, R1=0*	*primary data*	*Sodium tripolyphosphate production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*92be727d-d244-415c-b207-acd19462c0c6*	*2*	*1*	*2*	*2*	*2*

	proxy for Calcium phosphate	*kg*	*Not relevant, R1=0*	*primary data*	*Sodium phosphate production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*cafbb6ae-42e4-4020-bc57-06a7cca9583c*	*2*	*1*	*2*	*2*	*2*
	proxy for Aluminium hydroxide	*kg*	*Not relevant, R1=0*	*primary data*	*Aluminium sulphate powder production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*ab02995c-cbd5-4d04-8968-461f7d3310c0*	*2*	*1*	*2*	*2*	*2*

The foreground emissions of PM10 (or PM2.5) shall be measured by each company and included in the modelling of the cellulose production process.

5.10.2 List of processes expected to be run by the company

The only processes expected to be run by the company is the transport of raw materials and/or the transport of the product to the site. In case these processes are run by the company applying this PEFCR, then the following tables shall be filled in. The table shall be filled in for each typology of transport (truck, material, etc). For the various transport types, the datasets as defined in section 4.2.5 shall be used.

	Requirements for data collection purposes			**Requirements for modelling purposes**								**Remarks**
	Activity data to be collected	*Specific requirements (e.g. frequency, measurement standard, etc)*	*Unit of measure*	*Default dataset to be used*	*Dataset source (i.e. node)*	*UUID*	*TiR*	*GR*	*TeR*	*P*	*DQR*	
Transport	**Inputs**											
	Distance	Average year	km	*The most appropriate transport dataset among those available in the corresponding EF-node*	http://lcdn.thinkstep.com/Node/							
	Utilisation rate	Average year	%									

5.11 Data gaps

List of data gaps:

- Sorting of wood, paper and metals
- Infrastructure of sorting plant
- Infrastructure for insulation factory: conveyor belt
- Copper used in infrastructure

All the data gaps are also reported in the Excel file "PEFCR thermal insulation_life cycle stages" available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm and shall be excluded.

5.12 Data quality requirements

The horizontal rules (4.1.4) shall be applied.

5.12.1 Substitution of secondary datasets

The horizontal rules (4.1.4.6) shall be applied.

5.12.2 Re-calculation of the DQR values

The horizontal rules (4.1.4.2) shall be applied.

5.13 Additional environmental information

5.13.1 Reduced heat demand

The horizontal rule (4.3.1) shall be applied.

The Uc value of the non-insulated pitched roof shall equal 3.77 W/m²K (R_T value of 0.45 m²K/W).

5.13.2 Temporary effects of carbon storage and delayed emissions

The horizontal rule (4.3.2) shall be applied.

5.14 Life cycle stages

The details of all the information to be provided to model each life cycle stage, and the secondary datasets to be used, are available in the Excel file "PEFCR thermal insulation_life cycle stages" downloadable at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm.

In case one or more of the datasets needed to model a life cycle stage are not available among those included in the excel file, the applicant shall identify an appropriate dataset according to the procedure in section 4.1.4.6.

5.14.1 Raw materials acquisition for the thermal insulation product

The horizontal rules (4.2.1) shall be applied.

In case the insulation is put between the rafters and the results of a PEF study carried out in compliance with this PEFCR are used **to make comparisons/comparative assertions** (being them against the benchmark or against other thermal insulation products), then the amount (kg) of insulation between the rafters shall be calculated as follows: 92.5% x (insulation thickness (0.14 max)) m x density insulation (kg/m³).

In case the insulation is put between the rafters and the results of a PEF study carried out in compliance with this PEFCR are **not** used **to make comparisons/comparative assertions**, the calculation method for the amount (kg) of insulation shall be transparently reported and verified.

5.14.2 Raw materials acquisition for ancillary products

The following ancillary products shall be considered in the build-up of the pitched roof with massive timber rafters:

- Necessary fixings for the installation of the thermal insulation,
- Additional extensions (Oriented Standard Board) of the rafters to allow for insulation thicknesses larger than 14 cm if the insulation is put between the rafters (if needed),
- Vapour barrier,
- Sublayer.

Infrastructure needed for the raw materials acquisition for ancillary products shall be included. If this is lacking in the secondary dataset used for the raw material acquisition, the following assumption shall be taken: “Building, reinforced steel frame construction” with an amount of 7.26E-03 kg per kg of product, except for the manufacturing of galvanized steel. For the latter, the following infrastructure shall be accounted for: dataset “Building, reinforced concrete frame construction”, with an amount of 1.21E-01 kg per kg of galvanized steel.

Name of the process*	***Default amount kg per kg***	***Default dataset to be used***	***Dataset source***	***UUID***	***Default DQR***				***Overall quality***	***Most relevant process [Y/N]***
					P	*TiR*	*GR*	*TeR*		
Infrastructure for the raw materials acquisition for ancillary products	*7.26E-03*	*Infrastructure_Building, steel frame construction (1 m³ gross volume = 125 kg) | steel frame construction | single route, at plant | material quantities adjustable {GLO} [Unit process, single operation]*	*http://lcdn.thinkstep.com/Node/*	*55fed168-e828-45fb-aecb-a3d73672bb2a*	*2*	*1*	*2*	*2*	*2*	*N*
Infrastructure for Manufacturing of galvanized steel	*1.21E-01*	*Building, reinforced concrete frame construction (1 m³ gross volume = 242 kg) | reinforced concrete frame production | single route, at plant | material quantities adjustable {GLO} [Unit process, single operation]*	*http://lcdn.thinkstep.com/Node/*	*36a74991-0d96-46b5-b75b-3a96dcfc5a03*	*2*	*1*	*2*	*2*	*2*	*N*

5.14.3 Logistics

The horizontal rules (4.2.5) shall be applied.

5.14.3.1 Transport of the raw materials for the thermal insulation product

The horizontal rules (4.2.5.1) shall be applied.

5.14.3.2 Transport of the raw materials for the other ancillary products

The horizontal rules (4.2.5.2) shall be applied.

5.14.3.3 Transport of the packaging to be used for the thermal insulation product

The horizontal rules (4.2.5.3) shall be applied.

5.14.4 Manufacturing of the insulation product (gate to gate)

The Bill of Material (BOM) – including activity data related to energy and other resources - for each thermal insulation product used in the pitched roof with massive timber rafters shall include at least the following information per functional unit (m^2 of roof for the chosen Uc-value)[30]:

Table 23. BoM for loose fill cellulose applied in pitched roof

Input	Unit of measure
Paper - newspaper	kg
Flame retardants	kg
Other additives	kg
Energy for the production	MJ or kWh

The bill of material shall be based on real composition(s) and it shall be the object of verification. In case the BoM for a certain thermal insulation product is subject to periodic changes (e.g. due to price changes in raw materials or different origins of raw materials) then the BoM to be taken into consideration shall properly reflect this variability by taking into account the changes occurred at least during 12 consecutive months in the last 3 years from the date when the PEF study is finalised.

Outputs (emissions, waste, co-products) related to the production process of the thermal insulation product, including the ancillary materials (lubricated oils, etc.), shall be provided. In Table 24 the minimum list of output are listed to be declared. If real values based on measurements on certain emission(s) are not available, then the outputs shall be estimated/approximated based on generic datasets (as provided in the excel file “PEFCR thermal insulation_life cycle stages” downloadable at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm) or any other source of information and shall be justified (including the representativeness of the proxy used). It shall be clearly stated if any of the default set of emissions do not occur. The emissions shall be randomly verified by the verifier.

When generic data are used for heating processes (e.g. diesel, burned) or any other manufacturing process, it shall be checked if certain emissions are not double counted.

[30] A more detailed BOM is acceptable.

Table 24. Output for all insulation products in pitched roof application. *only one of them shall be measured.

Output	Unit of measure
Emissions to air	
Acetaldehyde	kg
Acetone	kg
Amino compounds	kg
Ammonia	kg
Carbon dioxide	kg
Carbon monoxide	kg
Chloride	kg
Dimethyl ether	kg
~~Dust/particles > 10 um~~	~~kg~~
Ethanol	kg
Fluoride	kg
Fluorine	kg
Formaldehyde	kg
Heavy metals, unspecified	kg
Hydrogen fluoride	kg
Hydrogen sulfide	kg
Methanol	kg
Nitrogen oxides	kg
Pentane	kg
Particulates, unspecified	kg
Particulates, PM2.5*	kg
Particulates, PM10*	kg
Phenol	kg
Sulphur oxides	kg
VOC/TOC, volatile organic compounds	kg
Water vapour	kg
Emissions to water	
BOD5	kg
COD	kg
Formaldehyde	kg
Phenol	kg
Hydrocarbons	kg
Suspended substances	kg
Waste flows	
Waste water	kg
Hazardous waste	kg
Inert waste	kg

Metallic agrafe (e.g. clips, staples)	kg
Mixed plastics	kg
Mixed waste	kg
Municipal solid waste	kg
Non-hazardous waste	kg
Paper	kg
Broken pallets	kg
Cardboard	kg
Wires	kg

Infrastructure shall be included for the manufacturing stage according to the requirements in section 5.14.14.

5.14.5 Manufacturing of the ancillary products for the build up

The following ancillary products shall be considered in the build-up of the pitched roof with massive timber rafters:

- Necessary fixings for the installation of the thermal insulation,
- Additional extensions (Oriented Standard Board) of the rafters to allow for insulation thicknesses larger than 14 cm if the insulation is put between the rafters (if needed),
- Vapour barrier,
- Sublayer.

For the modelling of these ancillary products, see excel file "PEFCR thermal insulation_life cycle stages" downloadable at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm.

Infrastructure needed for the manufacturing of the ancillary products shall be included. If this is lacking in the secondary dataset used, the following assumption shall be taken: "Building, reinforced steel frame construction – UUID: 55fed168-e828-45fb-aecb-a3d73672bb2a" with an amount of 7.26E-03 kg per kg product.

5.14.6 Packaging of the final product (cradle to gate)

The horizontal rules (section 4.2.6) shall be applied.

If no specific data is available regarding the packaging of the final product, the following default values shall be used.

Table 25. packaging activity data to be used.

Name	Amount per kg	Unit
PE film	0.00373	kg
PE film bag	0.00394	kg
Wooden Pallets (25 times reuse for the pallets to be considered)	0.00400	kg
Density of transported compressed product is equal to 250 kg/m^3		

5.14.7 Transport from production site to construction site

The horizontal rules (section 4.2.5.4) shall be applied.

5.14.8 Installation

The horizontal rules (section 4.2.7) shall be applied.

The loose fill cellulose insulation is applied into the construction by a machine. Therefore, the energy consumption of the blowing or spraying machine is considered. The electricity consumption for the dry blowing process of 1kg of insulation cellulose product is equal to 9,21E-04 MJ/kg.

For the electricity mix, the horizontal rules (section 4.1.6) shall be applied.

5.14.9 Use, maintenance and refurbishment

In standard conditions and if correctly applied, thermal insulation products applied in the pitched roof do not require maintenance, repair, replacements or refurbishment during the reference service life (RSL) of 50 years.

In case these standard conditions are not met, the horizontal rules (section 4.2.8) shall be applied.

5.14.10 Calculation of the number or replacements:

The horizontal rules (section 4.2.8.1) shall be applied.

5.14.11 Demolishing or dismantling

The horizontal rules (section 4.2.9) shall be applied.

5.14.12 Transport to the End of Life

The horizontal rules (section 4.2.5.5) shall be applied.

5.14.13 End of Life stage

5.14.13.1 Sorting

The horizontal rules (section 4.2.10.1) shall be applied.

For the calculation of the amount handling in the sorting plant (referring to the diesel consumed for loading and unloading of the sorted waste), the kg of material per m^3 of waste needs to be determined. This is determined by the density of the products (see section 4.2.10.1). For the thermal insulation products, the specific density shall be used. Following densities shall be assumed for the ancillary materials:

- Rafters (timber): 500 kg/m³
- Fixings (galvanised steel): 7850 kg/m³
- Extensions (OSB III): 730 kg/m³
- Vapour barrier: 350 kg/m³
- Sublayer (wind/water proofing): 350 kg/m³
- Packaging: 1000 kg/m³

5.14.13.2 End of Life scenarios for thermal insulation products

The horizontal rules (section 4.2.10.2) shall be applied.

5.14.13.3 End of Life scenarios for packaging materials

The horizontal rules (section 4.2.10.3) shall be applied.

5.14.13.4 End of Life scenarios for other materials

The horizontal rules (section 4.2.10.4) shall be applied.

5.14.13.5 End-of-life assumptions

The horizontal rules (section 4.2.10.5) shall be applied.

5.14.14 Infrastructure

The horizontal rules (section 4.2.11) shall be applied.

6 Vertical rules for application in non-accessible flat roofs with concrete structure

The vertical rules shall be used when performing a PEF study on an application (and thermal insulation product) claimed to be in compliance with this PEFCR. Whenever the vertical rules conflict the horizontal rules, the latter prevails over the former.

6.1 Scope

The vertical rules for the non-accessible flat roof with concrete structure are valid for the following thermal insulation products:

Product	Reference
Unfaced cellular glass board	EN 13167: 2015
Unfaced EPS grey board	EN 13163: 2015
Faced PU board	EN 13165: 2015

Thermal insulation products that already incorporate common elements, or the installation of which does not require certain common elements are excluded from the scope. Tapered thermal insulation products are not in the scope of this PEFCR.

6.2 Product classification (NACE/CPA)

See section 3.1.

6.3 Representative product

6.3.1 Build-up system assumptions

The scope of the non-accessible flat roof consists of a conventional roof with concrete structure. The baseline build up is shown in Figure 11.

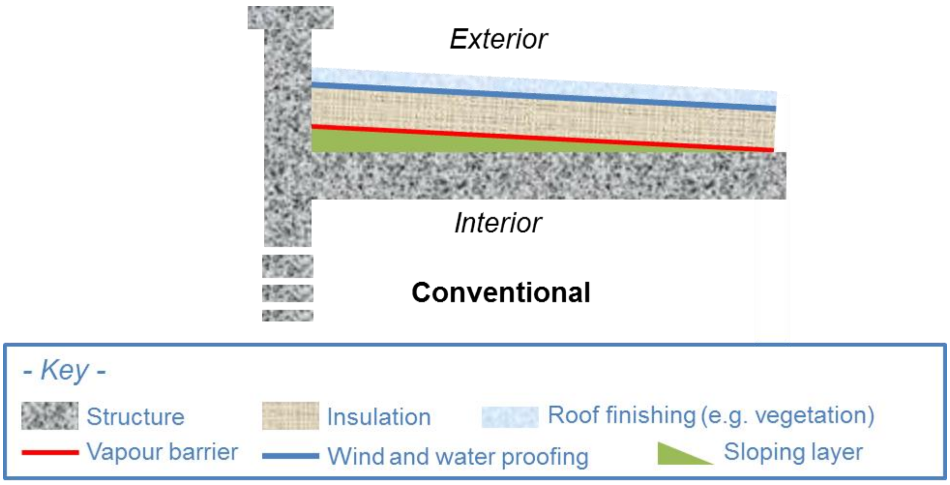

Figure 11: Default cross section of the non-accessible conventional flat roof (baseline build-up).

The build-up shall be described according to the information requested in Table 26. The calculation of the inventory flows specific to the build-up shall be calculated according to the corresponding horizontal rules available in the sections 4.2.2, 4.2.5.2 and 4.2.4.

Table 26. Specific build-up system assumptions for flat roof

Build-up products or processes	Default value	Unit
Insulation	Depends on the insulation thickness	kg/m²
Fixing of cellular glass: hot bitumen	5	kg/m²
Fixing of EPS and PU: glue (PU)	0.2	kg/m²
If needed:		
Fixing: hot bitumen	5	kg/m²
Heating of bitumen*	1.25	kWh/m²
Fixing of insulation: glue (PU)	0.2	kg/m²
Fixing of water proofing layer: glue (PU)	0.2	kg/m²
Fixing of vapour barrier: glue (PU)	0.2	kg/m²
Vapour barrier: bitumen seal, glass fleece	2.85	kg/m²

* The heating of bitumen shall be modelled in the life cycle stage 'Installation'.

The following parts shall be included in the modelling for the flat roof application**:**

- Thermal insulation products, including packaging,
- Necessary fixings for the installation of the thermal insulation,
- Vapour barrier, if needed;
- Fixing of the vapour barrier;
- Fixing of the water proofing.

The following parts shall be excluded from the scope, as they are not influenced by the insulation layer (i.e. are used regardless of the type of thermal insulation products):

- Interior finishing,
- Concrete structure, including slope;
- Water proofing,
- Additional roof finishing (paving, green roof, etc.).

Figure 12 shows the parts that are included and excluded from the scope. The parts excluded are indicated in a dark colour.

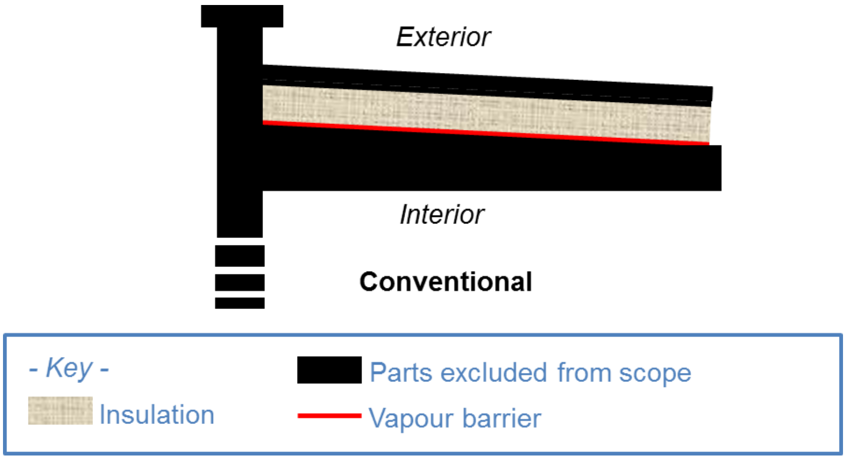

Figure 12: Default Scope of the PEFCR for the conventional flat roof.

If the results of a PEF study carried out in compliance with this PEFCR are used **to make comparisons/comparative assertions** (being them against the benchmark or against other thermal insulation products), then the following specific build-up shall be used and shall not be changed: reinforced concrete structure of 12 cm thickness with a lambda value of 2.100 W/m·K and a sloping layer in light weight concrete with an average thickness of 5 cm and a lambda value of 1.350 W/m·K and in line with the specific build-up assumptions of Table 26. The water proofing fixing and the vapour barrier (including fixings) shall be those listed in the Excel file "PEFCR thermal insulation_life cycle stages" (sheet raw material acquisition other) available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm.

If the results of a PEF study carried out in compliance with this PEFCR are used to calculate and communicate the PEF-profile of a thermal insulation product used in a flat roof (**without comparison/comparative assertions**), then the specific build-up might be adapted. In this case, the adapted build-up assumptions shall be clearly defined and shall be verifiable. In case the concrete floor in the baseline build-up is changed, the impact of the structural layer shall be included

The following requirements shall be fulfilled:

- The parts of the build-up that are excluded from the scope when taking into consideration the baseline build-up (see below) shall remain excluded, except for the structural layer;
- The thermal transmittance (Uc-value) shall be calculated for the flat roof. The Uc-value does not relate solely to the insulation material, but refers to the complete build-up (including the parts outside the scope).

The final thermal performance of the building element shall be in the range of the variation as defined in the functional unit (see E.3). The exact performance shall be calculated using the real thickness of the insulation product in the building element (using EN ISO 6946), and this value shall be used throughout the PEF study.

6.4 Functional unit

The functional unit of the thermal insulation in the flat roof with concrete structure is defined as:

"The thermal insulation of 1m^2 of a non-accessible flat roof with concrete structure, with an insulation thickness that gives a thermal transmittance Uc of the flat roof between 0.33 and 0.10 W/m²K, with a design life span of 50 years".

In case of benchmarking, the value for the thermal transmittance Uc of the flat roof mentioned in the functional unit shall be at least and as close as possible to 0.14 W/m²K.

The function(s)/service(s) provided:	A thermal insulation product applied in a non-accessible flat roof build-up as defined in Section 6.3.1. The product may only be applied above the concrete structure.
The extent of the function or service:	The amount of product needed to insulate 1 m^2 of the defined flat roof, including all ancillary materials required for fixings, vapour barrier, water proofing.
The expected level of performance:	An insulation thickness that gives a thermal transmittance Uc of the flat roof between 0.33 and 0.10 $W/(m^2.K)$ during its application over the service life of the roof.
The Reference Service Life (RSL) of the product:	50 years based on the expected average design life of the building.[8] - [11]

6.4.1 The reference service life of the product

The horizontal rule (section 3.3.1) shall be applied.

In addition, it is assumed that the reference service life of the water proofing (EPDM or bitumen) is 20 years (based on “BCIS (2006) Life Expectancy of Building Components – Surveyors’ experiences of buildings in use: A practical guide” – median typical life).

It is furthermore assumed that additional water proofing layers will be installed on top of the existing one and hence the water proofing layer does not need to be removed. In consequence, there is no need to replace the thermal insulation product during the design life span of the roof (50 years).

6.5 System boundaries – life cycle stages and processes

The horizontal rules (section 3.4) shall be applied.

6.6 EF impact assessment

See section 3.5.

6.7 Most relevant impact categories

The most relevant impact categories for pitched roof are the following:

- Climate change (37.9% of the total weighted impact, excluding toxicity)
- Resource use, fossil (28.7% of the total weighted impact, excluding toxicity)
- Particulate matter (12.4% of the total weighted impact, excluding toxicity)
- Photochemical ozone formation, human health (8.6% of the total weighted impact, excluding toxicity)

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.

6.8 Most relevant life cycle stages

The most relevant life cycle stages for flat roof are the following:

- Raw material acquisition for the insulation product;
- Raw material acquisition for the ancillary products;
- Manufacturing of the insulation product;
- Transport from production site to the construction site;
- End-of-life treatment of the thermal insulation product.

Table 27 shows the link between the most relevant impact categories and the life cycle stages where they happen.

Table 27. Contribution of the different life cycle stages to the most relevant impact categories for flat roof (characterised results).

		Life cycle stage				
		Raw material acquisition for insulation product	**Raw material acquisition for ancillary products**	**Manufacturing of the insulation product**	**Transport from production site to the construction site**	**End-of-life treatment**
Impact category	**Climate Change**	33.44%	8.96%	20.84%	9.74%	8.73%
	Photochemical ozone formation, human health	11.96%	46.49%	16.14%	7.35%	
	Particulate matter	75.03%	6.43%			
	Resource use (fossils)	34.35%	15.64%	14.38%	4.95%	12.34%

* the percentages refer to the characterised results.

6.9 Most relevant processes

Table 28 lists the processes identified as "most relevant" for thermal insulation product(s) used for a pitched roof with massive timber rafters. If a process is not included in Table 28 it means that it shall be considered as "other process" in the DNM matrix (see Table 6). The applicant shall declare which of these processes are under its operational control (Situation 1 of the Data Need Matrix, see Table 6).

Table 28. Most relevant processes for flat roofs

Life cycle stage	Most relevant processes	Impact categories affected			
		Climate change	**Photochemical ozone formation, human health**	**Particulate matter**	**Resource use (fossils)**
Raw materials acquisition for the insulation products	Polyurethane rigid foam production	14.11%	4.84%	4.94%	12.53%
	EPS beads production	13.96%	4.66%	2.75%	15.84%
	Polyester polyols production	5.37%	2.45%	1.44%	5.98%
	Feldspar (mining, open pit)			65.89%	

Raw materials acquisition for ancillary products	Bitumen adhesive compound production	5.68%	44.25%	2.86%	15.64%
	Methylene diphenyldiisocyanate production	3.28%	2.24%	3.57%	
Manufacturing of the insulation product	Thermal energy from natural gas	12.38%			7.13%
	Electricity	6.09%			7.25%
	Manufacturing of the EPS insulation product		16.14%		
	Waste incineration of plastics	2.37%			
Transport from production site to construction site**	Articulated lorry transport, Euro 4, Total weight >32 t (for EPS)	3.73%	4.07%		
	Articulated lorry transport, Euro 4, Total weight >32 t (for PU)	3.02%	3.28%		
	Articulated lorry transport, Euro 4, Total weight >32 t (for cellular glass)	1.24%			
	Diesel mix at filling station	1.75%			4.95%
End of life treatment	Waste incineration of PU	5.18%			2.58%
	Waste incineration of PS	3.55%			
	Waste incineration of plastics				9.76%

* the contributions shown in % refers to the characterised results per impact category

** the utility rate parameter differs due to different volumes of the insulation materials. It is 0,039707256, volume based for EPS and 0,084708813 volume based for PU.

6.10 Life cycle inventory

All newly created datasets shall be EF-compliant.

6.10.1 List of mandatory company-specific data

The following processes shall be under the operational control of the company implementing this PEFCR:

- The production process of the thermal insulation product (unfaced cellular glass board, unfaced EPS grey board, or faced PU board).

This means that no PEF study compliant with this PEFCR may be carried out without providing the company specific data listed in the tables below.

Data collection requirements for unfaced EPS grey board

	Requirements for data collection purposes			Requirements for modelling purposes								Remarks
	Activity data to be collected	*Specific requirements (e.g. frequency, measurement standard, etc)*	*Unit of measure*	*Default dataset to be used*	*Dataset source (i.e. node)*	*UUID*	*TiR*	*GR*	*TeR*	*P*	*DQR*	
EPS	Inputs:											
	Yearly tap water use	Average year	kg water/year	*Dummy de-ionised water*	-							
	Yearly diesel consumption	Average year	kg	*Diesel mix at filling station| from crude oil and bio components| consumption mix, at filling station| 7.23 wt.% bio components {EU-27} [LCI result]*	http://lcdn.thinkstep.com/Node/	e5c14d1c-9e2e-49eb-82b4-566e5265b18e	Not evaluated					proxy for Diesel, burned in building machine, conversion factor : 46,5 GJ/tonne
		Average year	kg	*Diesel combustion in construction machine | diesel driven | {GLO} [Unit process, single operation]*	http://lcdn.thinkstep.com/Node/	dae81b4f-688f-44cd-906b-9435d3843e65	2	2	3	2		
	Yearly natural gas use	Average year	MJ	*Thermal energy from natural gas| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]*	http://lcdn.thinkstep.com/Node/	81675341-f1af-44b0-81d3-d108caef5c28	1	1	1	2	1	Natural gas and proxy for propane
	Yearly light fuel oil use	Average year	MJ	*Thermal energy from light fuel oil (LFO)| technology mix regarding firing*	http://lcdn.thinkstep.com/Node/	e7510ad9-4bfa-4113-94b0-426e5f430c98	1	1	1	2	1	

				and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]								
	Yearly electricity use	Average year	kWh/year	*Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, to consumer| 1kV - 60kV {Country specific} [LCI result]*	http://lcdn.thinkstep.com/Node/	34960d4d-af62-43a0-aa76-adc5fcf57246	1	1	1	2	1	
	Outputs:											
	Yearly waste generation		kg	*Landfill of plastic waste| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	f2bea0f5-e4b7-4a2c-9f34-4eb32495cbc6	2	2	2	2	2	
	Waste packaging materials			*Waste packaging materials*	-							See section 4.2.10.3
	Emissions/resources:											
	Primary data	_	kg	*Pentane*								
	Primary data	_	kg	*Water*								

	Process name*	Unit of measurement (output)	Default				UUID	Default DQR				
			R_1	Amount per kg	Dataset	Dataset source		P	TiR	GR	TeR	Total
EPS	*Expandable polystyrene grey beads (virgin content)*	*kg*	*R1 = 0,02 A=0,5*	*primary data*	*EPS Beads| from styrene polymerization and foaming| production mix, at plant| 0.96- 1.04 g/cm3 {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	*bd1d3154-8fca-43e8-a40a-1113c1135689*	*2*	*1*	*1*	*1*	*1*
EPS	*EPS recycled content from packaging.*	*kg*		*primary data*	*Plastic granulate secondary (low metal contamination) | from post-consumer plastic waste, via grinding, metal separation, washing, pelletization | production mix, at plant | plastic waste with low metal fraction {EU-28} [Partly terminated system]*	http://lcdn.thinkstep.com/Node/	*3b801715-5e3f-426f-8b24-a84dbd4f3165 2 1 1 3 2*					

Data collection requirements for faced PU board

	Requirements for data collection purposes			Requirements for modelling purposes								Remarks
	Activity data to be collected	***Specific requirements (e.g. frequency, measurement standard, etc)***	***Unit of measure***	***Default dataset to be used***	***Dataset source (i.e. node)***	***UUID***	***TiR***	***GR***	***TeR***	***P***	***DQR***	
PU Insulation	Inputs:											
	Yearly tap water use	Average year	kg water/year	*Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result]*	https://lcdn.quantis-software.com/PEF/	212b8494-a769-4c2e-8d82-9a6ef61baad7	2	2	2	2	2	
	Yearly diesel consumption	Average year	kg	*Diesel mix at filling station| from crude oil and bio components| consumption mix, at filling station| 7.23 wt.% bio components {EU-27} [LCI result]*	http://lcdn.thinkstep.com/Node/	e5c14d1c-9e2e-49eb-82b4-566e5265b18e	Not evaluated					proxy for Diesel, burned in building machine, conversion factor : 46,5 GJ/tonne
		Average year	kg	*Diesel combustion in construction machine | diesel driven | {GLO} [Unit process, single operation]*	http://lcdn.thinkstep.com/Node/	dae81b4f-688f-44cd-906b-9435d3843e65	2	2	3	2		
	Yearly natural gas use	Average year	MJ	*Thermal energy from natural gas|*	http://lcdn.thinkstep.com/Node/	81675341-f1af-44b0-81d3-d108caef5c28	1	1	1	2	1	Natural gas and proxy for propane

				technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]								
	Yearly light fuel oil use	Average year	MJ	*Thermal energy from light fuel oil (LFO)| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]*	http://lcdn.thinkstep.com/Node/	e7510ad9-4bfa-4113-94b0-426e5f430c98	1	1	1	2	1	
	Yearly LPG use		MJ	*Thermal energy from LPG| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]*	http://lcdn.thinkstep.com/Node/	ade98dea-0c74-4ebb-94ef-f9686eb0ddc5	1	1	1	2	1	
	Yearly electricity use	Average year	kWh/year	*Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, to consumer| 1kV*	http://lcdn.thinkstep.com/Node/	34960d4d-af62-43a0-aa76-adc5fcf57246	1	1	1	2	1	

				- 60kV {Country specific} [LCI result]								
	Outputs:											
	Yearly waste generation		kg	*Waste incineration of plastics (unspecified)| waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment| production mix, at consumer| unspecified plastic waste {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	8137b889-a1d8-4109-8aa7-e2aaee38fa5f	1	1	2	2	1	
	Waste packaging materials		kg	*Waste packaging materials*	-							See section 4.2.10.3
	Emissions/resources:											
	Primary data	_	kg	*Pentane*								
	Primary data	_	kg	*Carbon dioxide, fossil*								

	*Process name**	*Unit of measurement (output)*	*Default*				*UUID*	*Default DQR*				
			R_1	*Amount per kg*	*Dataset*	*Dataset source*		*P*	*TiR*	*GR*	*TeR*	*Total*
PU Insulation	*Pentane*			*primary data*	*Pentane production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/ -	*18646e52-3f27-43de-81bb-68b82ba1538c*	*2*	*1*	*2*	*2*	*2*
	Polyurethane rigid foam			*primary data*	*Polyurethane rigid foam| from methylene diisocyanate (MDI) and polyols| production mix, at plant| 18- 53 kg/m3 {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	*1dfca12a-63dc-43bf-9263-cdfe3c972d89*	*2*	*2*	*1*	*1*	*1*
	Polyester polyols			*primary data*	*Polyester polyols| polycondensation| production mix, at plant| Hydroxyl value: 150-360, aromatic content: 5-50% {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	*c0f6557a-7df9-49b8-a11c-a4dcabd52b38*	*2*	*3*	*2*	*2*	*2*
	Additives			*primary data*	*Data Gaps*							
	Raw materials acquisition for the PU foam facing		*R1=0 A=05*	*primary data*	*HDPE granulates| Polymerisation of ethylene| production mix, at plant| 0.91- 0.96 g/cm3, 28 g/mol per repeating unit {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	*a3aefe5b-33c9-4f0c-87ec-d0291445cc61*	*1*	*2*	*1*	*1*	*1*

	Raw materials acquisition for the PU foam facing		*R1=0 A=05*	*primary data*	*Kraft paper, unbleached| production mix| at plant| per kg paper {EU-28+3} [LCI result]*	https://lcdn.quantis-software.com/PEF/	*9431095e-9602-4714-b99d-276ed71e7b7d*	*2.58*	*2.01*	*2.01*	*2.01*	*2*
	Raw materials acquisition for the PU foam facing		*R1=0 A=05*	*primary data*	*Epoxy resin production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*70db8519-2614-452c-a305-df1b0ed36c9c*	*2*	*1*	*2*	*2*	*2*
	Raw materials acquisition for the PU foam facing		*R1=0 A=05*	*primary data*	*Acrylic varnish| production mix| at plant| per kg varnish {EU-28+3} [LCI result]*	https://lcdn.quantis-software.com/PEF/	*e1552bfa-5f14-4988-bc54-9b716e619d0f*	*2*	*2*	*2*	*2*	*2*
	Raw materials acquisition for the PU foam facing		*R1=0 A=05*	*primary data*	*Urea-formaldehyde resin production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*68f33810-f063-4f61-899a-ea2bf18b5a46*	*2*	*1*	*2*	*2*	*2*
	Aluminium| virgin content| per kg		*R1=0 A=0,2*	*primary data*	*Aluminium ingot mix | primary production | consumption mix, to consumer | aluminium ingot product, primary production {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	*dd93261c-d6da-44ec-a842-78b4a42c2884*	*2*	*1*	*2*	*2*	*N/A*
	Aluminium| recycled content| per kg		*R1=0 A=0,2*	*primary data*	*Aluminium die-casting| secondary production, aluminium casting| single route, at plant| 2.7 g/cm3*	http://lcdn.thinkstep.com/Node/	*4ba6325f-7ae3-47ef-807b-9ea88269715f*	*3*	*2*	*3*	*3*	*2*

					{EU-28+EFTA} [LCI result]							
	Glass| virgin content| per kg		R1=0 A=05	primary data	Glass fibres| production mix| at plant| per kg glass fibres {EU-28+3} [LCI result]	https://lcdn.quantis-software.com/PEF/	20350b04-54e6-4298-9d61-c7722faa11f3	2	2	2	2	2
	Glass| recycled content| per kg		R1=0 A=05	primary data	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 {EU-27} [LCI result]	http://soda.rdc.yp5.be/processList.xhtml?stock=FEVE	20350b04-54e6-4298-9d61-c7722faa11f3	2.1	2.3	2.1	2.1	2,1

Data collection requirements for unfaced cellular glass board

	Requirements for data collection purposes			Requirements for modelling purposes								Remarks
	Activity data to be collected	***Specific requirements (e.g. frequency, measurement standard, etc)***	***Unit of measure***	***Default dataset to be used***	***Dataset source (i.e. node)***	***UUID***	***TiR***	***GR***	***TeR***	***P***	***DQR***	
Cellular Glass	Inputs:											
	Yearly tap water use	Average year	kg water/year	*Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result]*	https://lcdn.quantis-software.com/PEF/	212b8494-a769-4c2e-8d82-9a6ef61baad7	2.42	2.025	2.038	2.02	2.12	
	Yearly additives used	Average year	kg	*Bauxite (mining)| mining and processing| production mix, at mine| minerals gibbsite Al(OH)3, boehmite γ-AlO(OH) and diaspore α-AlO(OH) {GLO} [LCI result]*	http://lcdn.thinkstep.com/Node/	9c4e9a34-107d-466d-b609-66a3815a9cde	2	2	1	1	2	
		Average year	kg	*Carbon black, general purposes production| technology mix| production mix, at plant| 100% active*	http://ecoinvent.lca-data.com/	fde4abff-7cd7-4535-b472-481321d7d936	1	2	1	2	1	

				substance {RER} [LCI result]								
		Average year	kg	*Stainless steel cold rolled| hot rolling| production mix, at plant| stainless steel {ROW} [LCI result]*	http://lcdn.thinkstep.com/Node/	e07e4743-1ae6-407d-92c7-3fd62dc966e4	3	2	2	2	2	
		Average year	kg	*Kaolin production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	f57ebfdb-d033-4e45-aa13-25bbd71bb3e3	1	1	1	2	2	
		Average year	kg	*Dummy clay (ball mill)*	-							
	Yearly diesel consumption	Average year	kg	*Diesel mix at filling station| from crude oil and bio components| consumption mix, at filling station| 7.23 wt.% bio components {EU-27} [LCI result]*	http://lcdn.thinkstep.com/Node/	e5c14d1c-9e2e-49eb-82b4-566e5265b18e	Not evaluated					proxy for Diesel, burned in building machine, conversion factor : 46,5 GJ/tonne
		Average year	kg	*Diesel combustion in construction*	http://lcdn.thinkstep.com/Node/	dae81b4f-688f-44cd-906b-	2	2	3	2		

				machine | diesel driven | {GLO} [Unit process, single operation]		9435d3843e65						
	Yearly natural gas use	Average year	MJ	*Thermal energy from natural gas| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]*	http://lcdn.thinkstep.com/Node/	81675341-f1af-44b0-81d3-d108caef5c28	1	1	1	2	1	Natural gas and proxy for propane
	Yearly light fuel oil use	Average year	MJ	*Thermal energy from light fuel oil (LFO)| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]*	http://lcdn.thinkstep.com/Node/	e7510ad9-4bfa-4113-94b0-426e5f430c98	1	1	1	2	1	
	Yearly electricity use	Average year	kWh/year	*Electricity grid mix 1kV-60kV| AC, technology mix|*	http://lcdn.thinkstep.com/Node/	34960d4d-af62-43a0-aa76-adc5fcf57246	1	1	1	2	1	

				consumption mix, to consumer| 1kV - 60kV {Country specific} [LCI result]								
	Outputs:											
	Yearly waste generation		kg	*Treatment of residential wastewater, small plant| waste water treatment including sludge treatment| production mix, at plant| 1m3 of waste water treated {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	8126980a-29e9-416c-991d-2aa5fdad9062	2	2	2	2	2	
			kg	*Waste incineration of plastics (unspecified) | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment| production mix, at consumer| unspecified plastic waste*	http://lcdn.thinkstep.com/Node/	8137b889-a1d8-4109-8aa7-e2aaee38fa5f	1	1	2	2	1	

				{EU-28+EFTA} [LCI result]								
			kg	*Landfill of inert (glass)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site| {EU-28+EFTA} [LCI result]*	http://lcdn.thinkstep.com/Node/	01196227-0627-440c-9f2f-94b8f1e7d1ad	2	2	2	2	2	
	Waste packaging materials		kg	*Waste packaging materials*	-							See section 4.2.10.3
	Emissions/resources:											
	Primary data	_	kg	*all*								

	Process name*	***Unit of measurement (output)***	***Default***				***UUID***	***Default DQR***				
			R_1	***Amount per kg***	***Dataset***	***Dataset source***		***P***	***TiR***	***GR***	***TeR***	***Total***
Cellular Glass	*proxy for the Glass cullets*		*R1 = 0,49 A=0,5*	*primary data*	*Container glass, ER, Recycled Content 100% (provided by FEVE) - Aggregated | Recycled container glass*	*http://soda.rdc.yp5.be/processList.xhtml?stock=FEVE*	*ab4e945f-9955-4414-b3fb-d42507cc4e2d*	*2*	*2*	*2*	*2*	

					(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 {EU-27} [LCI result]							
	Virgin content (Raw materials aquisition for the CG insulation product| thermal insulation of 1 m² of a building element, flat roof application, virgin content| consumption mix| {EU-28+3} [Unit process, single operation]), modelled as follows:											
	Sand			*primary data*	*Silica sand production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*573168e4-8f9e-46a3-a684-6187deeea33d*	*2*	*1*	*2*	*2*	*2*
	Feldspar			*primary data*	*Feldspar (mining, open pit)| feldspar mining, washing, drying| production mix, at plant| ?2.56 g/cm3 {GLO} [LCI result]*	http://lcdn.thinkstep.com/Node/	*f30a5995-a7dd-4b76-ae27-8aa384c1df7f*	*3*	*2*	*3*	*3*	*2*
	Soda ash (sodium carbonate)			*primary data*	*Soda production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*546d4097-a453-4706-ac17-389325a04b6f*	*2*	*1*	*2*	*2*	*2*

	Iron oxide			*primary data*	*Ferrite (iron ore)| iron ore mining and processing| production mix, at plant| 5.00 g/cm3 {GLO} [LCI result]*	http://lcdn.thinkstep.com/Node/	*483f8675-daf6-4105-b0f7-699c7deb2e84*	*3*	*2*	*3*	*3*	*2*
	Sodium sulphate			*primary data*	*Sodium sulphate production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*a9580b7f-05dc-4015-84ad-af12afc90393*	*2*	*1*	*1*	*2*	*2*
	Sodium nitrate			*primary data*	*Sodium nitrate production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]*	http://ecoinvent.lca-data.com/	*a190aad2-48af-428a-b1e1-f27d10ca3f99*	*1*	*2*	*2*	*2*	*2*

6.10.2 List of processes expected to be run by the company

The only additional process expected to be run by the company is the transport of raw materials and/or the transport of the product to the site. In case these processes are run by the company applying this PEFCR,, then the following tables shall be filled in. The table shall be filled in for each typology of transport (truck, material, etc).

	Requirements for data collection purposes			Requirements for modelling purposes								Remarks
	Activity data to be collected	*Specific requirements (e.g. frequency, measurement standard, etc)*	*Unit of measure*	*Default dataset to be used*	*Dataset source (i.e. node)*	*UUID*	*TiR*	*GR*	*TeR*	*P*	*DQR*	
Transport	**Inputs**											
	Distance	Average year	km	*The most appropriate transport dataset among those available in the corresponding EF-node*	http://lcdn.thinkstep.com/Node/							
	Utilisation rate	Average year	%									

6.11 Data gaps

List of data gaps:

- Sorting of wood, paper and metals
- Infrastructure of sorting plant
- Infrastructure for insulation factory: conveyor belt
- Copper used in infrastructure
- PU additives (life cycle stage: raw material acquisition)
- Additives in the glue for fixing the PU insulation (life cycle stage: raw material acquisition others)

All the data gaps are also reported in the Excel file "PEFCR thermal insulation_life cycle stages" available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm and shall be excluded.

6.12 Data quality requirements

The horizontal rules (4.1.4) shall be applied.

6.12.1 Substitution of secondary datasets

The horizontal rules (4.1.4.6) shall be applied.

6.12.2 Recalculation of the DQR values

The horizontal rules (4.1.4.2) shall be applied.

6.13 Additional environmental information

6.13.1 Reduced heat demand

The horizontal rule (4.3.1) shall be applied.

The Uc value of the non-insulated flat roof shall equal 4.11 W/m²K (R_T value of 0.24 m²K/W).

6.13.2 Temporary effects of carbon storage and delayed emissions

The horizontal rule (4.3.2) shall be applied.

6.14 Life cycle stages

The details of all the information to be provided to model each life cycle stage, and the secondary datasets to be used, are available in the Excel file "PEFCR thermal insulation_life cycle stages" downloadable at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm

In case one or more of the datasets needed to model a life cycle stage are not available among those included in the excel file, the applicant shall identify an appropriate dataset according to the procedure in section 4.1.4.6.

6.14.1 Raw material acquisition for the thermal insulation product

The horizontal rules (section 4.2.1) shall be applied.

6.14.2 Raw material acquisition for ancillary products

The following ancillary products shall be considered in the build-up of the non-accessible flat roof with concrete structure:

- Necessary fixings for the installation of the thermal insulation,
- Vapour barrier, if needed.

For this life cycle stage the secondary datasets listed in the Excel file "PEFCR thermal insulation_life cycle stages" available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm shall be used. In case one or more of the datasets needed are not among those available, one of the options in section 4.1.4.6 shall be chosen.

6.14.3 Logistics

The horizontal rules (section 4.2.5) shall be applied.

6.14.3.1 Transport of the raw materials for the thermal insulation product

The horizontal rules (section 4.2.5.1) shall be applied.

6.14.3.2 Transport of the raw materials for the ancillary products

The horizontal rules (section 4.2.5.2) shall be applied.

6.14.3.3 Transport of the packaging to be used for the thermal insulation product

The horizontal rules (section 4.2.5.3) shall be applied.

6.14.4 Manufacturing of the insulation product (gate to gate)

The Bill of Material (BOM) for each thermal insulation product used in the flat roof shall include at least the following information per functional unit (m^2 of roof for the chosen Uc-value)[31]:

Table 29. BoM for flat roof application (Unfaced cellular glass board)

Input	Unit of measure
Sand	kg
Feldspar	kg
Iron ore	kg
Sodium carbonate	kg
Sodium sulphate	kg
Sodium nitrate	kg
Recycled flat glass	kg
Glass scrap	kg

[31] A more detailed BOM is acceptable.

Additives: carbon black	kg
Galvanised steel (electrodes oven)	kg
Clay (ball mill)	kg
Aluminium hydroxide	kg
Aluminium silicate	kg
Energy for production	MJ or kWh
Water for production	m³

Table 30. BoM for flat roof application (Unfaced EPS grey board)

Input	Unit of measure
Expandable polystyrene grey beads	kg
Recycled EPS from packaging waste	kg
Energy for production	MJ or kWh
Water for production	m³

Table 31. BoM for flat roof application (Faced PU board)

Input	Unit of measure
MDI	kg
Polyols	kg
Flame retardants	kg
Other additives	kg
Blowing agents (Pentane)	kg
Energy for production	MJ or kWh
Water for production	m³
Facing :	
Aluminium, primary	kg
Aluminium, recycled	kg
Glass, virgin	kg
Glass, recycled	kg
Energy for production	MJ or kWh
Water for production	m³

The bill of material shall be based on real composition(s) and it shall be the object of verification. In case the BoM for a certain thermal insulation product is subject to periodic changes (e.g. due to price changes in raw materials or different origins of raw materials) then the BoM to be taken into consideration shall properly reflect this variability by taking into account the changes occurred at least during 12 consecutive months in the last three years from the date when the PEF study is finalised.

Outputs (emissions, waste, co-products) related to the production process of the thermal insulation product, including the ancillary materials (lubricated oils, etc.), shall be provided. In Table 32 the minimum list of output are listed to be declared. If real values based on measurements on certain emission(s) are not available, then these shall be estimated/approximated based on generic datasets or any other source of information and shall be justified. It shall be clearly stated if any of the default set of emissions do not occur. The emissions shall be randomly verified by the verifier.

When generic data are used for heating processes (e.g. diesel, burned) or any other manufacturing process, it shall be checked if certain emissions are not double counted.

Table 32. Output for all insulation products in flat roof application. *Only one of them shall be measured.

Output	Unit of measure
Emissions to air	
Acetaldehyde	kg
Acetone	kg
Amino compounds	kg
Ammonia	kg
Carbon dioxide	kg
Carbon monoxide	kg
Chloride	kg
Dimethyl ether	kg
~~Dust/particles > 10 um~~	~~kg~~
Ethanol	kg
Fluoride	kg
Fluorine	kg
Formaldehyde	kg
Heavy metals, unspecified	kg
Hydrogen sulfide	kg
Methanol	kg
Nitrogen oxides	kg
Pentane	kg
Particulates, unspecified	kg
Particulates, PM2.5*	kg
Particulates, PM10*	kg
Phenol	kg
Sulphur oxides	kg
VOC/TOC, volatile organic compounds	kg
Water vapour	kg
Waste flows	
Facers waste	kg
HD_PE hood	kg
Lubrication oil	kg
Mixed plastics	kg
PE foil packaging	kg
PU waste	kg
Waste water	kg

Wooden packaging	kg

Infrastructure shall be included for the manufacturing stage according to the requirements in section 6.14.14.

6.14.5 Manufacturing of the ancillary products for the build up

The following ancillary products shall be considered in the build-up of the flat roof with concrete structure:

- Necessary fixings (types which are most often used) for the installation of the thermal insulation,
- Vapour barrier, if needed.

The secondary datasets to be used are those listed in Excel file available "PEFCR thermal insulation_life cycle stages" at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm. In case one or more of the datasets needed are not among those available, one of the options in section 4.1.4.6 shall be chosen.

As packaging of the ancillary products are used in small amounts, these are excluded from the PEF study.

6.14.6 Packaging of the final product

The horizontal rules (4.2.6) shall be applied.

If no specific data is available regarding the packaging of the final product, the following default values shall be used.

Table 33. Packaging activity data to be used.

Name	Amount for EPS grey board	Amount for faced PU board	Amount for unfaced cellular glass board	Unit
PE film	2.33E-02	1.09E-02	8.26E-08	kg
Corrugated board - uncoated	-	-	6.01E-08	kg
Wooden Pallets (25 times reuse for the pallets to be considered)	-	-	7.96E-06	kg

6.14.7 Transport from production site to construction site

The horizontal rules (4.2.5.4) shall be applied.

6.14.8 Installation

The horizontal rules (4.2.7) shall be applied.

Heating of bitumen shall be included in the installation phase. An energy use of 1.25 kWh/m² roof shall be assumed. The dataset "Thermal energy from LPG| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3}" (UUID: 0a068052-5ee2-40f4-9d63-7f62ba1b8b76) shall be used for the heating of bitumen.

6.14.9 Use, maintenance, and refurbishment

In standard conditions and if correctly applied, thermal insulation products applied in the flat roof do not require maintenance, repair, replacements or refurbishment during the reference service life (RSL) of 50 years.

In case these standard conditions are not met, the horizontal rules (section 4.2.8) shall be applied.

6.14.10 Calculation of the number or replacements:

The horizontal rules (section 4.2.8.1) shall be applied.

6.14.11 Demolishing or dismantling

The horizontal rules (4.2.9) shall be applied.

Table 34 Assumptions for the demolition at EoL - Demolishing or dismantling process

Process name & Dataset	***Amount per kg of demolished material***	***Unit of measurement (output)***	***Comments***	***UUID***	***Default DQR***			
					P	*TiR*	*GR*	*TeR*
Diesel combustion in construction machine | diesel driven | {GLO} [Unit process, single operation]	*0.04370/45.6*	*kg*	*conversion factor: 45.6 GJ/tonne*	*dae81b4f-688f-44cd-906b-9435d3843e65*	*2*	*2*	*2*	*2.9*

6.14.12 Transport to End of Life

The horizontal rules (4.2.5.5) shall be applied.

6.14.13 End of Life

6.14.13.1 Sorting

The horizontal rules (4.2.10.1) shall be applied.

For the calculation of the amount handling in the sorting plant (referring to the diesel consumed for loading and unloading of the sorted waste), the kg of material per m³ of waste needs to be determined. This is determined by the density of the products (see section 4.2.10.1). For the thermal insulation products, the specific density shall be used. Following densities shall be assumed for the ancillary materials:

- Fixings: 1000 kg/m³
- Vapour barrier: 350 kg/m³
- Wind/water proofing: 350 kg/m³
- Packaging: 1000 kg/m³

6.14.13.2 End of Life scenarios for thermal insulation products

The horizontal rules (section 4.2.10.2) shall be applied.

For the EoL processes the secondary datasets listed in the Excel file "PEFCR thermal insulation_life cycle stages" available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.htm shall be used. In case one or more of the datasets needed are not among those available, one of the options in section 4.1.4.6 shall be chosen.

6.14.13.3 End of Life scenarios for packaging materials

The horizontal rules (section 4.2.10.3) shall be applied.

6.14.13.4 End of Life scenarios for other materials

The horizontal rules (section 4.2.10.4) shall be applied.

6.14.13.5 End-of-life assumptions

The horizontal rules (section 4.2.10.5) shall be applied.

6.14.14 Infrastructure

The horizontal rules (section 4.2.11) shall be applied.

6.15 PEF results

6.15.1 Benchmark for pitched roofs

Thermal insulations do not generate any impacts during the use stage, therefore the use stage is not relevant.

Table 35 *Characterised values for the pitched roof* representative product

Impact category	Unit of measure	Value
Climate change (total)	kg CO_{2eq}	1.45E+01
- Climate change-biogenic		8.87E+00
- Climate change – land use and land transformation		1.45E-02
Ozone depletion	kg CFC11 $_{eq}$	1.00E-07
Particulate matter	disease incidence	9.06E-07
Ionising radiation, human health	kBq $U^{235}{}_{eq}$	4.42E-01
Photochemical ozone formation, human health	kg $NMVOC_{eq}$	4.09E-02
Acidification	mol $H+_{eq}$	4.57E-02
Eutrophication, terrestrial	mol N_{eq}	1.61E-01
Eutrophication, aquatic freshwater	kg P_{eq}	6.43E-04
Eutrophication, aquatic marine	kg N_{eq}	1.40E-02
Land use	Dimensionless (pt)	2.23E+03
Water use	m^3 $world_{eq}$	4.49E+00
Resource use, fossils	MJ	6.92E+01
Resource use, minerals and metals	kg Sb $_{eq}$	5.48E-05

Table 36 ***Normalised values for the pitched roof*** **representative product**

Impact category	Value*
Climate change	1.87E-03
Ozone depletion	4.28E-06
Particulate matter	1.42E-03
Ionising radiation, human health	1.05E-04
Photochemical ozone formation, human health	1.01E-03
Acidification	8.23E-04
Eutrophication, terrestrial	9.08E-04
Eutrophication, aquatic freshwater	2.52E-04
Eutrophication, aquatic marine	4.96E-04
Land use	1.68E-03
Water use	3.90E-04
Resource use, fossils	1.06E-03
Resource use, minerals and metals	9.47E-04

**expressed in person equivalent*

Table 37 ***Weighted values for the pitched roof*** **representative product**

Impact category	Value
Climate change	4.16E-04
Ozone depletion	2.89E-07
Particulate matter	1.36E-04
Ionising radiation, human health	5.62E-06
Photochemical ozone formation, human health	5.14E-05
Acidification	5.47E-05
Eutrophication, terrestrial	3.55E-05
Eutrophication, aquatic freshwater	7.44E-06
Eutrophication, aquatic marine	1.55E-05
Land use	1.41E-04
Water use	3.52E-05
Resource use, fossils	9.46E-05
Resource use, minerals and metals	7.65E-05
Total impact	1.07E-03

6.15.2 Benchmark for flat roofs

Thermal insulations do not generate any impacts during the use stage, therefore the use stage is not relevant.

Table 38 *Characterised values for the flat roof* representative product

Impact category	Unit of measure	Value
Climate change (total)	kg CO_{2eq}	2.81E+01
- Climate change-biogenic		2.40E-02
- Climate change – land use and land transformation		3.59E-02
Ozone depletion	kg CFC11 $_{eq}$	6.68E-06
Particulate matter	disease incidence	1.75E-06
Ionising radiation, human health	kBq $U^{235}{}_{eq}$	9.39E-01
Photochemical ozone formation, human health	kg $NMVOC_{eq}$	1.45E-01
Acidification	mol $H+_{eq}$	5.87E-02
Eutrophication, terrestrial	mol N_{eq}	2.17E-01
Eutrophication, aquatic freshwater	kg P_{eq}	4.53E-04
Eutrophication, aquatic marine	kg N_{eq}	2.11E-02
Land use	Dimensionless (pt)	1.83E+02
Water use	m^3 $world_{eq}$	4.60E+00
Resource use, fossils	MJ	4.44E+02
Resource use, minerals and metals	kg Sb $_{eq}$	2.80E-05

Table 39 *Normalised values for the flat roof* representative product

Impact category	Value*
Climate change	3.61E-03
Ozone depletion	2.85E-04
Particulate matter	2.74E-03
Ionising radiation, human health	2.23E-04
Photochemical ozone formation, human health	3.58E-03
Acidification	1.06E-03
Eutrophication, terrestrial	1.23E-03
Eutrophication, aquatic freshwater	1.78E-04
Eutrophication, aquatic marine	7.44E-04
Land use	1.37E-04
Water use	4.00E-04
Resource use, fossils	6.80E-03
Resource use, minerals and metals	4.83E-04

**expressed in person equivalent*

Table 40 *Weighted values for the flat roof* representative product

Impact category	Value
Climate change	8.02E-04
Ozone depletion	1.93E-05
Particulate matter	2.62E-04
Ionising radiation, human health	1.19E-05
Photochemical ozone formation, human health	1.82E-04
Acidification	7.03E-05
Eutrophication, terrestrial	4.80E-05
Eutrophication, aquatic freshwater	5.24E-06
Eutrophication, aquatic marine	2.32E-05
Land use	1.16E-05
Water use	3.61E-05
Resource use, fossils	6.07E-04
Resource use, minerals and metals	3.91E-05
Total impact	2.12E-03

7 Verification and validation

7.1 Defining the scope of the verification

Verification and validation of the EF study is mandatory whenever the EF study, or part of the information therein, is used for any type of external communication (i.e. communication to any interested party other than the commissioner or the practitioner of the study).

Verification means the conformity assessment process carried out by an environmental footprint verifier to demonstrate whether the EF study has been carried out in compliance with the PEFCR it declares compliance with and/or the most updated version of the PEF method adopted by the Commission.

Validation means the confirmation by the environmental footprint verifier who carried out the verification, that the information and data included in the EF study, EF report and the communication vehicles are reliable, credible and correct.

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 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[32];
- 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.

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

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

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

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

In particular, for the thermal insulation in the **pitched roof**, the verifier(s) shall validate and verify:

- Life cycle inventory:
  - Manufacturing of the insulation product: bill of materials;
  - Any cut-off;
  - Assumptions and modelling of dismantling processes;
  - Any specific EoL scenario for the insulation product;
  - If primary (specific) data is used for the infrastructure of the manufacturing of the insulation product: verification of the yearly production rate and reference service life of the building;
  - In case the insulation is put between the rafters and the results of a PEF study carried out in compliance with this PEFCR are **not** used **to make comparisons/comparative assertions**
  - The calculation method for the amount (kg) of insulation shall be verified;
  - Mandatory company specific foreground emissions shall be randomly verified by the verifier;
  - Mass balance;
  - The technical suitability and completeness of the build-up.

And for the thermal insulation in the **flat roof**:

- Life cycle inventory:
  - Manufacturing of the insulation product: bill of materials;
  - Any cut-off;
  - Assumptions and modelling of dismantling processes;
  - Any specific EoL scenario for the insulation product;
  - If primary (specific) data is used for the infrastructure of the manufacturing of the insulation product: verification of the yearly production rate and reference service life of the building;
  - Mandatory company specific foreground emissions shall be randomly verified by the verifier;
  - The technical suitability and completeness of the build-up.

8 References

[1] European Union, "PEF OEF methods," *Off. J. Eur. Union*, vol. 56, 2013.

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[3] International Organization for Standardization, "ISO 9229: Thermal insulation - Vocabulary," 2007.

[4] European parliament and Council, "Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings," *Off. J. Eur. Union*, pp. 13–35, 2010.

[5] European parliament and Council, "Comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements," *Off. J. Eur. Union*, pp. 18–36, 2012.

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[7] Commission European, "Product Environmental Footprint Pilot Guidance Guidance for the implementation of the EU Product Environmental Footprint (PEF) during the Environmental Footprint (EF) pilot phase," vol. V 4.0, pp. 1–55, 2014.

[8] CEN-TC88-WG2, "Working Draft for Product category rules (PCR) (WI 00088334)," no. March 2014. CEN, p. 19, 2014.

[9] European Commission, "DURABILITY AND THE CONSTRUCTION PRODUCTS DIRECTIVE," no. December, 2004.

[10] BBSR, "Nutzungsdauern von Bauteilen zur Lebenszyklusanalyse nach Bewertungssystem Nachhaltiges Bauen (BNB)," 2011.

[11] Stichting Bouwkwaliteit, "Bepalingsmethode Milieuprestatie Gebouwen en GWW-werken," 2014. [Online]. Available: https://www.milieudatabase.nl/imgcms/20141125_SBK_Bepalingsmethode_versie_2_0_definitief.pdf. [Accessed: 26-Jan-2015].

[12] Flemish Waste Agency, "Environment-related material performance of Building elements, project for the Flemish Waste Agency," 2012.

[13] ISO 6946:2007 Building components and building elements - Thermal resistance and thermal transmittance - Calculation method

[14] BCIS. (2006). Life Expectancy of Building Components - Surveyors' experiences of buildings in use - A practical guide. London, UK: Connelly-Manton Ltd

9 Annexes

Annex 1. List of EF normalisation and weighting factors

Table 41. Global normalisation factors for Environmental Footprint

Impact category	Model	Unit	global NFs for PEF	Person NF for PEF	Robustness of ILCD for the PEF impact assessment	Inventory coverage completeness	Inventory robustness	Comment
Climate change	IPCC, 2013	kg CO_2 eq	5.35E+13	7.76E+03	I	II	I	
Ozone depletion	World Metereological Organisation (WMO), 1999	kg CFC-11 eq	1.61E+08	2.34E-02	I	III	II	
Human toxicity, cancer	USEtox (Rosenbaum et al., 2008)	CTUh	2.66E+05	3.85E-05	II/III	III	III	
Human toxicity, non-cancer	USEtox (Rosenbaum et al., 2008)	CTUh	3.27E+06	4.75E-04	II/III	III	III	
Particulate matter	UNEP, 2016	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	Frischknecht et al., 2000	kBq U^{235}-eq	2.91E+13	4.22E+03	II	II	III	
Photochemical ozone formation, human health	Van Zelm et al., 2008, as applied in ReCiPe, 2008	kg NMVOC eq	2.80E+11	4.06E+01	II	III	I/II	
Acidification	Posch et al., 2008	mol H+ eq	3.83E+11	5.55E+01	II	II	I/II	
Eutrophication, terrestrial	Posch et al., 2008	mol N eq	1.22E+12	1.77E+02	II	II	I/II	

Eutrophication, freshwater	Struijs et al., 2009	kg P $_{eq}$	1.76E+10	2.55E+00	II	II	III	
Eutrophication, marine	Struijs et al., 2009	kg N $_{eq}$	1.95E+11	2.83E+01	II	II	II/III	
Land use	Bos et al., 2016 (based on)	pt	9.20E+15	1.33E+06	III	II	I I	The NF is built by means of regionalised CFs.
Ecotoxicity, freshwater	USEtox (Rosenbaum et al., 2008)	CTUe	8.15E+13	1.18E+04	II/III	III	III	
Water use	AWARE 100 (based on; UNEP, 2016)	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	ADP fossils (van Oers et al., 2002)	MJ	4.50E+14	6.53E+04	III	I	II	
Resource use, minerals and metals	ADP ultimate reserve (van Oers et al., 2002)	kg Sb $_{eq}$	3.99E+08	5.79E-02	III			

Table 42. Weighting factors for Environmental Footprint

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

Annex 2. Check-list for the PEF study

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

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

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

Annex 3. Critical review report of the PEFCR

Review Report for Product Environmental Footprint Category Rules for thermal insulation

Thermal insulation products in buildings:

- ***Cellulose insulation applied in pitched roofs with massive timber rafters***
- ***Applied in non-accessible flat roofs with concrete structure***

20 March 2018

Prepared by the Review Panel consisting of:

- Guido Sonnemann, University of Bordeaux, France, President of the Review Panel
- Johannes Kreissig, DGNB - German Sustainable Building Council, Germany
- Angela Schindler, Independent LCA expert, Germany

This review report complements the attached review statement that as such can be included in the PEFCR. We would also like to ask to change the text mentioned in the PEFCR in lines 900 to 917 by:

“The reviewers have checked if the following requirements are fulfilled:

- Has the PEFCR 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?
- Are the functional unit, allocation and calculation rules adequate for the product category under consideration?
- Are company specific and secondary datasets used to develop this PEFCR are relevant, representative, and reliable?
- Are the selected LCIA indicators and additional environmental information appropriate for the product category under consideration and is the selection done in accordance with the guidelines stated in the PEFCR Guidance version 6.3 and the most recent approved version of the PEF Guide?
- Are the benchmarks correctly defined?

- Do both life cycle based data and the additional environmental information prescribed by the PEFCR give a description of the significant environmental aspects associated with the product?

The answers to these questions are provided in the review report. Based on this report the reviewers have come up with a review statement. “

First of all, we would like to state that a tremendous amount of work and excellent comprehensive thinking have gone into the Product Environmental Footprint Category Rules (PEFCRs) for thermal insulation. It is clearly a challenge to cover the whole life cycle of thermal insulation products in the PEFCRs. As indicated in the disclaimer and the related section on limitations we agree that environmental information can be provided at different levels, depending on the goal of the communication.

The aim of this PEFCR is amongst others to enable the comparison and benchmarking of thermal insulation products. For this goal, it was decided to communicate the environmental information at the level of the application at building element level (i.e. specific pitched roof and flat roof). As said in the disclaimer and the section on limitations: “this allows to make comparisons at this level, but has some important limitations. First, a predefined build-up had to be defined for Europe and does not represent the exact build-up in several EU Member States. The build-up defined should hence be seen as a (fictive) reference for comparison, rather than an exact representation of the real situation. Second, this approach allows only to compare systems rather than products, meaning that the environmental information does not refer to the impact of a single insulation product, but includes the impact of one or more insulation product(s) in combination with other construction products to achieve a predefined performance. “

Next, we would like to highlight that we delivered the first review on the PEFCRs draft in January 2017 and that we received answers, according PEF guidance 6.6.16.5, addressing reviewers' comments’ on the first review jointly with the revised document in February 2018. With regard to a comment on the vertical rules we were informed that “they were developed since the very beginning to cover different insulation products. The fact that one product or two product groups decided to leave the pilot and vanish the work conducted by several partners (for more than 3 years) is not a justification to exclude this part.“ And with regard to a comment on the functional unit, we were told that “the aim of this PEFCR is the environmental assessment of thermal insulation products. From this point of view the PEFCR may be applicable to any insulation product.” We wonder if these answers are not in contradiction to the disclaimer and the section on limitations that both provide an understanding of the limitations of this PEFCR.

As reviewers, regrettably, we are not able to support the pre-formulated review statement that says: “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. The representative products correctly describe the average products installed 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).”

While we think that overall the horizontal rules mostly are applied in compliance with PEFCR Guidance v6.3, we had long discussions among us and with the Technical Secretariat on the application of the vertical rules to thermal insulation. This is because the disclaimer and the related chapter with limitations explain the applicability of the PEFCR to a limited range of materials and their specific building elements and in the case of Cellulose insulation applied in pitched roofs with massive timber rafters, the vertical rules have been applied to a single material, and in the case of non-accessible flat roofs with concrete structure, they have been applied to three materials. This means, that the benchmarking process supported by this PEFCR bears the risk to distort competition, due to tight constructional and fictive frame conditions, due to system rather than product benchmarking and due to a very limited number of available vertical rules. . In the case of the three materials for the non-accessible flat roofs with concrete structure, the review panel was informed by the European Commission that the representativeness has been checked by EC. The

Technical Secretariat ensured that they "will provide a statement in PEFCR highlighting that: The market share for the products in the scope of PEFCR is based on expert judgement".

In the second round of review we provided another table with our detailed review comments to the Technical Secretariat that on a case to case basis accepted, partially accepted or rejected our comments with justifications for different choices. Unfortunately, there are a number of rejected comments, with which we disagree with the decision made by the Technical Secretariat. Therefore, overall, some further improvements, enabling a biunique implementation in a PEF study with a reliable methodological approach, are recommended below. We think that their consideration is advisable so that "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)."

With regard to the functional unit we commented that a building element typically has to fulfil several functions depending on the building and its use in a certain context (e.g. on sound insulation, fire resistance, compressive strength, etc.). Therefore, we argued that in the definition of the functional unit there is need to define the performance of these other functions as well. If there is no requirement in the defined functional unit this is to be mentioned and in consequence the functional unit is not applicable for build-ups with additional requirements. This comment was rejected because the Technical Secretariat wants to limit themselves to the main function of the product because the PEF guidance requires to focus on the main application. Thermal insulation was defined by the pilot as main function. We would like to point out that for an application the technical performance of the solution has to be transparent, therefore the Technical Secretariat has to specify the technical performance or at least a range for the benchmark, otherwise a comparison with the benchmark is meaningless.

It is essential to define an unambiguous functional unit. The comment on the description of two versions for a functional unit has only been partly accepted. The application of a PEF study's result is not foreseeable; thus there can only be one valid result list. Practitioners are anyway free to perform calculations beyond the scope and rules of the PEFCR. These results will not be applicable for benchmarking. There cannot be seen an added value, but a risk for irritation, to describe how to conduct LCIAs not fully complying with this PEFCR.

With regard to allocation we remarked that the chapter on allocation rules was missing (according to the structure given in the PEFCR guidance v6.3, Annex E). The chapter was added with the indication that mass allocation was applied. However, we still wonder if this was done consistently and in principle it should only be applied if products are in same revenue/ unit order of magnitude.

We have also commented on how infrastructure is considered. In our opinion you cannot fix an average for completely different infrastructure (type and size of factory) as default. If you do not give different defaults for different materials, you shall use a worst case approach. The Technical Secretariat responded that the possibility is given in the PEFCR to manufacturer to collect data and declare their real infrastructure. In our opinion, this is not the issue, it is methodologically wrong to set average as default for a relevant process if there is a wide variance.

With regard to the minimum list of output which shall be provided by the producer (e.g. table 25) we still recommend to reduce the list to the emissions which occur in the process covered by the scope. Otherwise the practitioner has to check all these emissions and state that many of the default set of emissions do not occur.

Moreover, we highlighted that 2 digit numbers for paper, cardboard and mixed plastics are confusing and recommended to round to full numbers. The Technical Secretariat argued back that from PEF Guidance they are not able to change this, what does not make sense to us.

A final observation is that more attention in the revision would have allowed to align the document better to the general objectives of the PEFCR guidance on user-friendliness. It is our understanding that the PEFCR should transfer the general rules given in this guidance document into concrete calculation algorithms, wherever possible, in order to provide a manual applicable for practitioners. This is the intention of some of the detailed recommendations we provide.

Annex 4. Supporting studies

This section provides information on the supporting studies conducted for the development of this PEFCR. The relevant supporting studies for the final scope are included in this section. For each product group within the scope of this PEFCR at least one supporting study has been conducted. Table 43 provides an overview of the relevant supporting studies.

Table 43 Overview of the supporting studies conducted during the development of this PEFCR

PEFCR Pitched roof with massive timber rafters	
Product group	**Supporting study**
Loose fill cellulose	PEF supporting study Isocell PEF supporting study Isofloc PEF supporting study Wolfinger PEF supporting study Termex Selluvilla PEF supporting study Ekovilla VO PEF supporting study AISLAnat

PEFCR Flat roof with concrete structure	
Product group	**Supporting study**
Unfaced cellular glass board	PEF supporting study FOAMGLAS T4+
Unfaced EPS grey board	PEF supporting study EPS 60 HR SE (IsoBouw: Thermotop)
Faced PU board	PEF supporting study Eurothane Silver (Recticel)

All the studies include confidential information that may not be disclosed in this section of the PEFCR.

Loose fill cellulose

Introduction

This section provides the outcomes of the PEF supporting study for “Isocell” being produced by ISOCELL. The results and conclusions of this report shall be used for no other purpose than the development of the PEF Category Rules for thermal insulation products in buildings.

The supporting studies for 5 other cellulose products (PEF supporting study Isofloc (supporting study with a critical review by EC), .Wolfinger, Termex Selluvilla, Ekovilla VO, AISLAnat) were conducted and are also available. A critical review was however performed on the supporting study of Isofloc. As only the supporting study of Isocell contributed to the revisions of the PEFCR, the description below is limited to the supporting study of Isocell.

General information

Supporting study category	Thermal insulation product
Cellulose insulation	The product name is ISOCELL with a density 48 kg/m3 and the lambda value of the product is 0.039 W/(m.K).
Product identification (e.g. model number)	-
Product classification (CPA)	Code F.41.2 - Construction of residential and non-residential buildings (C - Manufacturing)
Company presentation	The company ISOCELL is a specialist in cellulose insulation. ISOCELL has earned a reputation in the construction industry through a range of innovative products in the field of cellulose insulation with a finish of the highest level.
Geographic validity of the supporting study	Europe (The product is produced in Austria and sold in 12 European countries)
Photo of the product	
Supporting study in conformance with	Product Environmental Footprint Category Rules (PEFCRs) for thermal insulation (Draft v.4.0 – February 2016)
Date of publication of supporting study	September 2016
Critical review status	This supporting study did not undergo a critical review.

Supporting studies flat roof with concrete structure

Unfaced cellular glass board

Introduction

This section provides the outcomes of the PEF supporting study for "FOAMGLAS T4+" being produced by Foamglas. The results and conclusions of this report shall be used for no other purpose than the development of the PEF Category Rules for thermal insulation products in buildings.

General information

Specific characteristic	Description
Name of the product	Cellular glass product "FOAMGLAS T4+", lambda value 0,041 W/(m·K). 
Product identification (e.g. model number)	FOAMGLAS T4+
Product classification (CPA) based on the latest CPA list version available	C (Manufactured Products); 23.99 (Other non-metallic mineral products) covers glass production.
Company presentation (name, geographic location)	Pittsburgh Corning Europe (PCE) factory Tessenderlo, Belgium
Date of publication of supporting study	June 2016
Geographic validity of the supporting study	sold all over the European market
Reference PEFCR the supporting study is in conformance with (incl. version number)	"Draft PEFCR for thermal insulation", version 4.0 from February 2016
Indication whether this report underwent a critical review process	This supporting study did not undergo a critical review.

Unfaced EPS grey board

Introduction

This section provides the outcomes of the PEF supporting study for "EPS 60 HR SE" being produced by Ertecee bv. The results and conclusions of this report shall be used for no other purpose than the development of the PEF Category Rules for thermal insulation products in buildings.

General information

Relevant Information	
Name of the product (including a photo)	Grey Expanded Polystyrene (EPS) Foam Insulation (with infra-red absorbers, density 15 kg/m³)
Product identification	EPS 60 HR SE (IsoBouw Thermotop)
Product classification (CPA)	*There is no single NACE code covering all thermal insulation products. Code F.41.2 – Construction of residential and non-residential buildings (C – Manufacturing) covers a much wider product group than the products in the scope of this PEFCR.*
Company presentation (name, geographic location)	Ertecee bv (Part of IsoBouw and part of Synbra), Oldenzaal (NL)
Date of publication of supporting study	15th June 2016
Geographic validity of the supporting study(countries where the product is consumed/sold)	Netherlands
PEFCR in conformance with	*Thermal insulation products in buildings:* • *Applied in non-accessible flat roofs with concrete structure*
Critical review	

Faced PU board

Introduction

This section provides the outcomes of the PEF supporting study for “Eurothane Silver” being produced by Recticel. The results and conclusions of this report shall be used for no other purpose than the development of the PEF Category Rules for thermal insulation products in buildings.

General information

Specific characteristic	Description
Name of the product (including a photo)	Eurothane Silver, thickness 160 mm, density of panels: 31,14 kg/m3 (foam + facer), lambda value of 0,022 W/m.K, Uc value of 0,1375 W/m²K 
Product identification	Eurothane Silver, production year 2015
Product classification (CPA) based on the latest CPA list version available	C (Manufactured Products); 22.21 Plastic products: plates, sheets, tubes and profiles
Company presentation (name, geographic location)	Recticel, S.A. Avenue des Olympiades 2, B - 1140 Brussels Belgium (Company n° VAT BE0405666668 Register of Legal Entities Brussels) (further referred to as "**Recticel**") Production location: Recticel Insulation nv, Tramstraat 6, B-8560 Wevelgem
Date of publication of supporting study	3 June 2016
Geographic validity of the supporting study (countries where the product is consumed/sold)	Belgium

Reference PEFCR the supporting study is in conformance with (incl. version number)	“Draft PEFCR for thermal insulation”, version 4.0 from February 2016
Indication whether this report underwent a critical review process	This supporting study did not undergo a critical review.

Annex 5. Examples of the applications of the thermal insulation products in buildings

The table and sketches below illustrate potential applications of thermal insulation products in buildings according to ISO/FDIS 9774.

Application			Sketch No.
Roof	Pitched roof	Unloaded insulation between rafters, fully supported	1
		Insulation separating rafters and outer covering	2
		Insulation separating supporting construction and outer covering	3
		Insulation beneath rafters	4
	Flat roof	Insulation between rafters or beams	5
		Inverted, insulation above roofing membrane including roof gardens and parking decks	6
		On steel deck, insulation beneath roofing membrane	7
		Accessible to light or heavy traffic or loads from roof garden (soil layer, plants, etc.) and parking decks (concrete pavers or slabs), insulation beneath roofing membrane	8
		Accessible only to maintenance personal, insulation beneath roofing membrane	9
Wall		Masonry or concrete wall, external insulation covered by rendering	10
		Timber stud construction, outside insulation and rendering directly supported by the studs	11
		Timber stud construction, insulation at the internal side with rendering	12
		Masonry or concrete wall, fully supported internal insulation supporting light protective internal facing (e.g. gypsum board)	13
		Masonry or concrete wall, internal insulation supporting light protecting facing, partly supported by studs	14
		Masonry or concrete wall, internal insulation with heavy self-supported protective internal facing (e.g. tiles at roomside)	15
		Timber or metal stud construction with boards covering, insulation between the studs	16
		Cavity wall construction, insulation between the leaves, cavity ventilated	17
		Cavity wall construction, cavity fully filled with insulation, outer leave not watertight	18
		Timber or metal stud construction with boards covering, insulation supported by boards; or masonry or concrete wall, supporting the insulation with ventilated exterior covering	19
		Wall under ground, external insulation behind waterproof membrane with mechanical protection	20
		Wall under ground, external insulation with direct contact to the ground	21
		Cellar or crawlspace hall, internal insulation with or without covering	22
Ceiling/floor		Insulation over the supporting construction or between the beams	23
		Insulation under load distributing flooring, fully supported	24
		Insulation under the construction	25
Foundation		Concrete, insulation under the slab with direct contact to the ground	26
		Concrete, insulation supported by the slab, above waterproof membrane, beneath load distributing flooring	27
		Concrete, insulation under the slab above waterproof membrane	28
		Frost insulation in or against the ground	29

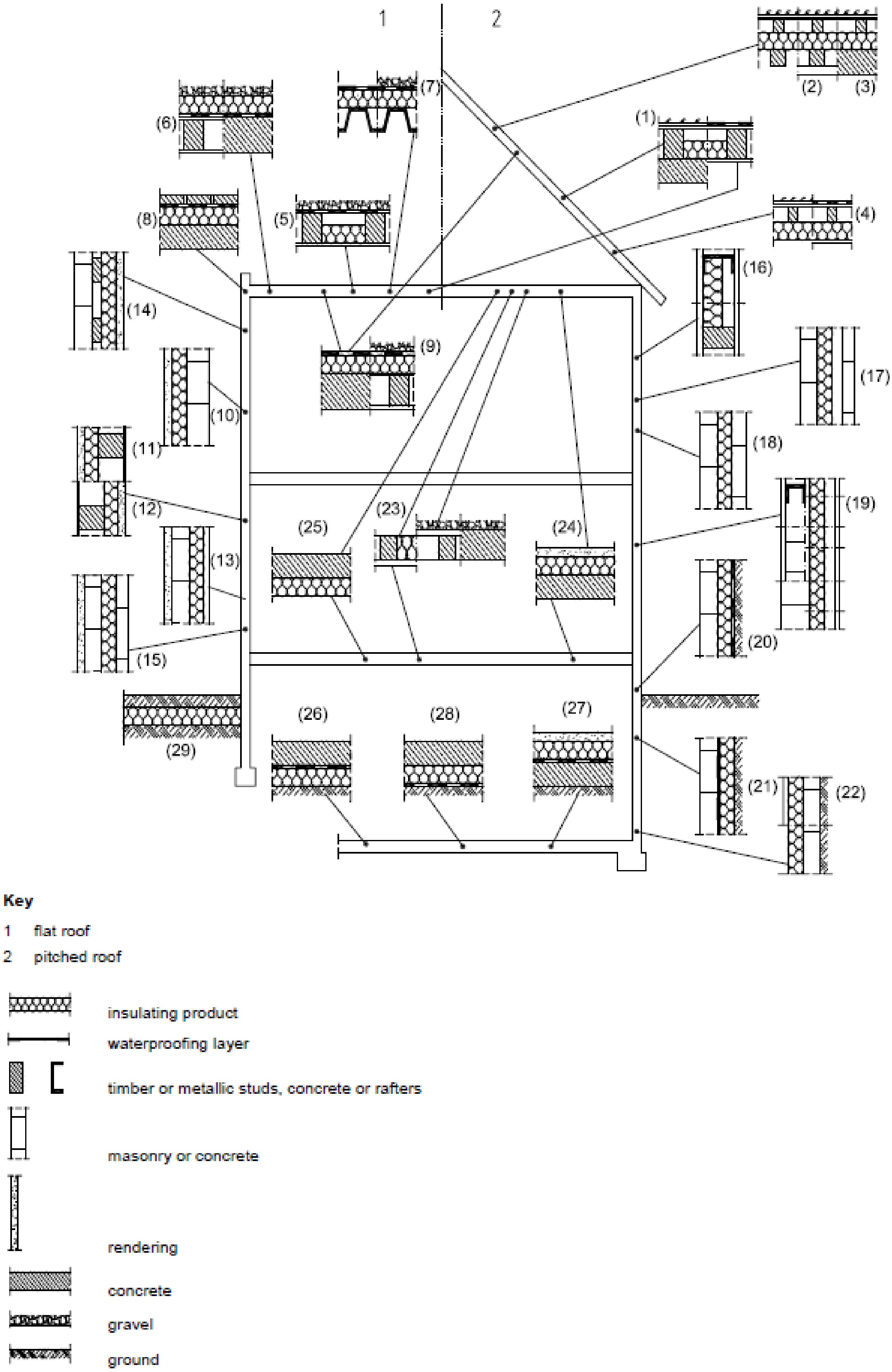
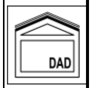
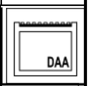
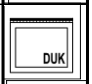
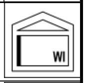
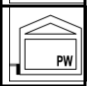
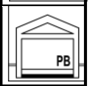


Figure 13 Sketches of potential applications of thermal insulation products in the building (ISO/FDIS 9774)

The table below illustrates potential applications of thermal insulation products in buildings according to the standard DIN 4108 – part 10.

Area of Application	**Designation**	**Application description**	
Ceiling, Roof	DAD	External insulation of warm pitched roof or ceiling insulation, protected against weathering, insulation under cover	
	DAA	External insulation of roof or ceiling, protected against weathering, insulation under water proofing	
	DUK	External insulation of the roof, exposed to the weather (inverted roof)	
	DZ	Insulation between the rafters, two-shell roof, top floor ceiling not readily walkable but accessible	
	DI	Interior insulation of the ceiling (underside) or the roof, insulation under the rafters / supporting structure, false ceiling etc.	
	DEO	Interior insulation of the ceiling or floor plate (top side) below floor screed without acoustic dampening requirements	
	DES	Interior insulation of the ceiling or floor plate (top side) below screed with acoustic dampening requirements	
Wall	WAB	External wall insulation behind covers	
	WAA	External wall insulation behind seal	
	WAP	External Thermal Insulation Composite System with render	
	WZ	Insulation of double-leaf walls, cavity wall insulation	
	WH	Insulation of wood frame and wood panel construction	
	WI	Interior wall insulation (insulation of walls from inside)	
	WTH	Insulation between the house partition walls with sound insulation requirements (between adjacent houses)	
	WTR	Insulation of partitioning walls (within one house)	
Perimeter	PW	External thermal insulation of walls in contact with soil (outside of the water proofing)	
	PB	External thermal insulation under the floor panel in contact with soil (outside of water proofing)	

Annex 6. Methodology for the calculation of the operational energy use at the level of the building element

The operational energy use of the building element shall be calculated by means of the equivalent degree days method.

The operational energy use (only space heating) is defined as:

$$Q_{d,SH} = \frac{\frac{Uc \times S \times EHDD \times 24 \times 3600}{10^6}}{\eta_{SH}} \times DLS$$

With: **$Q_{d,SH}$** = design value of space heating energy consumption over the design life span (DLS) of the building (MJ)

DLS = design life span of the building (years)

η_{SH} = overall efficiency of the space heating system (%)

Uc = thermal transmittance of the building element (i.e. pitched roof or flat roof) (W/m²K)

S = area of the building element (m²)

EHDD = number of yearly equivalent heating degree days (K.days/year)

Δtemperature = difference in temperature outside and indoor (K)

24 hours/day

3600 seconds/hour

The overall efficiency of the space heating system is defined as:

$$\eta_{SH} = \eta_{production} \times \eta_{distribution} \times \eta_{emission} \times \eta_{control}$$

With: **$\eta_{production}$** = efficiency of the production system of space heating service(s) (%)

$\eta_{distribution}$ = efficiency of the distribution system of space heating service(s) (%)

$\eta_{emission}$ = efficiency of the emission system of space heating service(s) (%)

$\eta_{control}$ = efficiency of the control system of space heating service(s) (%)

As the energy demand, and hence the energy savings due to a reduced demand, is influenced by several parameters, it is necessary to define fixed values for these to ensure harmonized results. The PEFCRs therefore include fixed values for several parameters influencing the transmission losses of the building element and hence the energy savings due to reduced heating. The parameters are summarized in Table 44.

Table 44 Fixed parameters for the calculation of the energy demand for space heating

Parameter	Value	source
Design life span of the building	50 years	Declared unit
Climate zone	Average climate – France (Strasbourg)	Ecodesign Windows
Heating degree days	2813*	Ecodesign Windows
η_{SH}	88%	Ecodesign thermal insulation
$\eta_{production}$	104%	Ecodesign thermal insulation
$\eta_{distribution}$	95%	Ecodesign thermal insulation
$H_{emission}$	95%	Ecodesign thermal insulation
$\eta_{control}$	95%	Ecodesign thermal insulation
S	1 m²	Declared unit

*Source: www.ecodesign-windows.eu/downloads/20141112_Lot32_2ndSHmeeting_Presentation_energy_Performance.pdf

In order to calculate the heat losses through the building element, the equivalent heating degree days need to be calculated, taking into account internal heat gains and useful solar gains. These internal heat gains and useful solar gains evidently depend on the building design, use of the building, orientation and insulation level. We assumed a well-insulated building with an average window area. The U-values assumed are based on the current energy performance legislation in Belgium and are summarized in Table 45.

Table 45 summary of the U-values assumed for the calculation of the equivalent degree days

Element	U-value (W/m²K)
Floor on grade	0.24
Outer wall	0.24
Roof	0.24
Windows	1.50

It is assumed that there are windows in each façade (freestanding building) with a window area in each façade of 25% of the façade surface.

The internal heat gains equal 542 J/s, which is calculated based on the building volume.

The above assumptions result in **1344 equivalent heating degree days** for France – Strasbourg, representing a moderate climate zone. This value shall be used for the calculation of the energy savings as additional information in PEF studies of thermal insulation materials in line with this PEFCRs.

Energy savings due to a reduced heating demand

The energy savings due to the insulation of the building element shall be calculated in comparison to a non-insulated building element (i.e. pitched and flat roof in the context of this PEF pilot). The heat resistance of the non-insulated building element variant is calculated in the same way as for the insulated variant. The difference in U-value between the insulated and non-insulated variant determines the heating savings as follows:

$$Q_{SH,savings} = Q_{SH,demand,insulated} - Q_{SH,demand,non-insulated}$$

<u>EU Final energy consumption in households by fuel</u>

The Table 46 provide the share of final energy consumption in households by fuel and datasets (proxy) used for modelling of energy savings during the use phase.

Table 46 Share of final energy consumption in households by fuel and datasets (proxy) used for modelling

<table>
<tr><th>Eurostat 2013 – EU (28 countries)</th><th>Share</th><th>EF compliant or ELCD data used</th></tr>
<tr><td>Gas</td><td>37%</td><td>Thermal energy from natural gas| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result] UUID: 81675341-f1af-44b0-81d3-d108caef5c28</td></tr>
<tr><td>Electricity</td><td>24%</td><td>EU mix_Conversion from electricity medium voltage to electricity low voltage| Transformation of medium voltage electricity to low voltage| Consumption mix, to consumer| grid losses, from 0,54% to 18,18% see general comments {GLO} [Unit process, single operation] UUID: 8d21c6d3-cc85-49c4-b275-21827ce193b7</td></tr>
<tr><td>Renewable Energies</td><td>15%</td><td>Proxy to Heat, from resid. heating systems from wood, consumption mix, at consumer, temperature of 70°C EU-27 S PEF</td></tr>
<tr><td>Total petroleum products</td><td>13%</td><td rowspan="3">Thermal energy from light fuel oil (LFO)| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result] UUID: e7510ad9-4bfa-4113-94b0-426e5f430c98</td></tr>
<tr><td>Derived heat</td><td>8%</td></tr>
<tr><td>Solid fuels</td><td>3%</td></tr>
</table>

<u>Results – energy savings of the pitched and flat roof</u>

The subsequent paragraphs summarize the results of the energy savings due to a reduced heating demand due to the insulation of the flat and pitched roof. The savings are calculated over a life span of 50 years and for 1 m² roof, in line with the declared unit of the roof for the basic build-up (benchmark).

a. <u>Flat roof</u>

In a first step, the U-values of both the non-insulated roof and the insulated roof shall be determined. The U-values are summarized in Table 47. It is to be noted that the U-value of the non-insulated roof shall be recalculated if a different concrete flooring (thickness or lambda value) is assumed. Beside the base case, also the two sensitivity cases (with lower and increased heat resistance compared to the base case) are calculated and represented in Table 47.

Note: The rule is to calculate the savings for the specific U-value and that these values are provided as example.

Table 47 U-values for the flat roof

	RT (m²K/W)	U (W/m²K)
Non-insulated roof	0.243	4.110
Insulated roof - base case	7.000	0.140
Insulated roof - sensitivity 1	3.000	0.330
Insulated roof - sensitivity 2	10.000	0.100

In a second step, the energy use for heating is calculated based on the U-values (Table 47), a life span of 50 years, a roof area of 1 m² and 1344 equivalent heating degree days. The results for the non-insulated roof and the three insulation levels are shown in Table *48*.

Table 48 Flat roof: energy use for heating in MJ per m² roof over a life span of 50 years.

	RT (m²K/W)	MJ/m²
Non-insulated roof	0.243	27132
Insulated roof - base case	7	943
Insulated roof - sensitivity 1	3	2199
Insulated roof - sensitivity 2	10	660

In a third step, the energy savings of the three insulation levels are calculated in comparison to the non-insulated flat roof. In a final step the environmental benefits related to the energy savings are calculated. Following assumptions are made for the calculation of the benefits.

b. Pitched roof

In a first step, the U-values of both the non-insulated roof and the insulated roof shall be determined. The U-values are summarized in Table *49*. It is to be noted that the U-value of the non-insulated roof shall be recalculated if a different size or inter-distance of the timber rafters is assumed than the base case. Beside the base case, also the two sensitivity cases (with lower and increased heat resistance compared to the base case) are calculated and represented in Table *49*..

Table 49 U-values for the pitched roof

	RT (m²K/W)	U (W/m²K)
Non-insulated roof	0.45	3.77
Insulated roof - base case	7	0.14
Insulated roof - sensitivity 1	3	0.33
Insulated roof - sensitivity 2	10	0.10

In a second step, the energy use for heating is calculated based on the U-values (Table *49*), a life span of 50 years, a roof area of 1 m² and 1344 equivalent heating degree days. The results for the non-insulated roof and the three insulation levels are shown in Table 50.

Table 50 Pitched roof: energy use for heating in MJ per m² roof over a life span of 50 years.

	RT (m²K/W)	MJ/m²
Non-insulated roof	0.45	24846
Insulated roof - base case	7	943
Insulated roof - sensitivity 1	3	2199
Insulated roof - sensitivity 2	10	660

In a third step, the energy savings of the three insulation levels are calculated in comparison to the non-insulated flat roof. In a final step the environmental benefits related to the energy savings are calculated. Following assumptions are made for the calculation of the benefits. Final energy saving for both applications are calculated based on the energy share mix in Table 34 and provided in the Table 40 and Table 41.

Table 51 Additional information on energy savings during the use phase for flat roof representative product for the U values 0.14, 0.33, 0.1

	Climate change	Ozone depletion	Ionising radiation, HH	Photochemical ozone formation, HH	Respiratory inorganics	Non-cancer human health effects	Cancer human health effects	Acidification terrestrial and freshwater	Eutrophication freshwater	Eutrophication marine	Eutrophication terrestrial	Ecotoxicity freshwater	Land use	Water scarcity	Resource use, energy carriers	Resource use, mineral and metals	Climate change - fossil	Climate change - biogenic	Climate change - land use and transform.
	kg CO2 eq	kg CFC11 eq	kBq U-235 eq	kg NMVOC eq	disease inc.	CTUh	CTUh	mol H+ eq	kg P eq	kg N eq	mol N eq	CTUe	Pt	m3 depriv.	MJ	kg Sb eq	kg CO2 eq	kg CO2 eq	kg CO2 eq
Electricity	7,57E+02	2,85E-07	3,18E+02	1,22E+00	2,31E-05	1,61E-05	6,09E-07	2,28E+00	1,58E-03	4,46E-01	4,55E+00	3,05E+01	4,79E+03	1,05E+02	1,30E+04	2,34E-04	7,54E+02	2,64E+00	6,71E-01
Light fuel oil	5,48E+02	1,09E-09	1,31E+00	9,71E-01	6,69E-06	1,21E-05	3,49E-06	1,06E+00	9,54E-05	3,20E-01	3,51E+00	7,07E+01	2,97E+01	8,49E-01	7,50E+03	1,58E-05	5,48E+02	1,37E-02	1,07E-02
Natural Gas	6,82E+02	6,22E-09	6,99E+00	5,94E-01	3,93E-06	8,12E-07	1,12E-07	5,18E-01	4,62E-05	1,66E-01	1,83E+00	5,69E+00	1,20E+02	3,58E+00	1,09E+04	2,75E-05	6,82E+02	6,22E-02	2,53E-02
Wood	2,85E+00	4,12E-06	6,47E+00	8,40E-01	1,91E-05	1,70E-05	4,41E-07	6,52E-01	2,19E-05	2,55E-01	2,79E+00	2,25E+01	0,00E+00	-9,46E+00	7,44E+02	5,01E-05	2,85E+00	0,00E+00	0,00E+00
Total RT 7	**1,99E+03**	**4,41E-06**	**3,33E+02**	**3,62E+00**	**5,28E-05**	**4,60E-05**	**4,65E-06**	**4,51E+00**	**1,74E-03**	**1,19E+00**	**1,27E+01**	**1,29E+02**	**4,93E+03**	**1,00E+02**	**3,22E+04**	**3,27E-04**	**1,99E+03**	**2,72E+00**	**7,07E-01**
Electricity	7,21E+02	2,71E-07	3,03E+02	1,16E+00	2,20E-05	1,53E-05	5,80E-07	2,17E+00	1,50E-03	4,25E-01	4,33E+00	2,90E+01	4,56E+03	1,00E+02	1,24E+04	2,23E-04	7,18E+02	2,52E+00	6,38E-01
Light fuel oil	5,21E+02	1,04E-09	1,25E+00	9,24E-01	6,37E-06	1,15E-05	3,32E-06	1,01E+00	9,09E-05	3,04E-01	3,34E+00	6,73E+01	2,83E+01	8,08E-01	7,14E+03	1,50E-05	5,21E+02	1,30E-02	1,02E-02
Natural Gas	6,49E+02	5,92E-09	6,65E+00	5,66E-01	3,74E-06	7,73E-07	1,06E-07	4,93E-01	4,40E-05	1,58E-01	1,74E+00	5,42E+00	1,14E+02	3,41E+00	1,04E+04	2,62E-05	6,49E+02	5,92E-02	2,41E-02
Wood	2,72E+00	3,92E-06	6,16E+00	7,99E-01	1,81E-05	1,62E-05	4,20E-07	6,21E-01	2,09E-05	2,43E-01	2,66E+00	2,15E+01	0,00E+00	-9,01E+00	7,08E+02	4,77E-05	2,72E+00	0,00E+00	0,00E+00
Total RT 3	**1,89E+03**	**4,20E-06**	**3,17E+02**	**3,45E+00**	**5,03E-05**	**4,38E-05**	**4,43E-06**	**4,29E+00**	**1,66E-03**	**1,13E+00**	**1,21E+01**	**1,23E+02**	**4,70E+03**	**9,54E+01**	**3,07E+04**	**3,11E-04**	**1,89E+03**	**2,59E+00**	**6,73E-01**
Electricity	7,66E+02	2,88E-07	3,21E+02	1,23E+00	2,34E-05	1,62E-05	6,16E-07	2,30E+00	1,60E-03	4,51E-01	4,60E+00	3,08E+01	4,84E+03	1,06E+02	1,32E+04	2,36E-04	7,62E+02	2,67E+00	6,78E-01
Light fuel oil	5,54E+02	1,10E-09	1,33E+00	9,81E-01	6,76E-06	1,23E-05	3,53E-06	1,07E+00	9,65E-05	3,23E-01	3,55E+00	7,15E+01	3,00E+01	8,58E-01	7,58E+03	1,60E-05	5,54E+02	1,39E-02	1,08E-02
Natural Gas	6,89E+02	6,29E-09	7,06E+00	6,01E-01	3,97E-06	8,21E-07	1,13E-07	5,24E-01	4,67E-05	1,68E-01	1,85E+00	5,75E+00	1,21E+02	3,62E+00	1,11E+04	2,78E-05	6,89E+02	6,29E-02	2,56E-02
Wood	2,88E+00	4,17E-06	6,54E+00	8,49E-01	1,93E-05	1,72E-05	4,46E-07	6,59E-01	2,22E-05	2,58E-01	2,82E+00	2,28E+01	0,00E+00	-9,56E+00	7,52E+02	5,06E-05	2,88E+00	0,00E+00	0,00E+00
Total RT 10	**2,01E+03**	**4,46E-06**	**3,36E+02**	**3,66E+00**	**5,34E-05**	**4,65E-05**	**4,70E-06**	**4,56E+00**	**1,76E-03**	**1,20E+00**	**1,28E+01**	**1,31E+02**	**4,99E+03**	**1,01E+02**	**3,25E+04**	**3,31E-04**	**2,01E+03**	**2,75E+00**	**7,14E-01**

Table 52 Additional information on energy savings during the use phase for the pitched roof representative product for the U values 0.14, 0.33, 0.1

	Climate change	Ozone depletion	Ionising radiation, HH	Photochemical ozone formation, HH	Respiratory inorganics	Non-cancer human health effects	Cancer human health effects	Acidification terrestrial and freshwater	Eutrophication freshwater	Eutrophication marine	Eutrophication terrestrial	Ecotoxicity freshwater	Land use	Water scarcity	Resource use, energy carriers	Resource use, mineral and metals	Climate change - fossil	Climate change - biogenic	Climate change - land use and transform.
	kg CO2 eq	**kg CFC11 eq**	**kBq U-235 eq**	**kg NMVOC eq**	**disease inc.**	**CTUh**	**CTUh**	**mol H+ eq**	**kg P eq**	**kg N eq**	**mol N eq**	**CTUe**	**Pt**	**m3 depriv.**	**MJ**	**kg Sb eq**	**kg CO2 eq**	**kg CO2 eq**	**kg CO2 eq**
Electricity	6,91E+02	2,60E-07	2,90E+02	1,11E+00	2,11E-05	1,47E-05	5,56E-07	2,08E+00	1,44E-03	4,07E-01	4,15E+00	2,78E+01	4,37E+03	9,61E+01	1,19E+04	2,13E-04	6,88E+02	2,41E+00	6,12E-01
Light fuel oil	5,00E+02	9,93E-10	1,20E+00	8,86E-01	6,11E-06	1,11E-05	3,18E-06	9,70E-01	8,71E-05	2,92E-01	3,20E+00	6,46E+01	2,71E+01	7,75E-01	6,85E+03	1,44E-05	5,00E+02	1,25E-02	9,77E-03
Natural Gas	6,22E+02	5,68E-09	6,38E+00	5,42E-01	3,59E-06	7,41E-07	1,02E-07	4,73E-01	4,22E-05	1,52E-01	1,67E+00	5,20E+00	1,09E+02	3,27E+00	9,98E+03	2,51E-05	6,22E+02	5,68E-02	2,31E-02
Wood	2,60E+00	3,76E-06	5,91E+00	7,66E-01	1,74E-05	1,55E-05	4,03E-07	5,95E-01	2,00E-05	2,33E-01	2,55E+00	2,06E+01	0,00E+00	-8,64E+00	6,79E+02	4,57E-05	2,60E+00	0,00E+00	0,00E+00
Total RT 7	**1,82E+03**	**4,03E-06**	**3,04E+02**	**3,31E+00**	**4,82E-05**	**4,20E-05**	**4,24E-06**	**4,12E+00**	**1,59E-03**	**1,08E+00**	**1,16E+01**	**1,18E+02**	**4,50E+03**	**9,15E+01**	**2,94E+04**	**2,99E-04**	**1,81E+03**	**2,48E+00**	**6,45E-01**
Electricity	6,55E+02	2,46E-07	2,75E+02	1,05E+00	2,00E-05	1,39E-05	5,27E-07	1,97E+00	1,37E-03	3,86E-01	3,93E+00	2,64E+01	4,14E+03	9,10E+01	1,13E+04	2,02E-04	6,52E+02	2,29E+00	5,80E-01
Light fuel oil	4,74E+02	9,40E-10	1,14E+00	8,39E-01	5,79E-06	1,05E-05	3,02E-06	9,19E-01	8,25E-05	2,76E-01	3,04E+00	6,12E+01	2,57E+01	7,34E-01	6,49E+03	1,37E-05	4,74E+02	1,18E-02	9,26E-03
Natural Gas	5,89E+02	5,38E-09	6,04E+00	5,14E-01	3,40E-06	7,02E-07	9,67E-08	4,48E-01	3,99E-05	1,44E-01	1,58E+00	4,92E+00	1,04E+02	3,10E+00	9,45E+03	2,38E-05	5,89E+02	5,38E-02	2,19E-02
Wood	2,47E+00	3,56E-06	5,60E+00	7,26E-01	1,65E-05	1,47E-05	3,82E-07	5,64E-01	1,90E-05	2,21E-01	2,41E+00	1,95E+01	0,00E+00	-8,18E+00	6,44E+02	4,33E-05	2,47E+00	0,00E+00	0,00E+00
Total RT 3	**1,72E+03**	**3,82E-06**	**2,88E+02**	**3,13E+00**	**4,57E-05**	**3,98E-05**	**4,02E-06**	**3,90E+00**	**1,51E-03**	**1,03E+00**	**1,10E+01**	**1,12E+02**	**4,27E+03**	**8,67E+01**	**2,78E+04**	**2,83E-04**	**1,72E+03**	**2,35E+00**	**6,11E-01**
Electricity	7,00E+02	2,63E-07	2,94E+02	1,12E+00	2,14E-05	1,48E-05	5,62E-07	2,10E+00	1,46E-03	4,12E-01	4,20E+00	2,82E+01	4,42E+03	9,72E+01	1,20E+04	2,16E-04	6,96E+02	2,44E+00	6,19E-01
Light fuel oil	5,06E+02	1,00E-09	1,21E+00	8,97E-01	6,18E-06	1,12E-05	3,22E-06	9,82E-01	8,81E-05	2,95E-01	3,24E+00	6,53E+01	2,74E+01	7,84E-01	6,93E+03	1,46E-05	5,06E+02	1,27E-02	9,89E-03
Natural Gas	6,30E+02	5,74E-09	6,45E+00	5,49E-01	3,63E-06	7,50E-07	1,03E-07	4,79E-01	4,27E-05	1,53E-01	1,69E+00	5,26E+00	1,11E+02	3,31E+00	1,01E+04	2,54E-05	6,29E+02	5,74E-02	2,34E-02
Wood	2,63E+00	3,81E-06	5,98E+00	7,75E-01	1,76E-05	1,57E-05	4,07E-07	6,02E-01	2,02E-05	2,36E-01	2,58E+00	2,08E+01	0,00E+00	-8,74E+00	6,87E+02	4,63E-05	2,63E+00	0,00E+00	0,00E+00
Total RT 10	**1,84E+03**	**4,08E-06**	**3,07E+02**	**3,35E+00**	**4,88E-05**	**4,25E-05**	**4,29E-06**	**4,17E+00**	**1,61E-03**	**1,10E+00**	**1,17E+01**	**1,20E+02**	**4,56E+03**	**9,25E+01**	**2,97E+04**	**3,02E-04**	**1,83E+03**	**2,51E+00**	**6,53E-01**