Final PCR

LCA:TIM project

LCA: Ten Insulation Materials
"Het opstellen van het opstellen van regels, het uitvoeren van levenscyclusanalyses inclusief dataverzameling en het geven van beleidsaanbevelingen m.b.t. vijf niet-hernieuwbare (glaswol, rotswol, PUR, EPS, XPS) en vijf hernieuwbare (schapenwol, papiervlokken, vlasisolatie, houtvezelisolatie, hennepisolatie) thermische isolatiematerialen voor spouwmuren"
(Bestek met nummer: DG5/PP/DDL/11032)

Task 1
Product Category Rules for Environmental Product Declarations for Thermal Insulation Materials on the Belgian Market

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COLOFON

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DU	Declared Unit
EPD	Environmental product declaration
EPS	Expanded polystyrene
FU	Functional Unit
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
NDA	Non Disclosure Agreement
PCR	Product Category Rule(s)
PIR	Polyisocyanurate
PUR	Polyurethane
RSL	Reference service life
UFFI	Urea-formaldehyde foam insulation
XPS	Extruded polystyrene
FPS	Federal Public Service

CHAPTER 1 INTRODUCTION

The Federal Public Service of Health and Environment (here after called FPS Health)[1] would like to gain insights in the potential environmental impacts of different thermal insulation products for walls available on the Belgian market. The building sector is responsible for a significant part of energy consumption, use of water and other raw materials and waste production which causes impacts on environment and human health. A transition to a sustainable building practice will demand a "mind shift". Both on an international scale and in Belgium, efforts were undertaken to clarify aspects of sustainability of building products and elements. Moreover different types of insulation products exist and insights into the environmental impacts of the different insulation materials are important and required. A life cycle assessment (LCA) is a suitable method to analyse the environmental impacts of a product, process and/or system, from an entire life cycle perspective. ISO standards define a framework for undertaking Life Cycle Analyses (ISO 14040 (ISO, 2006a) en ISO 14044 (ISO, 2006b)). On the European level these efforts resulted in standards, designed by CEN TC 350. From which for this assignment EN 15804 (CEN, 2012), EN 15643-2 (CEN, 2011a), EN 15942 (CEN, 2011b) and EN 15978 (CEN, 2011c) are the most important.

In this framework the FPS Health commissioned a project to VITO, the so-called LCA:TIM project[2] The LCA:TIM project consists of 4 main tasks:

Task 1 - Definition of product category rules
In the first task a set of specific rules, requirements and guidelines for the execution of LCAs and the creation of EPDs of insulation products for the building sector in Belgium are established. They are published in the form of Product Category Rules (PCR) for Thermal Insulation Materials on the Belgian Market. The objective of this PCR is to increase the comparability, accuracy and transparency of LCAs and EPDs created by different persons or instances.

Task 2 - Execution of life cycle assessments
In a second task LCAs are performed according to the PCR created in task 1. The LCAs are cradle-to-grave LCAs based on company specific data for insulation materials. The LCAs are made for 5 non-renewable insulation materials (rock wool, glass wool, EPS, XPS and PUR) and 5 renewable insulation materials (sheep wool, hemp, wood fiber, flax and cellulose). With the experiences gained during task 2, the PCR document of task 1 is updated.

Task 3 - Communication of the results
In a third task readable leaflets with environmental information (based on LCA) for all standard insulation materials for walls available on the Belgian market will be created. The leaflets are meant to inform (future) builders.

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[1] Health, safety of the foodchain, environment - DG5 Environment

[2] Het opstellen van regels, het uitvoeren van levenscyclusanalyses inclusief dataverzameling en het geven van beleidsaanbevelingen m.b.t. vijf niet-hernieuwbare (glaswol, rotswol, PUR, EPS, XPS) en vijf hernieuwbare (schapenwol, papiervlokken, vlasisolatie, houtvezelisolatie, hennepisolatie) thermische isolatiematerialen voor spouwmuren (bestek nr DG5/PP/DDL/11032)

Task 4 - Policy recommendations
In the last task recommendations towards policy makers will be formulated. This will include opportunities for improvement and possibilities for policy support measures. The recommendations concern the environmental impacts of of insulation materials for walls.

The advisory committee, as listed in the distribution list, served as an interactive platform to give feedback on the project process and the content. The advisory committee has been contacted on a regular basis and the LCA:TIM project team took into account their feedback as much as possible. The advisory committee did not have decision power on the endorsement of this document. The steering committee was in charge of the decisions during the execution of the study.

With the present document the project consortium is reporting on task 1 of the LCA:TIM project (Product Category Rules for Environmental Product Declarations for Thermal Insulation Materials on the Belgian Market).

This PCR is the result of a project commissioned by the FPS Health with the objective to develop a common operational methodology for thermal insulation materials on the Belgian market.

During the development of the Product Category Rules (PCR) for insulation materials on the Belgian market we fully used experiences from ongoing work within the European CEN TC 350 framework (especially the EN 15804 and related (pre)standards), the ISO 14025 guidelines on Type III environmental declarations, the ISO 14040 and ISO 14044 guidelines for LCA and the ISO 21930 on sustainability in building construction, environmental declaration of building products. Also the experiences and results from different specific LCA studies that will be carried out for 10 insulation materials applied in building walls representative on the Belgian market are used (Life cycle assessment of thermal insulation materials for walls in the Belgian building context, FPS Health, 2013).

On the Belgian market many actors are confronted with the problem of selecting insulation materials for specific applications. In order to include considerations regarding sustainability, information should be collected and made available in a precisely defined format. The aim of this document is to elaborate rules for describing the environmental impacts related to thermal insulation materials available on the Belgian building market.

Steering committee
The PCR has been prepared in commission of FPS Health. The following persons were part of the steering committee:

- Bram Soenen (FPS Health)
- Denis Pohl (FPS Health)
- Dieter De Lathauwer (FPS Health) – chair

Project team
The PCR has been prepared in commission of FPS Health. The following persons are part of the project team:

- Andrew Norton (Renuables)
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- Wim Debacker (VITO)

For an overview of the stakeholders and the advisory committee we refer to Annex 1 of this PCR.

Critical review

This PCR has been critically reviewed by stakeholders and external international experts (2.0- LCA Consultants and Renuables).

Period of validity

This PCR is valid until a change is communicated by FPS Health. The version of the PCR shall be mentioned on the EPD.

CHAPTER 2 TERMS AND DEFINITIONS

For the purposes of this document, the following terms and definitions are applied.

Additional technical information
Information that forms part of the EPD by providing a basis for the development of scenarios.

Biomass
Material of biological origin, excluding material embedded in geological formations or transformed to fossilized materials and excluding peat (adapted from ISO 14021, amendment 1).

Construction product
Item manufactured or processed for incorporation in construction works (adapted from ISO 6707-1:2004 and EN 15643-1:2010).

Comparative assertion
Environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function.

Co-product
Any of two or more marketable materials, products or fuels from the same unit process, but which is not the object of the assessment. Co-product, by-product and product have the same status and are used for identification of several distinguished flows of products from the same unit process. From co-product, by-product and product, waste is the only output to be distinguished as a non-product.

Construction element
Part of a construction containing a defined combination of products.

Declared unit
Quantity of a construction product for use as a reference unit in an EPD for an environmental declaration based on one or more information modules (adapted from ISO 21930:2007).

Environmental performance
Performance related to environmental impacts and environmental aspects (adapted from ISO 15392:2008 and ISO 21931-1:2010).

Functional equivalent

Quantified functional requirements and/or technical requirements for a building or an assembled system (part of works) for use as a basis for comparison (adapted from the definition in ISO 21931-1:2010).

Functional unit

Quantified performance of a product system for a building product for use as a reference unit in an EPD based on LCA (adapted from EN ISO 14040:2006).

Information module

Compilation of data to be used as a basis for a Type III environmental declaration, covering a unit process or a combination of unit processes that are part of the life cycle of a product (adapted from EN ISO 14025:2010).

Life cycle assessment (LCA)

Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (adapted from EN ISO 14044:2006).

Life cycle inventory analysis (LCI)

Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle (adapted from EN ISO 14040:2006).

Non-renewable energy

Energy from sources which are not defined as renewable energy sources.

Non-renewable resource

Resource that exists in a finite amount that cannot be replenished on a human time scale.

Product category

Group of building products that can fulfil equivalent functions.

Product category rules (PCR)

Set of specific rules, requirements and guidelines for developing Type III environmental declarations (EPDs) for one or more product categories (adapted from EN ISO 14025:2010).

Renewable energy

Energy from renewable non-fossil sources (examples: wind, solar, aero thermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases) (adapted from the definition in Directive 2009/28/EC).

Renewable resource

Resource that is grown, naturally replenished or naturally cleansed, on a human time scale. A renewable resource is capable of being exhausted, but may last indefinitely with proper stewardship (examples include: trees in forests, grasses in grassland, fertile soil) (adapted from ISO 21930:2007).

Renewable material

Material that is composed of biomass from a living source and that can be continually replenished (adapted from ISO 14021, amendment 1).

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 may form the basis of estimating the service life under other in-use conditions (adapted from ISO 21930:2007).

Scenario

Collection of assumptions and information concerning an expected sequence of possible future events.

Third party

Person or body that is recognized as being independent of the parties involved, as concerns the issues in question.

Type III environmental product declaration (EPD)

Environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional information for a given product.

CHAPTER 3 OBJECTIVE OF THE PCR

An EPD (Environmental product declaration) according to the standard EN 15804 provides quantified environmental information for building materials on a harmonized and scientific basis. It should also provide information on the release of dangerous substances to indoor air, soil and water during the use stage of the building.

The purpose of EPDs in the construction sector is to provide a basis for assessing the environmental performance of buildings and building elements and identifying those, which cause less stress to the environment. An EPD must be based on a Life Cycle Assessment (LCA). The requirements for these underlying LCAs are elaborated in CHAPTER 7 of this PCR.

The intended application of this PCR (Product Category Rules) is to give guidelines for carrying out environmental product declarations (EPDs) for thermal insulation materials on the Belgian building market and to set the rules for the underlying requirements of the LCA.

The user of this PCR will be manufacturers of thermal insulation materials for the building sector and other interested parties.

The objective of this PCR for thermal insulation materials on the Belgian building market is to ensure:

- the provision of verifiable and consistent data for EPD, based on LCA (Life Cycle Assessment) covering the cradle-to-gate life cycle phases of the insulation material;
- the provision of verifiable and consistent product related technical data or scenarios for the assessment of the environmental performance of thermal insulation materials for the building sector;
- the provision of verifiable and consistent product related technical data or scenarios potentially related to the health of users for the assessment of the performance of thermal insulation materials for the building sector;
- the communication of the environmental information of thermal insulation materials for the building sector from business to business;
- the basis for the communication of the environmental information of thermal insulation materials for the building sector to consumers (subject to additional requirements).

The EPDs that are made based on this PCR can be used as an input source for a more comprehensive LCA for a building or building element (e.g. building wall) or any other construction works, if the inventory data are documented and made publicly available.

This PCR is valid for all insulation materials that can be applied for thermal insulation in buildings and is in compliance with:

- the standard EN 15804, Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products;
- the requirements of ISO 14025, Environmental labels and declarations – Type III environmental declarations – Principles and procedures;
- the provisions in ISO 14040 and the ISO 14044 series of standards, Environmental management — Life cycle assessment;

unless stated otherwise in this PCR.

The PCR is also based on experiences gained during several company specific LCA studies of thermal insulation materials for building walls carried out within the project framework for the FPS Health (LCA of 10 insulation materials – LCA:TIM[3]).

The overall aim of the LCA:TIM project is to develop readable data sheets with environmental information (based on LCA) for standard insulation materials for wall insulation available on the Belgian market. The leaflets are meant to inform (future) builders. In order to develop these data sheets it was decided to appeal to some practical experiences with LCAs for walls. The LCAs are cradle-to-grave LCA based on company specific data for the production of the insulation materials: 5 LCAs for building application with non-renewable insulation materials (rock wool, glass wool, EPS, XPS and PUR) and 5 LCAs for building application with renewable insulation materials (sheep wool, hemp, wood fiber, flax and paper flakes). This PCR takes into account the experiences gained during these LCAs.

[3] voor het FOD Volksgezondheid & Leefmilieu project "Opstellen van regels, het uitvoeren van levenscyclusanalyses inclusief dataverzameling en het geven van beleidsaanbevelingen m.b.t. vijf niet-hernieuwbare (glaswol, rotswol, PUR, EPS, XPS) en vijf hernieuwbare (schapenwol, papiervlokken, vlasisolatie, houtvezelisolatie, hennepisolatie) thermische isolatiematerialen voor spouwmuren."

CHAPTER 4 PRODUCT CATEGORY DEFINITION

This PCR is valid for all thermal insulation materials which are available on the Belgian building market.

The product group "thermal insulation materials in Belgium" includes all kind of thermal insulation materials prepared for trade. Some examples are:

- Cellular glass;
- Cotton;
- EPS;
- Flax;
- Glass wool;
- Grass;
- Hemp;
- Perlite;
- PIR;
- PUR;
- (Recycled) paper;
- (Recycled) textiles;
- Rock wool;
- Sheep wool;
- Straw;
- UF;
- Vermiculite;
- Wood;
- XPS;
- ...

The following information shall be valid for EPDs following this PCR:

Product group
The product group includes "thermal insulation materials for building applications".

Technical performance
The main technical data and properties of insulation materials will be given.

Life cycle stages considered (cradle to gate)
Product stage (raw materials supply, transportation to manufacturer, manufacturing and packaging).

CHAPTER 5 OMPARABILITY OF EPDS FOR INSULATION MATERIALS

In principle the comparison of insulation materials on the basis of their EPD is defined by the contribution they make to the environmental performance of the building. Consequently comparison of the environmental performance of thermal insulation materials using the EPD information shall be based on the insulation material's use in and its impacts on the building, and shall consider the complete life cycle from the cradle to the grave: product stage, construction process stage, use stage and end-of-life stage.

Comparisons are possible at the sub-building level, e.g. for building elements, assembled systems, building components, building products for one or more life cycle stages. In such cases the principle that the basis for comparison of the assessment is the entire building, shall be maintained by ensuring that:

- the same functional requirements as defined by legislation or in the client's brief are met, and;
- the environmental performance and technical performance of any assembled systems, components, or products excluded are the same, and;
- the amounts of any material excluded are the same, and;
- excluded processes or life cycle stages are the same, and;
- the influence of the product systems on the operational aspects and impacts of the building are taken into account.

The information provided for such comparison shall be transparent to allow the purchaser or user to understand the limitations of comparability. A justification shall be given for any excluded aspects.

CHAPTER 6 ADDITIONAL INFORMATION

In this PCR the following three categories of additional information which are not directly derived from the underlying LCA also need to be addressed. The additional technical information and the additional information on emissions to indoor air, soil and water during the use phase are directly taken from the EN 15804. The additional information on biogenic CO2 is added in the framework of this PCR for thermal insulation materials.

- **Additional technical information**, describing technical conditions underlying scenarios and characterizing the insulation material's technical and functional performance during the optional life cycle stages (construction, use and the end-of-life (EOL)) or any scenario based calculations of the LCA based parameters (see also chapter 8 of this PCR for further guidance):
  - Additional technical information supports the consistent development of scenarios by which the LCA derived parameters of the optional life cycle stages can be calculated and declared;
  - However the manufacturer may choose to declare additional technical information without calculating optional life cycle stages to ensure proper understanding of a product's function in a building and thus support proper scenario development at the building level;
  - If optional life cycle stages, (e.g. end of life stage in a "cradle-to gate with options" or "cradle-to-grave") are declared in the EPD, the scenarios to which the calculated parameters relate shall be specified according to paragraph 7.3 of the EN 15804 and be included in the EPD.
  - Additional technical information is declared in the module to which it refers (e.g. technical information about the use of the insulation material in the appropriate use stage);
  - Any additional technical information shall be documented separately from the LCA derived parameters;
  - If an EPD claims to cover all life cycle stages, all relevant optional modules shall be calculated for specified scenarios and the LCA derived parameters shall be declared.
  - If additional technical information is not complete at the product level this shall be stated.

- **Additional information on emissions to indoor air, soil and water during the use stage**, describing release of dangerous substances into indoor air, soil and water which are not covered by LCIA. This additional information is required:

  - Indoor air: the following information shall be provided for insulation materials exposed to indoor air after their installation in buildings during the use stage in order to support use stage scenarios with respect to health at the building level:
    - ✓ Emissions to indoor air, according to the horizontal standards on measurement of release of regulated dangerous substances from construction products using harmonised testing methods according to the provisions of the respective Technical Committees for European product standards, when available (CEN TC 351).

- ✓ If the horizontal standards on measurement of release of regulated dangerous substances from construction products using harmonised test methods according to the provisions of the respective technical committees for European product standards are not available, the EPD can lack this information (CEN TC 351).

- ○ Soil and water: the following information shall be provided for insulation materials exposed to soil and water after their installation in buildings during the use stage in order to support use stage scenarios for soil and water pollution at the building level:
  - ✓ Release to soil and water according to the horizontal standards on measurement of release of regulated dangerous substances from construction products using harmonised testing methods according to the provisions of the respective Technical Committees for European product standards, when available (CEN TC 351).
  - ✓ If the horizontal standards on measurement of release of regulated dangerous substances from construction products using harmonised test methods according to the provisions of the respective technical committees for European product standards are not available, the EPD can lack this information (CEN TC 351).

The EPD does not need to give this information if the horizontal standards on measurement of release of regulated dangerous substances from construction products using harmonised test methods according to the provisions of the respective technical committees for European product standards are not available. At the time this PCR was created (March 2013), the horizontal standards were not yet available.

- **Additional information** on biogenic CO_2, describing biogenic CO_2 uptake and sequestration:

  - ○ Biogenic CO_2 uptake:
    The biogenic CO_2 that is taken up during cultivation or growth of the renewable materials is assumed to be released again at the EOL. Since we consider the product stage and the EOL stage, the net balance of biogenic CO_2 will be neutral. Therefore it is decided not to consider biogenic CO_2 uptake and release in the LCA calculations. However in the EPD the results about biogenic uptake will be presented as additional information. Carbon uptake describes the uptake and release of CO_2 by plants. In this project the Phyllis database is used to determine the quantity of carbon in natural materials (http://www.ecn.nl/phyllis/single.html).

  - ○ Biogenic CO2 sequestration:
    Results about carbon sequestration will be presented as additional information. Biogenic sequestration describes the gain for the environment of CO_2 sequestration during the lifetime of plant based materials, according to ILCD handbook, PAS 2050, aspects of ISO 14044:2006 chapters 4.2.3.5, 4.2.3.6.2 and 4.3.2.1.
    The inventorying is done as follows: the duration for which LCIA impacts of released emissions is calculated, is typically explicitly or implicitly indefinite. Exclusively in case of the Global Warming Potential (GWP) the much shorter perspective “GWP 100 years” is widely used.
    The related characterisation factors used are typically those provided as part of the Intergovernmental Panel on Climate Change (IPCC) reports. Source: ILCD Handbook 7.4.3.7.3.

Carbon sequestration is modelled as a Correction flow for delayed emission of carbon dioxide (within first 100 years) as “Emissions to air”. It is measured in the flow property “Mass*years” and the reference unit “kg*a”. The flow is to carry a GWP 100 impact factor of “-0.01 kg CO_2-equivalents” per 1 kg*a. The information about the assumed time of emission and the actual amount of the emission shall be documented in the unit process and hence available for review.
These new elementary flows should be used in addition to the normal elementary flows including the flow “Carbon dioxide” as “Resources from air” that model the physical uptake of CO_2 into biomass. Source: ILCD Handbook 7.4.3.7.3.

CHAPTER 7 REQUIREMENTS FOR THE UNDERLYING LCA

Life cycle assessment (LCA) is a methodology that allows the evaluation of the environmental effects of a product, considering all the relevant stages in its life cycle. An LCA should be, in principle, starting from the mining of raw materials to the waste dumping ('cradle to grave'), and going through the manufacturing, use and eventual re-use or recycling processes.

In a cradle to grave LCA a functional unit considering all cradle to grave processes must be defined. Nevertheless, in that case a well-defined function (or more) should be taken into account, e.g. thermal insulation for a building wall, roof or floor. Because in these applications thermal insulation is combined with different materials/building components, different solutions based on the same functional unit are difficult to comply.

The LCA practitioner will have to decide: a theoretical LCA based on exactly the same function(s), or a more pragmatic approach where he/she acknowledges the different performances of practical solutions.

EPDs according to this PCR shall at least communicate on the product stage (**cradle to gate**). The underlying LCA for the product stage shall include:

- Raw materials production or cultivation (supply);
- Transport of the raw materials to manufacturer;
- Manufacturing of the insulation materials;
- Packaging of the insulation materials.

EPDs can also be developed but looking at the additional life cycle phases:

- cradle to gate with options: the product stage and selected further life cycle stages. Such an EPD is said to be "cradle to gate with options" and becomes an EPD based on the product stage plus other selected optional modules, e.g. end-of-life information modules.
- cradle to grave: in this case the EPD covers the product stage, installation into the building, use and maintenance, replacements, demolition, waste processing for re-use, recovery, recycling and disposal, and disposal and is said to be 'cradle to grave' and becomes an EPD of construction products based on a LCA, covering the entire life cycle.

7.1. GOAL AND SCOPE DEFINITION

In the first phase of the LCA-study, the intended use of the LCA (the goal) and the breadth and depth of the study (the scope) have to be clearly defined. The scope definition has to be consistent with the goal of the study. In the following paragraphs aspects that should be clearly and unambiguous agreed upon at the start of the study are shortly discussed (ISO 14040 / ISO 14044).

The *goal definition* of an LCA must include a clear and unambiguous description of:

- the reasons for carrying out the LCA;
- the intended use of its results;
- the audience(s) to which the results are intended to be communicated.

In the *scope definition* of an LCA, the following items must be considered and clearly described:

- the product system to be studied;
- the functions of this product system;
- the functional unit;
- the product system boundaries;
- allocation procedures;
- types of impact and methodology of impact assessment, and subsequent interpretation to be used;
- data requirements;
- data quality requirements;
- assumptions;
- limitations;
- type of critical review, if any;
- type and format of the report required for the study.

The scope should be sufficiently well-defined to ensure that the breadth, the depth and the detail of the study are compatible and sufficient to address the goal.

The paragraphs below outline some guidelines for the definition of the goal and scope of the LCA underlying EPDs created according to this PCR.

7.1.1. FUNCTION OF THE PRODUCT SYSTEM, FUNCTIONAL AND DECLARED UNIT

A functional unit defines the way in which the identified ‘functions’ or ‘performance characteristics’ of the product are quantified. The primary purpose of the functional unit is to provide a reference by which material flows (input and output data) of a construction product’s LCA results and any additional information are normalised to produce data expressed on a common basis.

Due to the fact that it will be impossible for realistic day-to-day construction techniques to obtain identical functional solutions for thermal insulation materials in Belgium, the functional unit in a cradle to grave LCA for an insulation material will primarily be based on the thermal performance of the insulation material. Qualitatively the other performance characteristics can be defined too: acoustics, moister buffering, impact resistance, etc.

A declared unit is used instead of the functional unit when the **precise function** of the product **or scenarios** for its life cycle stages at the building level are not stated or unknown (EN 15804). Since only the product stage is mandatory in this PCR, a declared unit will be used for the cradle-to-gate EPD that is based on this PCR.

A declared unit is defined based on an expected value (declared) of thermal property of the insulation material assessed from measured data at reference conditions of temperature and humidity.

Cradle to gate EPD (mandatory) => declared unit (DU)

The declared unit (cradle-to-gate) is: 1 m^2 of a thermal insulation material with a thickness that gives a declared thermal resistance of 1 (R = 1 m^2K/W).

The weight density (kg/m^3) should be specified in the EPD.

The weight (kg) should be specified in the EPD.

The thermal conduction (λ_d in W/mK) should be specified in the EPD and proven with a valid technical agreement.

Packaging of the insulation material will be included.

The application of the thermal insulation material will be described in the EPD.

Cradle to gate EPD with options and Cradle to grave EPD (optional) => functional unit (FU)

The functional unit (cradle-to-gate with options/cradle-to-grave) is: 1 m^2 of a thermal insulation material with a thickness that gives a design thermal resistance of 1 (R = 1 m^2K/W) and with an expected average reference service life of 60 years.

The weight density (kg/m^3) should be specified in the EPD.

The weight (kg) should be specified in the EPD.

The thermal conduction (λ_d in W/mK) should be specified in the EPD and proven with a valid technical agreement.

Packaging of the insulation material will be included.

The application of the thermal insulation material will be described in the EPD.

The declared unit (cradle-to-gate) and the functional unit (cradle-to-gate with options, cradle-to-grave) can be expressed as:

$FU = DU = R \cdot \lambda \cdot \rho \cdot A$ [kg]

where;

R = thermal resistance [m^2K/W]
λ = thermal conduction [W/mK]
ρ = density of insulation product [kg/m^3]
A = Area [m^2], here 1 m^2.

For some insulation materials the environmental impacts related to other R-values (different than 1 m^2K/W) can be found by simple multiplication. In that case the insulation material has the same technical performance characteristic for variety of R-values. In the EPD a table for different insulation thicknesses may be worked out showing the factor the environmental impacts for R = 1 has to be multiplied to give the corresponding environmental impacts for a given thickness.

For other insulation materials it is not that straightforward: changing R-values will also change the technical performance characteristics of the insulation material. Often different production processes are needed. In that case different EPDs should be made for the same insulation material, with a different R-value, having other technical performance characteristics.

Cradle-to-gate EPD shall be as specific as possible. For instance for certain insulation materials there will be limited modification to the production of the insulation material itself for use in a variety of applications and one EPD will be sufficient. However for others there are fundamental changes needed in the production and composition for use in different building applications. In that case there is a need to have separate EPDs or sub- sections in one EPD with separate tables to make sure the EPD data are relevant for the application focused on.

Cradle-to-gate EPDs based on this PCR, declaring the environmental impacts of the insulation materials per m^2 for an R-value of 1 shall also describe the minimum level of ancillary materials (e.g. membranes or barriers) that are required in specific applications.

7.1.2. SYSTEM BOUNDARIES

The LCA based information in an EPD may cover several life cycle stages: product stage, construction process stage, use stage and end of life stage.

An EPD for thermal insulation materials available on the Belgian building market with reference to this PCR, shall at least communicate on the product stage (cradle-to-gate EPD).

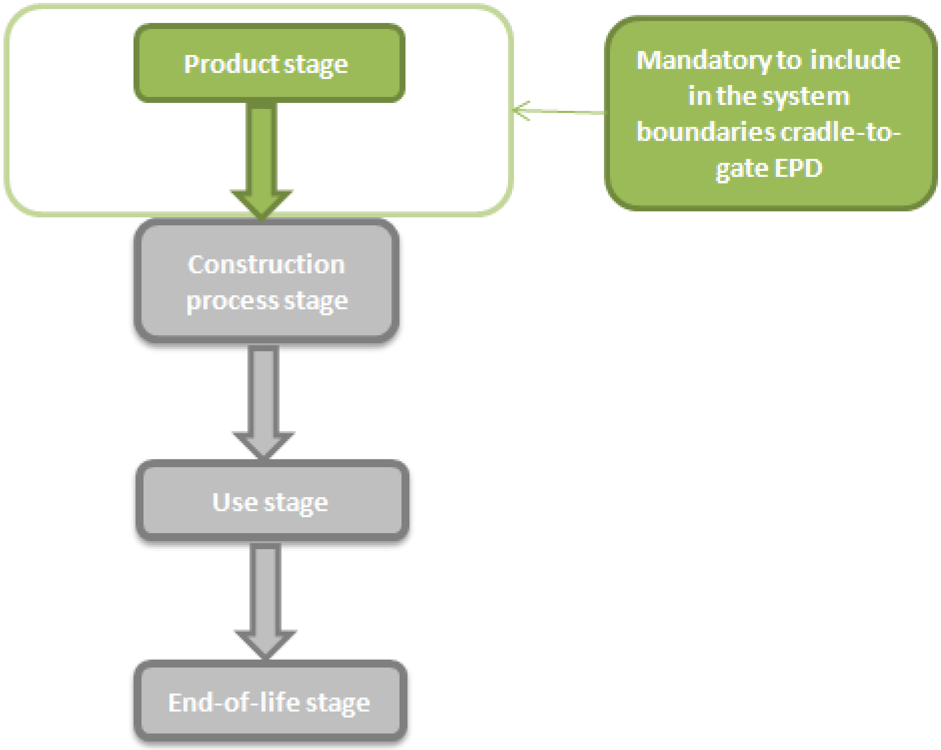

Figure 1: System boundaries

Types of EPD with respect to life cycle stages covered

The LCA based information in an EPD may cover (see Figure 2):

- The product stage only. Such an EPD covers raw material supply, transport, manufacturing and associated processes; this EPD is said to be “cradle to gate” and becomes an EPD based on information modules A1 to A3;
- The product stage and selected further life cycle stages. Such an EPD is said to be “cradle to gate with options” and becomes an EPD based on information modules A1 to A3 plus other selected optional modules, e.g. end-of-life information modules C1 to C4. Information module D may be included in this EPD;
- The life cycle of a product according to the system boundary (see 6.3.4). In this case the EPD covers the product stage, installation into the building, use and maintenance, replacements, demolition, waste processing for re-use, recovery, recycling and disposal, and disposal and is said to be 'cradle to grave' and becomes an EPD of construction products based on a LCA, i.e. covering all information modules A1 to C4. In this EPD the information module D may be included.

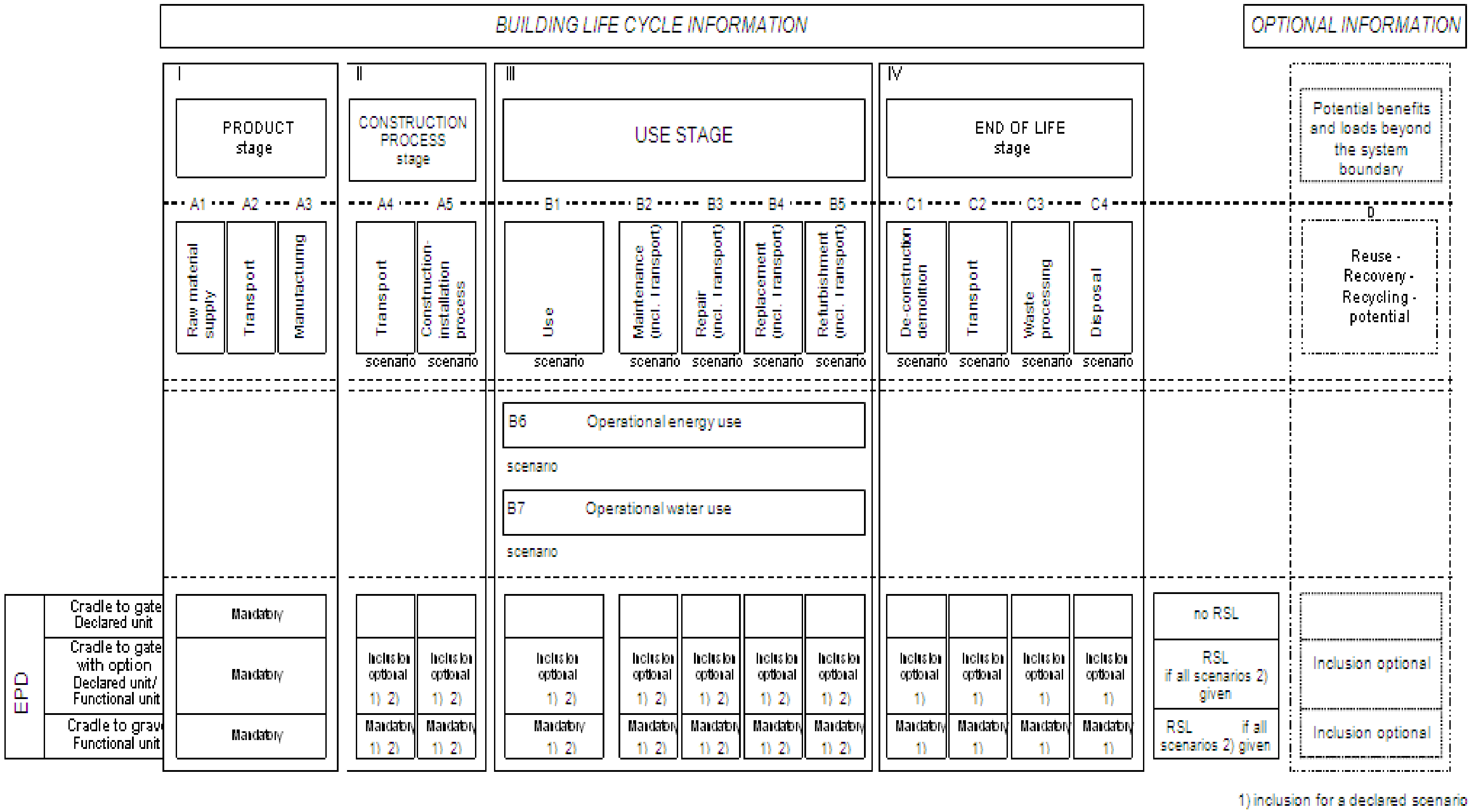

Figure 2: Overview of the different information modules according to EN 15804

In the underlying LCA studies based on this PCR for thermal insulation materials for building applications the following life cycle stages can be included (CEN TC 350 framework documents, EN 15804):

- **Product stage (mandatory to declare in the EPD from cradle-to-gate)**: The product stage includes (Module A, sections A1, A2 and A3):
  - A1, raw material extraction, cultivation and processing, processing of secondary material input (e.g. recycling processes),
  - A2, transport to the manufacturer,
  - A3, manufacturing, including packaging,

  including provision of all materials, products and energy, as well as waste processing up to the end-of waste or disposal of final residues during the product stage.

- **Construction process stage (optional to declare)**: The construction process stage includes (Module A, sections A4, A5):
  - A4, transport to the building site;
  - A5, installation into the building;

  including provision of all materials, products and energy, as well as waste processing up to the end-of-waste state or disposal of final residues during the construction process stage. These information modules also include all impacts and aspects related to any losses during this construction process stage (i.e. production, transport, and waste processing and disposal of the lost products and materials).

- **Use stage (optional to declare):**

  The use stage, related to the **building fabric** includes (Module B, sections B1, B2, B3, B4 and B5):
  - B1, use or application of the installed product;
  - B2, maintenance;
  - B3, repair;
  - B4, replacement;
  - B5, refurbishment;

  including provision and transport of all materials, products and related energy and water use, as well as waste processing up to the end-of-waste state or disposal of final residues during this part of the use stage. These information modules also include all impacts and aspects related to the losses during this part of the use stage (i.e. production, transport, and waste processing and disposal of the lost products and materials).

  The use stage related to the **operation of the building** includes (Module B, sections B6 and B7):
  - B6, operational energy use (e.g. operation of heating system and other building related installed services);
  - B7, operational water use;

  These information modules include provision and transport of all materials, products, as well as energy and water provisions, waste processing up to the end-of-waste state or disposal of final residues during this part of the use stage.

- **End of life stage (optional to declare)**: The end-of-life stage includes:
  - C1, de-construction, demolition:
  - C2, transport to waste processing;
  - C3, waste processing for reuse, recovery and/or recycling;
  - C4, disposal;

including provision and all transports, provision of all materials, products and related energy and water use.

- **Benefits and loads beyond the system boundary (optional to declare).** Module D includes:
  - D, reuse, recovery and/or recycling potentials, expressed as net impacts and benefits.

7.1.3. DATA REQUIREMENTS

The EPD describes a specific product and shall therefore be calculated using specific data for at least the processes the producer of the specific product has influence on. Generic data may be used for the processes the producer cannot influence e.g. processes dealing with the production of input commodities, e.g. raw material extraction or electricity generation, often referred to as upstream data. Documentation of technological, geographical and time related representativeness for generic data shall be provided in the project report.

→ **Description of data**

The use of specific or average background data shall be documented. As a rule the following distribution will be applied:

- Average background data: for the production of all materials except the insulation materials;
- Specific data: for manufacturing of the insulation material;
- The mix of electricity used is the official one in the country where main energy consuming processes take place, if site-specific data cannot be obtained. The mix of electricity (calculation procedure) is documented in the next chapter on LCI. Green electricity has been considered if proved;
- Hazardous waste shall be specified according to EU Directives 91/689/EEC and 75/442/EEC (specific and/or average background).

Documentation of technological, geographical and time related representativeness for generic data shall be provided in the life cycle inventory.

Data quality requirements for insulation materials can differ from those used for the other materials that were treated as background processes (secondary data).

- For insulation materials company specific data shall be used – primary data;
- For the other materials that are part of the application (e.g. an insulated wall), secondary data can be used.

→ **Criteria for inclusion of inputs and outputs**

Criteria for the exclusion of inputs and outputs (cut-off rules) shall not be applied in order to hide data. All inputs and outputs to a (unit) process shall be included in the calculation, for which data are available. Data gaps shall be filled by conservative assumptions with average or generic data. Any assumptions for such choices shall be documented.

For example: for the production of the insulation materials in the LCA:TIM project all raw materials are listed in the inventory, even if the amount (mass percentage) is relatively small. No cut-off rules are applied for the production of the insulation materials.

→ **Data quality requirements**

The quality of the data used to calculate an EPD shall be addressed in the project report (see paragraph 8 of the EN 15804 and ISO 14044:2006, paragraph 4.2.3.6). In addition the following specific requirements apply for insulation products:

- Data shall be as current as possible. Data sets used for calculations shall have been updated within the last 10 years for generic data and within the last 5 years for producer specific data.
- Data sets shall be based on 1 year averaged data. Deviations shall be justified and documented.
- The time period over which inputs to and outputs from the system shall be accounted for is 100 years from the year for which the data set is deemed representative. A longer time period shall be used if relevant.
- The technological coverage shall reflect the physical reality for the declared product.
- Generic data shall be checked for plausibility by the verifier of the EPD. This verification process is simplified when pre-verified generic data are used.

In the LCA:TIM project the following specific rules and approaches were applied:

- The ecoinvent database (version 2012, v2.2) is consulted for environmental data of the other wall component (e.g. bricks, plaster) and the auxiliary materials (e.g. mortar, screws).
- Due to a lack of Belgian life cycle inventory (LCI) data, the generic LCI-data from the ecoinvent database are adapted to the Belgian context according to the MMG project (Debacker et al., 2012). For the production of materials processes representative for Western Europe will always be chosen to guarantee the geographical representativeness.
- If there are no Western European processes available in the database, country specific data have been used. However the energy mix used in those data as well as the transportation modes used, have been replaced by respectively the European electricity mix and European transportation steps. By production is meant only the production of the specific product. The electricity mix of the underlying processes (e.g. production of raw materials which are used in the production process) will not be modified to the Western European version. Sensitivity analyses demonstrate that changing the electricity mix of the underlying processes does not have a significant influence on the result (Spirinckx, 2009).
- Data quality requirements for insulation materials differed from those used for the other materials that were treated as background processes (secondary data).
  - For insulation materials company specific data are used – primary data;
  - For the other materials that are part of the wall, secondary data are used – in this study the ecoinvent data records (ecoinvent database -version 2012, v2.2).
- Per wall type the same ecoinvent datarecords are used for all materials (except the insulation materials). If comparisons in task 3 are made, this will not induce important data quality inconsistencies, since the focus of this project is on insulation materials and the results are mainly communicated on that level.
- Accuracy: for all data we decided to use 5 significant digits.

7.1.4. CRITICAL REVIEW

A critical review is a process to verify whether an LCA has met the requirements of international (ISO) standards for methodology, data collection and reporting. Whether and how a critical review will be conducted should be specified in the scope of the study.

Three types of critical review are defined by ISO 14040 and ISO 14044. One can decide on the type of critical review:

- internal review, performed by an internal expert independent of the LCA-study;
- expert review, performed by an external expert independent of the LCA-study;
- review by interested parties, performed by a review panel chaired by an external independent expert - the panel includes interested parties that will be affected by conclusions drawn from the LCA-study, such as government agencies, non-governmental groups or competitors.

Critical review by internal expert
A critical review may be carried out by an internal expert. In such a case, an expert independent of the LCA shall perform the review. The review statement, comments of the practitioner and any response to recommendations made by the reviewer shall be included in the LCA background report.

Critical review by an external expert
A critical review may be carried out by an external expert. In such a case, an external expert independent of the LCA shall perform the review. The review statement, comments of the practitioner and any response to recommendations made by the reviewer shall be included in the LCA background report.

Critical review by panel of interested parties
A critical review may be carried out as a review by interested parties. In such a case, an external independent expert should be selected by the original study commissioner to act as chairperson of a review panel of at least three members. Based on the goal and scope of the study, the chairperson should select other independent qualified reviewers. This panel shall include other interested parties affected by the conclusions drawn from the LCA, such as government agencies, non-governmental groups, competitors and affected industries. For the life cycle impact assessment (LCIA), the expertise of reviewers in the scientific disciplines relevant to the important impact categories of the study, in addition to other expertise and interest, shall be considered. The review statement and review panel report, as well as comments of the expert and any responses to recommendations made by the reviewer or by the panel, shall be included in the LCA-report.

When an LCA-study will be used to make a comparative assertion that is disclosed to the public, the ISO-standards require a critical review by interested parties to be conducted. In all other cases, critical reviews in LCA are optional and may utilize any of the three review options mentioned above.

7.1.5. VERIFICATION

Data availability for verification

To facilitate verification it is considered good practice to make the following information available to the verifier, taking into account data confidentiality according to ISO 21930:2007 (paragraph 7.4 and 9.1):

- analysis of material and energy flows to justify their inclusion or exclusion;
- quantitative description of unit processes that are defined to model processes and life cycle stages of the declared/functional unit;
- attribution of process and life cycle data to datasets of an LCA-software (if used);
- LCIA results per modules of unit processes, e.g. structured according to life cycle stages;
- LCIA results per production plant/product if generic data is declared from several plants or for a range of similar products;
- documentation that substantiates the percentages or figures used for the calculations in the end-of-life scenario;
- documentation that substantiates the percentages and figures (number of cycles, prices, etc.) used for the calculations in the allocation procedure, if it differs from the PCR.

Verification and validity of an EPD

Type III Environmental Product Declarations shall be verified according to transparent procedures established by the programme operator (not yet available in Belgium). The independent verification shall as a minimum confirm the following:

- Conformance with this PCR;
- Conformance with ISO 14040 series of standards;
- Conformance with general programme instructions for the Type III environmental declaration;
- That data evaluation includes coverage, precision, completeness, representativeness, consistency, reproducibility, sources and uncertainty;
- The plausibility, quality and accuracy of the LCA-based data;
- The quality and accuracy of additional environmental information;
- The quality and accuracy of the supporting information.

After verification an EPD is valid for a 5 year period from the date of issue, after which it shall be reviewed and verified. An EPD shall only be reassessed and updated as necessary to reflect changes in technology or other circumstances that could alter the content and accuracy of the declaration.
An EPD does not have to be recalculated after 5 years, if the underlying data has not changed significantly. The process for verification and establishing the validity of an EPD shall be in accordance with EN ISO 14025 and ISO 21930.

Note: a reasonable change in the environmental performance of a product to be reported to the verifier is +/- 10% on any one of the declared parameters of the EPD. Such a change may require an update of the EPD.

7.2. INVENTORY ANALYSIS

The inventory analysis involves data collection and calculation procedures to quantify the inputs and outputs that are associated with the product system under study. This includes use of resources, releases to air, water and soil. Procedures of data collection and calculation should be consistent with the goal and the scope of the study. The results of the inventory analysis may constitute the input for the life cycle assessment as well as an input for the interpretation phase.

Input and output data have to be collected for each process that is included in the system boundaries. After collection, the data for the different processes have to be related to the declared unit and aggregated over the life cycle phases considered in the underlying LCA.

Inventory analysis is an iterative process. As data are collected and the system is better known, new data requirements or limitations may become apparent. This may require better or additional data to be collected or system boundaries to be refined.

7.2.1. DATA COLLECTION

The data collection process focuses on the life cycle stages as mentioned in 7.1.2.

The data collection shall follow the guidance provided in EN ISO 14044:2006, 4.3.2. Qualitative and quantitative data for inclusion in the inventory shall be collected for each unit process that is included within the system boundaries (product stage, transportation to construction site and end-of-life stage). The collected data, whether measured, calculated or estimated, are utilized to quantify the inputs and outputs of a unit process.

When data have been collected from public sources, the source shall be referenced. For those data that may be significant for the conclusion of the study, details about the relevant data collection process, the time when data have been collected, and further information about data quality indicators shall be referenced. If such data do not meet the data quality requirements, this shall be stated.

To avoid misunderstanding, it is important to describe each process (input and output flows) and to draw process flow diagrams that outline the unit process and their interrelationships.

The inventory phase within the LCA:TIM project is performed according to the ISO14040 and ISO14044 (data inventory) standards (ISO, 2006a and b). The LCA study is representative for Belgium and therefore most inventory data are representative for the Belgian context. For background data European data have been used. The used LCI data are consistently reported in this chapter so that they can be reproduced. The data collection of the different insulation materials is performed by the manufacturers together with the project team and described in more detail in the final LCA background report (task 2 of the LCA:TIM project). For data on the other wall elements the ecoinvent database (version 2012, v2.2) has been used.

Examples of data collection sheets can be find in Annex A of ISO 14044:2006 or in the final LCA background report of the LCA:TIM project (task 2 - Life cycle assessment of thermal insulation materials for walls in the Belgian building context).

7.2.2. CALCULATING DATA

The calculation procedures described in ISO 14044 shall apply. The same calculation procedures shall be applied consistently throughout the study. When transforming the inputs and outputs of combustible material into inputs and outputs of energy the net calorific value of fuels shall be applied according to scientifically based and accepted values specific to the combustible material.

7.2.3. ALLOCATION PROCEDURES

→ General

Most industrial processes produce more than the intended product. Normally more than one input is needed to produce one product and sometimes products are co-produced with other products. Intermediate and discarded products can be recycled to become inputs for other processes. When dealing with systems involving multiple products and recycling processes, allocation should be avoided as far as possible. Where unavoidable, allocation should be considered carefully and should be justified.

In this PCR, the rules for allocation are based on the guidance given in ISO 14044:2006, 4.3.4. However, the basic procedures and assumptions used in ISO 14044 have been refined in order to reflect the goal and scope of the EN 15804.

The use of upstream data, which does not respect the allocation principles described in this standard shall be clearly stated and justified in the project report. These data shall be in line with EN 15804 allocation rules. The principle of modularity shall be maintained. Where processes influence the product's environmental performance during its life cycle, they shall be assigned to the module in the life cycle where they occur. The sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation. This means no double counting or omission of inputs or outputs through allocation is permitted.

→ Co-product allocation

Allocation shall be avoided as far as possible by dividing the unit process to be allocated into different sub-processes that can be allocated to the co-products and by collecting the input and output data related to these sub-processes.

If a process can be sub-divided but respective data are not available, the inputs and outputs of the system under study should be partitioned between its different products or functions in a way which reflects the underlying physical relationships between them; i.e. they shall reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system.

In the case of joint co-production, where the processes cannot be sub-divided, allocation shall respect the main purpose of the processes studied, allocating all relevant products and functions appropriately. The purpose of a plant and therefore of the related processes is generally declared in its permit and should be taken into account. Processes generating a very low contribution to the overall revenue may be neglected.

Joint co-product allocation shall be allocated as follows:

- Allocation shall be based on physical properties (e.g. mass, volume) when the difference in revenue from the co-products is low;
- In all other cases allocation shall be based on economic values;
- Material flows carrying specific inherent properties, e.g. energy content, elementary composition (e.g. biogenic carbon content), shall always be allocated reflecting the physical flows, irrespective of the allocation chosen for the process.

Contributions to the overall revenue of the order of 1% or less is regarded as very low. A difference in revenue of more than 25 % is regarded as high.

Within the LCA:TIM project (task 2 - Life cycle assessment of thermal insulation materials for walls in the Belgian building context) the joint co-product allocation in case of for example sheep wool has been based on economic allocation. The prices of wool and meat have been taken into consideration.

→ **Allocation procedure of reuse, recycling and recovery**

According to EN 15804 the end-of-life system boundary of the construction product system is set where outputs of the system under study, e.g. materials, products or construction elements, have reached the end-of-waste point. Therefore, waste processing of the material flows (e.g. undergoing recovery or recycling processes) during any module of the product system (e.g. during the production stage, use stage or end-of-life stage) are included up to the system boundary of the respective module.

Where a secondary material or fuel crosses the system boundary e.g. at the end-of-waste state and if it substitutes another material or fuel in the following product system, the potential benefits or avoided loads can be calculated based on a specified scenario which is consistent with any other scenario for waste processing and is based on current average technology or practice. If today’s average is not available for the quantification of potential benefits or avoided loads, a conservative approach shall be used.

Within the LCA:TIM project (task 2 - Life cycle assessment of thermal insulation materials for walls in the Belgian building context) allocation for recycling was needed for example for the use of glass cullets for the production of glass wool. In that case the crushing of the glass waste into glass cullets and the transportation of the glass cullets from the crusher to the glass wool production plant are allocated to the glass wool insulation. Transportation of glass waste to the crusher is allocated to the life cycle that used the glass. This is also called the recycled content approach which is in line with the EN 15804 (end of waste status).

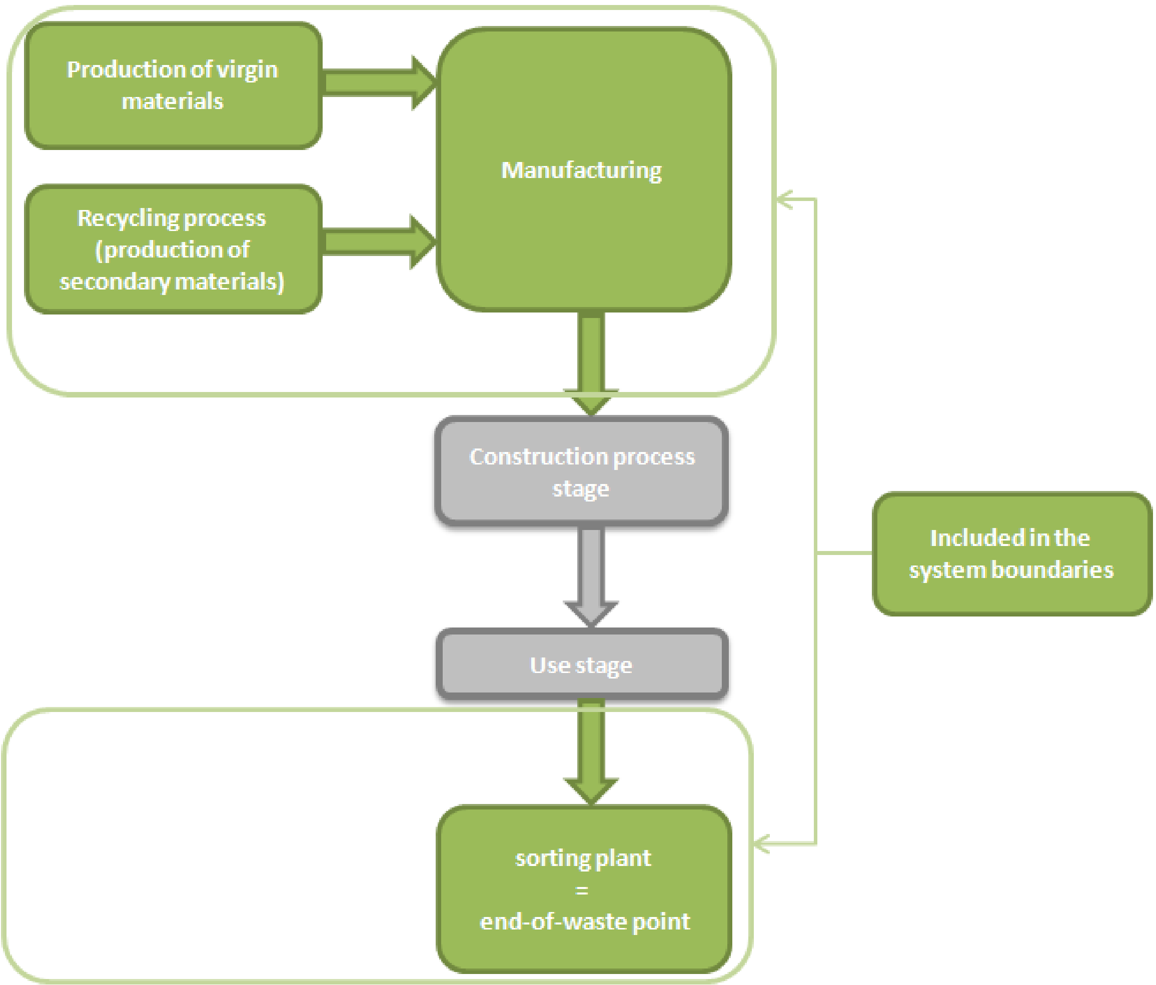

Figure 3: Illustration of the boundaries in case of reuse, recycling and recovery

7.2.4. BENEFITS AND LOAD BEYOND THE SYSTEM BOUNDARY (SEE MODULE D IN FIGURE 2 OF THIS PCR)

Where relevant, in the informative module D of the EN 15804 one can declare potential loads and benefits of secondary material, secondary fuel or recovered energy leaving the product system. Module D recognises the "design for reuse, recycling and recovery" concept for buildings by indicating the potential benefits of avoided future use of primary materials and fuels while taking into account the loads associated with the recycling and recovery processes beyond the system boundary.

The amount of secondary material output, which is for all practical purposes able to replace one to one the input of secondary material as closed loop is allocated to the product system under study and not to module D in the EN 15804.

Information module D aims at transparency for the environmental benefits or loads resulting from reusable products, recyclable materials and/or useful energy carriers leaving a product system e.g. as secondary materials or fuels.

Any declared net benefits and loads from net flows (for calculation of the net amounts see 6.4.3.3) leaving the product system that have not been allocated as co-products and that have passed the end-of-waste state shall be included in module D.

Avoided impacts from allocated co-products shall not be included in Module D.

7.2.5. MODELLING OF BIOGENIC CARBON UPTAKE AND SEQUESTRATION

→ **Biogenic uptake**

The biogenic CO_2 that is taken up during cultivation or growth of the renewable materials is assumed to be released again at the EOL. Since we consider the product stage and the EOL stage, the net balance of biogenic CO_2 will be neutral.

Therefore it is decided not to consider biogenic CO_2 uptake and release in the LCA calculations. However in the EPD the results about biogenic uptake will be presented as additional information. Carbon uptake describes the uptake and release of CO_2 by plants. In this project the Phyllis database is used to determine the quantity of carbon in natural materials (http://www.ecn.nl/phyllis/single.html). For the LCA:TIM project the Phyllis database is used to determine the quantity of carbon in natural materials.

Table 1 shows an overview of amount of carbon stored in some plants.

Table 1: Overview of biogenic carbon in some plants

	amount of carbon stored in plant (weight%)
flax	46,6
hemp	44,8
paper	49,1
wood	51,9

→ **Biogenic sequestration**

Biogenic sequestration describes the gain for the environment of CO2 sequestration during the lifetime of plant based materials.

The modelling is done according to ILCD handbook, PAS 2050, aspects of ISO 14044 (ISO, 2006b) chapters 4.2.3.5, 4.2.3.6.2 and 4.3.2.1.

The duration for which LCIA impacts of released emissions are calculated, is typically explicitly or implicitly indefinite. For Global Warming Potential (GWP) the much shorter perspective “GWP 100 years” is used in this study.

The related characterisation factors used are typically those provided as part of the Intergovernmental Panel on Climate Change (IPCC) reports (*ILCD Handbook 7.4.3.7.3.*).

Carbon sequestration is modelled as a Correction flow for delayed emission of carbon dioxide (within first 100 years) as “Emissions to air”.

The reason to see carbon sequestration as a correction flow is explained in the ILCD handbook, paragraph 7.4.3.7.3: "Climate change is hence implicitly considered to be a problem of the next 100 years (3 to 4 generations). The long-term removal of CO2 from the atmosphere and storage in long-living goods is hence politically promoted.

The difficulty is that the GWP 100 relates to the effect after the emission has taken place i.e. it counts the climate change impact of emissions that occur nowadays exert within the next 100 years. However, these emissions may also occur in the future (in e.g. 80 years when a now newly built house is broken down). Assigning a full GWP 100 factor to these emissions that happen in 80 years would contradict the logic of the GWP 100 detailed above, as in that case their climate change effect for 180 years from now would be accounted for. It is measured in the flow property "Mass*years" and the reference unit "kg*a".

The flow is to carry a GWP 100 impact factor of "-0.01 kg CO2-equivalents" per 1 kg*a.

The assumed time of emission is equal to the lifespan of the products, for this study assumed to be 60 years. The actual amount of the emission is based on the amount of stored carbon in the plant cells.

These new elementary flows should be used in addition to the normal elementary flows including the flow "Carbon dioxide" as "Resources from air" that model the physical uptake of CO_2 into biomass (*ILCD Handbook 7.4.3.7.3.).*

Table 2 presents the carbon sequestration in plants.

Table 2: Carbon sequestration in plants

plant	carbon sequestration in plant (kg CO2 eq./kg plant)
flax	-1,0252
hemp	-0,9856
paper	-1,0802
wood	-1,1418

Table 3presents the carbon sequestration in plant based insulation materials. This means the decrease of global warming per kilogram of insulation material over 60 years, due to the storing of the biogenic carbon uptake of the plants during photosynthesis.

Table 3: Carbon sequestration in insulation materials

insulation material	carbon sequestration in insulation material (kg CO2 eq./kg insulation material)
flax insulation	-0,76890
hemp insulation	-0,85747
paper flakes insulation	-0,97218
woodfibre insulation	-0,91344

7.2.6. TYPES OF IMPACT AND METHODOLOGY OF IMPACT ASSESSMENT, AND SUBSEQUENT INTERPRETATION TO BE USED

The impact assessment phase of the LCA is aimed at evaluating the significance of potential environmental impacts using the results of the life cycle inventory analysis. In general, this process involves associating inventory data with specific environmental impacts and attempting to understand those impacts.

In other words, the list of data gathered during the life cycle inventory will be reduced to a set of parameters describing the environmental impact of the product.

The impact assessment is carried out using characterisation factors applied in the International Reference Life Cycle Database (ILCD) provided by the European Commission – DG Joint Research Centre - Institute for Environment and Sustainability and shall follow the respective updates of the ILCD.

By means of the characterisation factors loads are translated into impacts. The emission of methane is for example 21 times more effective as carbon dioxide per kg of emitted substance in terms of global warming. This will be taken into account in the calculations and the result is the sum of the different impacts for the specific impact category (global warming in the example above).

→ **Environmental impact categories (mandatory to declare)**

Table 4 presents the different environmental impact categories that will be considered in the LCIA (life cycle impact assessment). These impact categories are also presented in the EN 15804.

Table 4: Overview of environmental impact categories and impact assessment methods

Parameters describing environmental impacts (CEN TC 350)		
Environmental impact	**unit**	**Impact assessment method**
Global warming potential, GWP;	kg CO_2 equiv	ReCiPe midpoint
Depletion potential of the stratospheric ozone layer, ODP;	kg CFC 11 equiv	ReCiPe midpoint
Acidification potential of soil and water, AP;	kg SO_2 equiv	ReCiPe midpoint
Eutrophication potential, EP;	kg $(PO_4)^{3-}$ equiv	CML 2002
Formation potential of tropospheric ozone, POCP;	kg Ethene equiv	CML 2002
Abiotic depletion potential (ADP-elements) for non fossil resources[a]	kg Sb equiv	CML 2002
Abiotic depletion potential (ADP-fossil fuels) for fossil resources[a]	MJ, net calorific value	Cumulated energy demand
[a] *The abiotic depletion potential is calculated and declared in two different indicators:* • *ADP-elements: include all non renewable, abiotic material resources (i.e. excepting fossil resources);* • *ADP-fossil fuels include all fossil resources*		

The characterisation factors for global warming, ozone layer depletion and acidification shall be taken from the ReCiPe method, midpoint factors need to be selected.

The characterisation factors for eutrophication, photochemical oxidation and ADP (elements) shall be taken from CML (Institute of Environmental Sciences Faculty of Science University of Leiden, Netherlands). The characterisation factors for ADP-fossil fuels are the net calorific values at the point of extraction of the fossil fuels and shall be taken from the cumulated energy demand method.

→ Additional environmental impact categories (optional to declare)

On request of FPS Health, an additional set of environmental impact categories is selected. One can declare on these in the EPD. However the declaration is optional and not mandatory.

The additional set of environmental impact categories are the same as the environmental impact categories that are used within the OVAM (Flemish Public Waste Agency) project on "Material based Environmental profiles of building elements" (Debacker et al., 2012).

Therefore the additional environmental impact categories as listed in Table 5 can be considered in the LCA and can be reported in the EPD (optional). The impact assessment methods from which characterisation factors shall be taken are shown in the third column of Table 5

Table 5: Overview of additional environmental impact categories and assessment methods

Additional environmental impact categories (CEN+)		
Environmental impact	**unit**	**Impact assessment method**
Land occupation	Species.yr	ReCiPe endpoint (interim)
Land transformation	Species.yr	ReCiPe endpoint (interim)
Marine ecotoxicity	kg 1,4 DB equivalent	ReCiPe midpoint
Freshwater ecotoxicity	kg 1,4 DB equivalent	ReCiPe midpoint
Terrestrial ecotoxicity	kg 1,4 DB equivalent	ReCiPe midpoint
Human toxicity (cancer)	DALY	ReCiPe endpoint
Human toxicity (non-cancer)	DALY	ReCiPe endpoint
Particulate matter formation	DALY	ReCiPe endpoint
Ionising radiation, human health	DALY	ReCiPe endpoint
Water depletion	m^3	ReCiPe endpoint

More information on the life cycle impact assessment methods that should be used, can be found in Annex 2 of this PCR. Different software programs exist to assist in the calculation of environmental impacts.

→ Additional environmental indicators

Conform EN 15804 in addition to the environmental impact categories, the EPD also needs to declare on additional environmental indicators. These indicators are divided into:

- Parameters describing resource use (Table 6);
- Other environmental information describing different waste categories and output flows (Table 7).

Table 6: Overview of parameters describing resource use

Parameters describing resource use (CEN TC 350)	
Parameter	**unit**
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ, net calorific value
Use of renewable primary energy resources used as raw materials	MJ, net calorific value
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, net calorific value
Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials	MJ, net calorific value
Use of non renewable primary energy resources used as raw materials	MJ, net calorific value
Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, net calorific value
Use of secondary material	kg

Use of renewable secondary fuels	MJ, net calorific value
Use of non renewable secondary fuels	MJ, net calorific value
Use of net fresh water	m^3

Table 7: Overview of Other environmental information describing different waste categories and output flows

Other environmental information describing waste categories (CEN TC 350)	
Parameter	**unit**
Hazardous waste disposed	kg
Non hazardous waste disposed	kg
Radioactive waste disposed	kg
Other environmental information describing output flows (CEN TC 350)	
Parameter	**unit**
Components for re-use	kg
Materials for recycling	kg
Materials for energy recovery	kg
Exported energy	MJ per energy carrier

7.3. IMPACT ASSESSMENT AND INTERPRETATION OF THE ENVIRONMENTAL PROFILES

The impact assessment phase of LCA is aimed at evaluating the significance of potential environmental impacts using the LCI results. In general, this process involves associating inventory data with specific environmental impact categories and category indicators, thereby attempting to understand these impacts.

The impact assessment and the interpretation will be performed according to the ISO 14040 and ISO 14044 guidelines (2006).

The results of the inventory analysis are linked to specific environmental damage categories (e.g. global warming, acidification, etc.). It is important to note that the inventory results generally do not include spatial, temporal, dose-response or threshold information. Therefore, impact assessment cannot and is not intended to identify or predict *actual* environmental impacts. Instead, the impact assessment predicts *potential* environmental damages (impacts) related to the system under study.

The different environmental impact categories presented in the EN 15804 (2012) will be used. These environmental impact categories are divided into different groups, more specifically:

- Parameters describing environmental impacts expressed with impact categories of LCIA;
- Parameters describing resource use derived from LCI;
- Other environmental information describing waste categories and output flows derived from LCI.

An overview of the different indicators is presented in paragraph 7.2.6 of this PCR. We refer to Annex 2 for the methodology that should be used to assess the different environmental burdens/benefits into the different environmental impact categories.

In the interpretation phase of an LCA, the results of the inventory analysis and the impact assessment should be critically analysed and interpreted in line with the defined goal and scope of the study. In discussing the results of the individual profiles of the different insulation materials, it is important to know whether or not a process has a significant contribution to an environmental impact category. The ISO framework (ISO 14044, Annex B) should be used. According to ISO the importance of contribution of a life cycle phase in a certain impact category can be interpreted as follows:

- A: contribution > 50 %: most important, significant influence;
- B: 25 % < contribution ≤ 50 %: very important, relevant influence;
- C: 10 % < contribution ≤ 25 %: fairly important, some influence;
- D: 2,5 % < contribution ≤ 10 %: little important, minor influence;
- E: contribution < 2,5 %: not important, negligible influence.

CHAPTER 8 GUIDANCE FOR SCENARIOS FOR THE APPLICATION SPECIFIC PHASES (GATE TO GRAVE)

8.1. GENERAL

Scenarios for certain life cycle stages should support the application of product related data in the corresponding life cycle stage of the building assessment. Additional technical information (see chapter 6 of this PCR) will support the consistent development of scenarios by which the LCA derived parameters of optional life cycle stages can be calculated and declared. Therefore, if optional life cycle stages are declared, the scenarios to which the calculated parameters relate shall be specified and be included in the EPD.

If an EPD claims to cover all life cycle stages (**cradle to grave**) all relevant optional modules shall be calculated for specified scenarios and the LCA derived parameters shall be declared.

For an EPD covering **cradle to gate with options**, the optional modules may be calculated and the LCA derived parameters may be declared.

Alternatively, in the **cradle to gate** EPD, a manufacturer may choose to declare additional technical information without calculating optional life cycle stages to ensure proper understanding of a product's function in a building and thus support proper scenario development at the building level.

Additional technical information is declared in the module, to which it refers (e.g. technical information about the use of a product in the appropriate use stage modules B).

Any additional technical information shall be documented separately from the LCA derived parameters.

If additional technical information is not complete at the product level as specified, this shall be stated.

The following paragraphs give further guidance on the establishment of technical information and scenario for the life cycle phases: from gate to grave.

8.2. CONSTRUCTION STAGE (MODULE A4 AND A5)

The construction process stage includes (Module A, sections A4, A5, see Figure 2 in this PCR):

- A4, transportation of the insulation material from manufacturer to the building site;
- A5, installation of the insulation material into the building;

The construction stage implies:

- Transportation of the insulation material from the manufacturer to Brussels (assumed location for the installation site);
- Transportation of other building materials to the construction site;

- Installation of the insulation material in the building, including manufacture and transportation of ancillary materials and any energy or water required for installation or operation of the construction site.
- Construction process waste and thus the additional production processes to compensate for the loss of products;
- Waste processing of the waste from packaging of the insulation material and waste related to the insulation material during the construction processes up to the end-of-waste state or disposal of final residues;
- Installation of the insulation material into the building
- It also includes on-site operations to the insulation material.

The following paragraphs give further guidance on the construction process stage.

8.2.1. TRANSPORT TO BRUSSELS

If additional technical information is provided in the EPD for transport from the production gate to the construction site, the following information shall be provided to specify the transport scenarios used or to support development of the scenarios at the building level. The information in the next table is not exhaustive.

Parameter	Parameter unit expressed per functional unit
Fuel type consumption of vehicle or vehicle type used for transport e.g. long distance truck, boat etc.	Litre of fuel type per distance or vehicle type, Commission Directive 2007/37/EC (European Emission Standard)
Distance	km
Maximum load per vehicle type	ton
Actual load per vehicle type	ton
Capacity utilisation (including empty returns)	%
Bulk density	kg/m³
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	
Further assumptions for scenario development	Units as appropriate

If the transportation of the insulation material from the producer to Brussels is a volume limited transportation (amount of cargo on a truck limited by volume and not by weight), allocation shall be based on volume.

8.2.2. TRANSPORT FROM BRUSSELS TO THE CONSTRUCTION SITE

If additional technical information is provided in the EPD for transport from the production gate to the construction site, the following information shall be provided to specify the transport scenarios used or to support development of the scenarios at the building level. The information in the next table is not exhaustive.

Parameter	Parameter unit expressed per functional unit
Fuel type consumption of vehicle or vehicle type used for transport e.g. long distance truck, boat etc.	Litre of fuel type per distance or vehicle type, Commission Directive 2007/37/EC (European Emission Standard)
Distance	km
Maximum load per vehicle type	ton
Actual load per vehicle type	ton
Capacity utilisation (including empty returns)	%
Bulk density	kg/m³
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	
Further assumptions for scenario development	Units as appropriate

If the transportation of the insulation material from Brussels to the construction site is a volume limited transportation (amount of cargo on a truck limited by volume and not by weight), allocation shall be based on volume.

8.2.3. INSTALLATION OF THE INSULATION MATERIAL IN THE BUILDING

If additional technical information is provided in the EPD for installation of the insulation material in the building, the following information shall be provided to specify the insulation's installation scenarios or to support development of the scenarios describing the insulation's installation at the level of the building assessment. The information in the next table is not exhaustive.

Parameter	Parameter unit expressed per functional unit
Ancillary materials for installation (specified by material) of the insulation material	kg or other units as appropriate
Water use	m³
Other resource use	kg

Quantitative description of energy type (regional mix) and consumption during the installation process of the insulation material	kWh or MJ
Waste materials on the building site before waste processing, generated by the installation of the insulation material	kg
Output materials (specified per type) as result of waste processing at the building site (e.g. collected for recycling, for energy recovery, disposal) and specify by route	kg
Direct emissions to ambient air, soil and water	kg
Further assumptions for scenario development	Units as appropriate

Within the LCA:TIM project (task 2 – Life cycle assessment of thermal insulation materials for walls in the Belgian building context) the construction process stage covers the transportation of the materials from the manufacturer to the construction site and the installation of the material in the building wall. The construction stage implies:

- Transportation of the material from the manufacturer to Brussels (assumed location for the installation site);
- Transportation of other building materials to the construction site are modelled according to the scenarios developed in the MMG project (Debacker et al., 2012);
- Construction waste of 5% is considered for all materials. This scenario is in line with the scenario used in the MMG study (Debacker et al., 2012). In this phase the definition of "End of Waste" should be applied for construction waste (see below);
- All 5% construction waste leftovers are transported for 105 km with a large truck to the sorting plant. 105 km has been used for transportation of all leftovers. 105 km is the mean transportation distance of left-overs going to land fill and left-overs going to incineration. This is modelled according to the scenarios developed in the MMG project (Debacker et al., 2012);
- End-of-life of the construction waste and packaging waste materials
- Transportation of equipment and labour force necessary in this life cycle stage are neglected due to a lack of data.

8.3. USE STAGE (MODULE B1 TO B7)

The use stage, related to the **building fabric** includes (Module B, sections B1, B2, B3, B4 and B5, see Figure 2 of this PCR):

- B1, use or application of the installed insulation material;
- B2, maintenance;
- B3, repair;
- B4, replacement;
- B5, refurbishment.

The use stage related to the **operation of the building** includes (Module B, sections B6 and B7, see Figure 2 of this PCR):

- B6, operational energy use (e.g. operation of heating system and other building related installed services);
- B7, operational water use.

The use stage includes the optional information modules covering the period from the handover of the building or construction works to when it is deconstructed or demolished. The duration of the use stage of products may be different from the required service life of a building.

The use stage includes the use of construction products, equipment and services in their proper function. It also includes their use for protecting, conserving, moderating or controlling a building, e.g. modules describing the building operation through building related services such as heating, cooling, lighting, water supply and internal transport (provided e.g. by lifts and escalators). It also includes maintenance (including cleaning), repair, replacement and refurbishment.

It is recognised that it may be difficult to separate all use stage processes and the connected aspects and impacts into these separate modules. However, any deviation from the categorisation of aspects and impacts into Modules B1-B5 and B6-B7 shall be transparently reported and justified.

Modules B1 to B5 are not taken into account in the LCA:TIM project (task 2 – Life cycle assessment of thermal insulation materials for walls in the Belgian building context). The reason for the exclusion is the lack of specific data on these activities. For this reason no impacts are allocated to these activities. The exclusion of maintenance (Module B2), repair activities (Module B3) and refurbishment (Module B5) – which can be substantially different for different building elements – can induce biases in the overall evaluation of the building elements. However due to a lack of specific information for the different building wall types, this could not be modelled in the LCA:TIM project (task 2 – Life cycle assessment of thermal insulation materials for walls in the Belgian building context).

8.3.1. USE OF INSTALLED INSULATION MATERIAL (B1)

The module “use of the installed insulation material” covers environmental aspects and impacts arising from components of the building and construction works during their normal (i.e. anticipated) use, which are assigned to module B1 (in terms of any emissions to the environment and not covered by sections B2 to B7.

8.3.2. MAINTENANCE (B2)

The module “Maintenance” covers the combination of all planned technical and associated administrative actions during the service life to maintain the insulation material installed in a building, in a construction works or its parts in a state in which it can perform its required functional and technical performance, as well as preserve the aesthetic qualities of the product. This will include preventative and regular maintenance activity such as cleaning, and the planned servicing, replacement or mending of worn, damaged or degraded parts. Water and energy usage required for cleaning, as part of maintenance shall be included in this module, and not in modules B6 and B7.

The boundary of "maintenance" shall include in addition:

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

If additional technical information is provided in the EPD for maintenance of the insulation material in the building, the following information shall be provided to specify the insulation's maintenance scenarios or to support development of the scenarios describing the insulation's maintenance at the level of the building assessment. The information in the next table is not exhaustive.

Parameter	Parameter unit expressed per functional unit
Maintenance process	Description of source where description can be found
Maintenance cycle	How many times per reference service life or per year
Ancillary materials for maintenance (e.g. cleaning agent) - specify	kg/cycle
Waste material resulting from maintenance – specify	kg/cycle
Net fresh water consumption during maintenance	m^3/cycle
Energy input during maintenance (e.g. energy for maintenance processes) - specify	kWh/cycle
Further assumptions for scenario development	Units as appropriate

8.3.3. Repair (B3)

The module "repair" covers a combination of all technical and associated administrative actions during the service life associated with corrective, responsive or reactive treatment of the insulation material or its parts installed in the building or construction works to return it to an acceptable condition in which it can perform its required functional and technical performance. It also covers the preservation of the aesthetic qualities of the insulation material. Replacement of a broken component or part due to damage should be assigned to "repair", whereas replacement of a whole element due to damage should be assigned to the module "replacement".

The boundary for "repair" shall include:

a) repair process of the repaired part of a component including:
   1) the production of the repaired part of a component and of ancillary materials;
   2) use of related energy and water;
   3) the production and transport aspects and impacts of any wastage of materials during the repair process;

b) the transportation of the repaired part of component and ancillary materials, including production aspects and impacts of any waste of materials during the repair related transportation;
c) the-end-of-life processes of any waste from transportation and the repair process, including the part of the component and ancillary materials removed.

If additional technical information is provided in the EPD for repairing of the insulation material in the building, the following information shall be provided to specify the insulation's reparation scenarios or to support development of the scenarios describing the insulation's reparations at the level of the building assessment. The information in the next table is not exhaustive.

Parameter	Parameter unit expressed per functional unit
Repair process	Description of source where description can be found
Inspection process	Description of source where description can be found
Repair cycle	How many times per reference service life or per year
Ancillary materials (e.g. lubricants) - specify	kg/cycle
Waste material resulting from repair - specify	kg/cycle
Net fresh water consumption	m^3/cycle
Energy input during repair (e.g. energy for repair processes) - specify	kWh/cycle
Further assumptions for scenario development	Units as appropriate

8.3.4. Replacement (B4)

The module "replacement" covers the combination of all technical and associated administrative actions during the service life associated with the return of a construction product to a condition in which it can perform its required functional or technical performance, by replacement of a whole construction element.

Replacement of a broken component or part due to damage should be included as "repair", but replacement of a whole construction element due to damage should be considered as "replacement". Replacement of a whole construction element as part of a concerted replacement programme for the building should be considered as "refurbishment".

The boundary for "replacement" shall include:
- the production of the components and of ancillary materials used for replacement;
- replacement process, including related water and energy use and the production aspects and impacts of any waste of materials used during the replacement process;

- the transportation of the component and ancillary materials used for replacement, including production aspects and impacts of any losses of material damaged during transportation;
- the end-of-life processes of any losses suffered transportation and the replacement process, including the components and ancillary materials removed.

If additional technical information is provided in the EPD for replacing of the insulation material in the building, the following information shall be provided to specify the insulation's replacement scenarios or to support development of the scenarios describing the insulation's replacement at the level of the building assessment. The information in the next table is not exhaustive.

Parameter	Parameter unit expressed per functional unit
Replacement cycle	How many times per reference service life or per year
Energy input during replacement (e.g. energy for replacement processes) - specify	kWh/cycle
Exchange of worn parts during the life cycle of the insulation material	kg
Further assumptions for scenario development	Units as appropriate

We experienced from the LCA:TIM project that life time and service life time or important issues in this area. The longer a building, an element, a material can be used, the more the environmental loads generated by the initial production and construction can be spread over several years. Since buildings, or at least subparts, have a long live expectancy if they fulfil basic criteria (structural stability, sound insulation, fire resistance...), this is in building sector an important issue.

For the LCA:TIM project (task 2 – Life cycle assessment of thermal insulation materials for walls in the Belgian building context) the average age of housing units in Belgium is (approximately) 60 years. This means, in case the same number of units would have been produced yearly, a lifetime of 120 years. Of course during this period many sub parts are replaced.

The choice of the lifetime has serious consequences on the importance of subparts since they may generate important effects due to:

- Dismantling (in difficult situations);
- EOL of subparts (reuse, recycle, incineration with or without heat recovery, dumping);
- Replacement (in difficult situations) in order to be able to continue using parts with longer lifetime.

An additional problem is that in future subparts may be replaced by products with other performances (heating systems with higher efficiency, glazing systems with better thermal insulation, higher reflection of solar radiation and better optical characteristics; improved ventilation systems, etc.). A basic "precaution" principle is not to speculate on future inventions, but to use, for comparisons sake, the replacement of parts by identical types. This principle is applied in the modelling of replacement in this LCA study.

The reference service life time of the insulation materials and building wall is a factor with a high uncertainty. The LCA:TIM project team asked the participating manufactures for information on the lifespan of the insulation materials. This information is however seldom available.

The LCA:TIM project team did however not get sufficient reliable information on life span of the different insulation materials concerned. The LCA:TIM project team however reported on all the available information (labo testing, reports, studies, etc.) about the life span of the insulation materials made available by manufacturers of insulation materials. This is be reported in the inventory phase of the LCA:TIM final LCA background report (task 2 – Life cycle assessment of thermal insulation materials for walls in the Belgian building context).

The project team finally assumed a reference service life for the buildings wall of 60 years. This is an assumption, and cannot always well based on documents received by the manufacturers, as clearly can be seen in table above. More research towards the RSL is one of the recommendations that comes out of this LCA:TIM LCA project.

As a consequence of the lack of data of manufacturers, the relative difference of reference service life (RSL) for insulation materials used in several types of building walls has not been taken into account.

A sensitivity analysis for a life span of 120 years (basic scenario 60 years) with replacements of identical types for all the materials used in the specific wall type has been performed. The results are reported in the LCA:TIM final LCA background report (task 2 – Life cycle assessment of thermal insulation materials for walls in the Belgian building context).

8.3.5. Refurbishment (B5)

The module "refurbishment" covers the combination of all technical and associated administrative actions during the service life of a product associated with the return of a building or other construction works or their parts to a condition in which it can perform its required functions. These activities cover a concerted programme of maintenance, repair and/or replacement activity, across a significant part or whole section of the building. Restoration activities should be included within refurbishment.

The boundary for refurbishment shall include:

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

If additional technical information is provided in the EPD for the refurbishment of the insulation material in the building, the following information shall be provided to specify the insulation's refurbishment scenarios or to support development of the scenarios describing the insulation's refurbishment at the level of the building assessment. The information in the next table is not exhaustive.

Parameter	Parameter unit expressed per functional unit
Refurbishment process	Description of source where description can be found
Refurbishment cycle	How many times per reference service life or per year
Energy input during refurbishment (e.g. energy for refurbishment processes) - specify	kWh/cycle
Material input during refurbishment (e.g. lubricant) - specify	kg/cycle
Waste material resulting from refurbishment - specify	kg/cycle
Further assumptions for scenario development	Units as appropriate

8.3.6. Reference service life (RSL)

RSL information to be declared in an EPD covering the use stage shall be provided by the manufacturer. The RSL shall refer to the declared technical and functional performance of the product within a building. It shall be established in accordance with any specific rules given in European product standards and shall take into account ISO 15686-1, -2, -7 and -8. Where European product standards provide guidance on deriving the RSL, such guidance shall have priority.

Information on the product's RSL requires specification of compatible scenarios for the product stage, construction process stage and use stage. RSL is dependent on the properties of the product and reference in-use conditions. These conditions shall be declared together with a RSL and it shall be stated that the RSL applies for the reference conditions only.

The RSL shall be verifiable.

Requirements and guidance on the estimation of service life are given in normative Annex A of the EN 15804.

If additional technical information is provided in the EPD for the reference service life of the insulation material in the building, the following information shall be provided to specify the insulation's reference service life or to support development of the scenarios describing the insulation's reference service life at the level of the building assessment. The information in the next table is not exhaustive.

Parameter	Parameter unit expressed per functional unit
Reference service life	Years
Declared product properties (at the gate) and finishes, etc.	Unit as appropriate
Design application parameters (if instructed by the manufacturer), including the references to the appropriate practices and application codes	Unit as appropriate
An assumed quality of work, when installed in accordance with the manufacturer's instructions	Unit as appropriate
Outdoor environment, (for outdoor applications), e.g. weathering, pollutants, UV and wind exposure, building orientation, shading, temperature	Unit as appropriate
Indoor environment (for indoor applications), e.g. temperature, moisture, chemical exposure	Unit as appropriate
Usage conditions, e.g. frequency of use, mechanical exposure	Unit as appropriate
Maintenance e.g. required frequency, type and quality and replacement of components	Unit as appropriate
Further assumptions for scenario development	Units as appropriate

8.3.7. USE OF ENERGY (B6) AND USE OF WATER (B7)

Use of energy

The boundary of the module "Energy use to operate building integrated technical systems'' shall include energy use during the operation of the product (the integrated building technical system), together with its associated environmental aspects and impacts including processing and transportation of any waste arising on site from the use of energy.

Integrated building technical systems are installed technical equipment supporting operation of a building or construction works. This includes technical building systems for heating, cooling, ventilation, lighting, domestic hot water and other systems for sanitation, security, fire safety, internal transport and building automation and control and IT communications.

Aspects related to the production, transportation and installation of equipment required to supply energy to the building shall be assigned to Modules A1-A5. Energy use during maintenance, repair, replacement or refurbishment activities for the equipment shall be assigned to Modules B2-B5. Aspects related to the waste processing and final disposal of equipment shall be assigned to Modules C1-C4.

LCA:TIM project calculation for the building walls:
The operational energy use of the building wall in the LCA:TIM project (U-value of 0,24 W/m².K for the basic scenario and 0,15 W/m².K for a sensitivity analysis) is taken into account to be able to distinguish between the environmental impacts related to:

- The production of the insulation materials, the installation and the end of life of these materials; and
- The operational energy use of the building wall (at building element level).

For example: an higher amount of insulation materials in a building wall will lead to an increase of the environmental impacts for the product stage, construction process stage and the end-of-life stage. On the contrary this higher insulation level (more insulation materials applied in the building wall) will result in a lower operational energy consumption. In order to get an insight into the ratio between the product level (building wall components) and the energy losses throughout the wall the operational energy use (B6) has been taken into account in this LCA study.

The operational energy use (Module B6) of the building wall is calculated by means of the equivalent degree method. Modelling of the operational energy will be performed in line with the MMG study (Debacker et al., 2012). For the analysis of energy use during the use phase only the energy consumption of heating due to transmission losses will be considered[4]. The energy use will be modelled by means of the 'equivalent degree days'-method using the following assumptions:

- 1200°d5 (Allacker 2010);
- Condensation boiler with global efficiency of 88%;
- Cooling is not considered for the Belgian climate;
- As proposed by EN 15804 (CEN, 2012) equipment for cooking, washing, entertainment, communication, etc. is not included.

Because the object of study is limited to (the life cycle of) 1m² of exterior wall, energy consumption during the life span of the wall (and building) is therefore restricted to transmission losses via 1m² of wall under clearly defined conditions

<u>Use of water</u>
The module "Operational water use by building integrated technical systems" covers the period from the handover of the building or construction works to when the building is deconstructed or demolished. The boundary of the module "operational water use by building integrated technical systems" shall include water use during the operation of the product (the building integrated technical system), together with its associated environmental aspects and impacts considering the life cycle of water including production and transportation and waste water treatment.
Building integrated technical systems are installed technical equipment to support operation of building. This includes technical building systems for cooling, ventilation, humidification, domestic hot water and other systems for sanitation, security, fire safety, internal transport.

If additional technical information is provided in the EPD for the use of energy and water during use of the insulation material in the building, the following information shall be provided to specify the use scenarios for use of water and energy or to support development of the scenarios describing the relation between the insulation material and the use of water and energy at the level of the building assessment. The information in the next table is not exhaustive.

[4] In line with EN 15978:2011 §8.6.5

[5] The lower the K-value of a building, the lower the equivalent degree days. 1200 equivalent degree days corresponds to a well insulated house with an average inner temperature of 18°C.

Parameter	Parameter unit expressed per functional unit
Ancillary materials specified by material	kg or units as appropriate
Net fresh water consumption	m^3
Type of energy carrier, e.g. electricity, natural gas, district heating	kWh
Power output of equipment	kW
Characteristic performance, e.g. energy efficiency, emissions, variation of performance with capacity utilisation etc.	Units as appropriate
Further assumptions for scenario development, e.g. frequency and period of use, number of occupants	Units as appropriate

For the LCA:TIM project (task 2 - Life cycle assessment of thermal insulation materials for walls in the Belgian building context) the operational water use was not relevant.

8.4. End of Life stage (Module C1 to C4)

The end-of-life stage of the construction product starts when it is replaced, dismantled or deconstructed from the building or construction works and does not provide any further functionality. It can also start at the end-of life of the building, depending on choice of the product's end-of-life scenario.
During the end-of-life stage of the product or the building, all output from dismantling, deconstruction or demolition of the building, from maintenance, repair, replacement or refurbishing processes, all debris, all construction products, materials or construction elements, etc. leaving the building, are at first considered to be waste.

This output however reaches the end-of-waste state when it complies with all the following criteria:

- the recovered material, product or construction element is commonly used for specific purposes;
- a market or demand, identified e.g. by a positive economic value, exists for such a recovered material, product or construction element;
- the recovered material, product or construction element fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products;
- the use of the recovered material, product or construction element will not lead to overall adverse environmental or human health impacts.

The "specific purpose" in this context is not restricted to the function of a certain product but can also be applied to a material serving as input to the production process of another product or of

energy. The criterion for "overall adverse environmental or human health impacts" shall refer to the limit values for pollutants set by regulations in place at the time of assessment and where necessary shall take into account adverse environmental effects. The presence of any hazardous substances exceeding these limits in the waste or showing one or more properties as listed in existing applicable legislation, e.g. in the European Waste Framework Directive, prevents the waste from reaching the end-of-waste state.
The end-of-life system boundary of the construction product system to module D is set where outputs, i.e. secondary materials or fuels, have reached the "end-of-waste" state.

The end-of-life (EOL) stage includes (Module C, sections C1, C2, C3 and C4, see also Figure 2 of this PCR):

- C1, de-construction, demolition:
- C2, transport to waste processing;
- C3, waste processing for reuse, recovery and/or recycling;
- C4, disposal.

If additional technical information is provided in the EPD for the EOL of the insulation material in the building, the following information shall be provided to specify the insulation's EOL scenarios or to support development of the scenarios describing the insulation's EOL at the level of the building assessment. The information in the next table is not exhaustive.

Parameter	Parameter unit expressed per functional unit
Collection process specified per type	kg collected separately
	kg collected with mixed construction waste
Recovery system specified per type	kg for re-use
	kg for recycling
	kg for energy recovery
Disposal specified per type	kg product or material for final depostion
Assumption for scenario development e.g. transporatation	Units as appropriate

Overview of the scenarios used within the LCA:TIM project on building walls:

Scenario for dismantling and demolition (C1)

Due to the fact that dismantling is mainly done by manual operations, no impacts are allocated to the non-destructive dismantling. The demolition processes mainly uses energy for mechanical operations and they cause emissions of particulate matter (PM). For all insulation materials, the following pragmatic assumptions will be considered[6] (Debacker et al., 2012):

[6] Based on econinvent v2.2

- Diesel consumption for mechanical operations: 0,0437 MJ/kg material (modelled by means of the ecoinvent datarecord: Diesel burned in building machine, GLO-U).
- Emission of particulate matters (PM):
    - PM < 2,5um: 1,66 x 10^{-5} kg/kg material;
    - PM > 2,5um en < 10um: 6,34 x 10^{-5} kg/kg material;
    - PM > 10um: 8,35x 10^{-5} kg/kg material.

Scenario for transportation to a sorting plant or collection plant (C2)

For the LCA:TIM LCA study we assumed that for recycling the end of waste status is reach just after the sorting plant (Debacker et al., 2012). Transportation to a recycling facility and the recycling process itself is allocated to the product system that uses the recyclates as a replacement of virgin raw materials.

Example of glass cullets used for glass wool:

Impact allocated to the glass producer:

- transport of broken glass to a sorting plant.

Impacts allocated to the glass wool producer:

- transport of broken glass from sorting plant to crusher;
- crushing of glass cullets;
- use of glass cullets for glass wool production => avoided production of virgin raw materials for the production of glass wool.

Example of waste paper for the production of paper flakes insulation:

Impact allocated to the paper producer:

- transport of waste paper to a processing company (considered as sorting plant).

Impacts allocated to the paper flakes producer:

- transport of waste paper from the processing company (sorting plant) to the paper flakes producer;
- the waste paper is placed on a conveyor belt from where is goes into the production process of the paper flakes insulation => avoided production of virgin raw materials for the production of paper flakes insulation.

Materials intended to be landfilled or incinerated will be transported from the sorting plant to the final EOL treatment plant.

For transportation of waste flows to the EOL waste treatment plant, the following transport scenarios will be considered in case there are no specific data available (MMG project, Debacker et al., 2012):

Transportation dististance: Transportation from the demolition (construction) site to a sorting/collection plant: 30 km

Transportation mode: Transportation from the demolition (construction) site to a sorting/collection plant will be modelled as follows:

- Fraction that is not sorted on site (mixed container):
    - 90% with heavy truck (>16t);
    - 10% with truck between 7,5 and 16 ton.

For the LCA:TIM LCA project the project team assumed that the sorting on site has no effect upon the total transportation.

Scenario for sorting of materials (C3)

The following scenarios will be applied for the sorting process (Debacker et al., 2012):

- We assumed no sorting on site;
- The demolition fraction will be transported to a waste sorting plant.
- At the sorting plant the upgrading for reuse (sorting, sieving, breaking, washing, filtering, testing …) is done as well;
- Special requirements for burning with heat recovery (see further).

For the LCA:TIM project the impact of sorting on site will not be considered (negligible). The following generic scenario will be considered for the sorting in a special sorting plant (for the fraction that will not be sorting on site) (Debacker et al., 2012):

- Electricity for mechanical sorting processes: 0,0022 kWh/kg material;
- Heat emission because of mechanical sorting processes: 0,00792 MJ/kg material;
- Diesel for loading: Depends on the density of the material. For the different materials (including insulation materials) the same densities as used in MMG (Debacker et al., 2012) have been used;
- Infrastructure for sorting including land occupation and land transformation, and energy for administrative facilities: 1 x 10-10 plant/kg material.

The “End of Waste (EOW)”-point is defined at the “gate” of the sorting plant. This may include that certain “upgrading” processes together with “sorting” processes are allocated to the “End of Waste”-point of the previous phase. In case the sorted waste on site is transported to a sorting plant (but a (first) sorting is avoided in that location) the same principle is applied. This implies that the transport to the sorting plant is included in the “previous” cycle (before the “EOW”). The possible case that the “sorted waste” is directly transported to an upgrading process is neglected by making the hypothesis that the full fraction passes the “sorting plant” including the transport to this plant.

Scenario for transportation from the sorting plant to waste treatment plant (integrated in C2)

For transportation of waste to the EOL waste treatment plant, the following transport scenarios will be considered in case there are no specific data available.

Transportation distances: Transportation from the sorting/collection plant to EOL treatment will be modelled by means of:

- 50 km for landfill;
- 100 km for incineration.

Transportation mode:

- 100% with heavy truck >16t.

Scenarios for disposal (C4)

Table 8 gives the scenario that will be applied in case there are no specific data available for EOL of the insulation materials. The materials that go to landfill or incineration do not undergo a specific treatment (e.g. to preserve for leaching in case of landfill). They go directly to landfill or incineration without any further preparation.

Table 8: Scenarios for waste treatment of insulation materials

Type	Description	% landfill	% incineration	% Recycling and reuse
Insulation that is combustible	EPS, flax, hemp, PUR, sheepwool woodfiber, XPS	0	100	0
Insulation that is not combustible	Glass wool, glass blowing wool, paper flakes, rock wool	100	0	0

8.5. Benefits and load beyond the product system boundary (Module D)

Information module D aims at transparency for the environmental benefits or loads resulting from reusable products, recyclable materials and/or useful energy carriers leaving a product system e.g. as secondary materials or fuels.

Any declared net benefits and loads from net flows leaving the product system that have not been allocated as co-products and that have passed the end-of-waste state shall be included in module D.

Avoided impacts from allocated co-products shall not be included in Module D.

The information in module D may contain technical information as well as the quantified predetermined LCA derived parameters.

CHAPTER 9 CONTENT OF THE ENVIRONMENTAL PRODUCT DECLARATION

9.1. DECLARATION OF GENERAL INFORMATION

→ Description of company/organization

The name of the company/organization as well as the place(s) of production shall be indicated. General information about the company/organization can be included.

- Product/producer specific information
- Generic information (federation, sector... in B)
- Generic information (international databases, e.g. ecoinvent)

→ Description of the thermal insulation material

The description of the insulation material shall enable the user to identify the insulation material unambiguously. The characterisation includes:

- Description of the insulation material's use and the functional or declared unit of the insulation product according to this PCR;
- Product identification by name (including any product code) and a simple visual representation of the insulation material for which the EPD is developed;
- Description of the main product components and or materials;
- Flow diagram of main production processes
- Other information on the insulation material, like for instance obtained environmental and/or health labels.

→ PCR identification

Reference to this PCR.

→ Name of programme and programme operator

→ Name and address of LCA experts (data input)

→ Name and address of third party controller or peer reviewer (input control)

→ Date of declaration and period of validity

The date the declaration was issued and the 5 year period of validity (in case a critical review has been done)

→ Information on which stages are not considered

The EPD shall mention which life cycle stages are included.

→ Comparability statement

A statement that EPD of insulation materials may not be comparable if they do not comply with this PCR.

→ In case of EPD from averaged data

In the case where an EPD is declared as an average environmental performance for a number of insulation materials a statement to that effect shall be included in the declaration together with a description of the range/variability of the LCIA results.

→ Representativeness of the EPD

The site(s), manufacturers or those representing them for whom the EPD is representative.

→ Declaration of material content

The declaration of material content of the insulation material shall list as a minimum substances contained in the product that are listed in the "Candidate List of Substances of Very High Concern for authorisation" when their content exceeds the limits for registration with the European Chemicals Agency.

→ Information on where explanatory material may be obtained

Contact details for additional explanatory materials.

→ Demonstration of verification

The following informationshall be clearly provided in Type III environmental declarations:

- Reference to document that serves as core PCR;
- Independant verification of the declaration, according to EN ISO 14025 (internal or external);
- When appropriate: name of third party verifier.

9.2. DECLARATION OF ENVIRONMENTAL PARAMETERS DERIVED FROM LCA

To illustrate the product system studied, the EPD shall contain a flow diagram of the processes included in the LCA. They shall be sub-divided at least into the life cycle stages of the product: production, and if applicable construction, use and end-of-life (see Figure 2). The stages may be further sub-divided.

→ Rules for declaring LCA information per module

In order to support the application of the modular information of an EPD in an environmental building assessment, it is necessary to provide information in a modular way. Module D may be addressed in any type of EPD.

The EPD shall specify which EPD-type is declared (see Figure 2):

- A "Cradle to Gate" EPD:
  For a "Cradle to Gate" EPD a declaration of the RSL is not possible. The RSL shall be declared as: "not specified". Normally in this type of EPD module D is not declared.
- A"Cradle to Gate with Options" EPD:
  For a "Cradle to Gate with Options" EPD the declaration of the RSL is possible only if all scenarios for the modules A1-A3 and B1-B5 are given (see Figure 2).
- A "Cradle to Grave" EPD:
  For a "Cradle to Grave" EPD (life cycle declaration covering all modules in the stages A to C) a declaration of the RSL is required. In some cases certain modules may not be relevant to the environmental performance of a product. In such cases the irrelevant module shall be declared as "not relevant". Such a declaration shall not be regarded as an indicator result of zero Information shall be supplied in a modular way.

The product stage of the thermal insulation material is mandatory, the other stages are optional to report on.

→ Parameters describing environmental impacts

Information on environmental impacts is expressed with the impact category parameters of LCIA using characterisation factors:

- The predetermined parameters from Table 1 are required and shall be included in the EPD;
- The predetermined parameters from Table 2 are optional to include in the EPD.

→ Parameters describing resource use

The parameters shown in Table 6 are required and should be reported on.

→ Other environmental information describing different waste categories and output flows

The parameters shown in Table 7 are required and should be reported on.

9.3. ADDITIONAL TECHNICAL INFORMATION AND SCENARIOS

9.3.1. ADDITIONAL INFORMATION ON RELEASE OF DANGEROUS SUBSTANCES TO INDOOR AIR, SOIL AND WATER DURING THE USE STAGE AND ADDITIONAL INFORMATION ON THE BIOGENIC CO_2

→ Indoor air

See chapter 6 of this PCR.

→ Soil and water

See chapter 6 of this PCR.

9.3.2. ADDITIONAL INFORMATION ON THE BIOGENIC CO_2 UPTAKE AND SEQUESTRATION

See chapter 6 of this PCR.

9.3.3. SCENARIOS

All scenarios used, both the scenarios defined by the manufacturer and the scenarios mentioned in this documents shall be communicated in the EPD. See chapter 8 of this PCR.

9.4. AGGREGATION OF INFORMATION MODULES

The indicators declared in the individual information modules of a product life cycle A1 to A5, B1 to B7, C1 to C4 and module D as described in Figure 2 shall not be added up in any combination of the individual information modules into a total or sub-total of the life cycle stages A, B, C or D. As an exception information modules A1, A2, and A3 may be aggregated.

9.5. ADDITIONAL INFORMATION MODULE "D"

Module D may include:

- reuse, recovery and/or recycling potentials.

9.6. UNITS

SI units shall be used. Basic units are: metre (m), kilogram (kg), molecular weight in grams (mol). All resources are expressed in kg.
Exceptions are:

- Resources used for energy input (primary energy), which are expressed as kWh or MJ, including renewable energy sources e.g. hydropower, wind power;
- Temperature, which is expressed in degrees Celsius;
- Time, which is expressed in practical units depending on the assessment scale: minutes, hours, days, years

CHAPTER 10 REFERENCES

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ISO 15686-1. 2011. Buildings and constructed assets – Service life planning: Part 1: General principles and framework

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ISO 15686-8. 2008. Buildings and constructed assets – Reference service life and service-life estimation.

ISO 21930. 2007. Sustainability in building construction -- Environmental declaration of building products.

EN 15804. 2012. - Sustainability of construction works - Environmental product declarations – Core rules for the product category of construction products.

CEN/TR 15941. 2010. Sustainability of construction works-Environmental product declaration – Methodology for selection and use of generic data.

ANNEX 1

Involvement of the producers of thermal insulation materials for the building sector

This PCR will be based on experiences with several specific LCA studies on insulation materials that are performed in close collaboration with producers of insulation materials. The following thermal insulation materials that are used for building walls on the Belgian market were studied and information was delivered by their respective manufacturers, federations, merchandizers:

- Rock wool: Rockwool Belgium
- Glass wool: Saint-Gobain Construction Products Belgium Isover and Knauf Insulation
- PUR: Recticel Belgium and Federplast
- EPS: ISOMO, Styfabel and Federplast
- XPS: Jackodur, Abriso and Federplast
- Sheep's wool: Walotex, Doscha (the Netherlands, Belgium) and Black Mountain (UK)
- Paper flakes: CPB (trade name Isocell) Belgium
- Flax: Isovlas (the Netherlands)
- Wood fibre: Pavatex Benelux (Switzerland)
- Hemp: Thermohanf, Germany

Involvement of stakeholders

A first and a second version of PCR was discussed with several stakeholders. Comments and feedback that we received afterwards were integrated in this version of PCR as far as possible.

The following stakeholders were present at the stakeholder consultation of the 20th of April 2012:

- Quentin De Hults, BASF
- Laurie Dufourni, BBF
- Jos Leyssens, Bostoen
- Liesbet Temmerman, CERAA
- Georges Timmermans, CIR - Isolatie raad
- Caspar Rutten, CPB
- Lieven De Boever, CTIB-TCHN
- Wouter Kroon, Doscha BV
- Anouk Van De Velde, EVOLIAS
- Jan Teugels, Federatie Vezel-cement
- Hans Delannoye, FLIDAIS
- Luc Van der Auwera, HOMATHERM
- Shpresa Kotaji, HUNTSMAN/FEDERPLAST
- Caroline Henrotay, IBGE – BIM
- Jonas Eykens, ISOPROC
- Steven Deman, ISOPROC
- Rogier van Mensvoort, Isoulas
- Pieter Van Laere, ISOVER
- Nadine Cielen, ISOVER
- Els Bleus, ISOVER
- Peter Tulkens, Knauf Insulation
- Frank De Troyer, KULeuven ASPRO
- Philippe Hugo, LeRelais-Metisse
- Romain Gaignard, NMC s.a.
- Roos Servaes, OVAM

- Eline De Brocker, OVAM
- Piet Vitse, PCE-FOAMGLAS
- Jozef Van Zele, Recticel Insulation
- Louis Sempels, Rockwool
- Horia Bali, SGCP NV
- Catherine Grimonpont, SPF Economie
- Marc Van De Perre, STEICO SE
- Lutgarde Neirinckx, STYFABEL
- Emilie Gobbo, UCL - architecture & climat
- Sophie Trachte, UCL - architecture & climat
- Franck Dufraumont, VCB
- Georges Devent, Vlasverbond
- Stefaan Delorge, WALOTEX (DOSCHA)
- Patrick De Ceuster, Wevel vzw
- Johan Van Dessel, WTCB
- Lisa Wastiels, WTCB

Advisory committee

The PCR has been prepared in close consultation with an advisory committee. The following persons are part of the advisory committee:

- Andrew Evans (Black Mountain)
- Anita Ory (BBF / Wienerberger)
- Anna Conrad-Smith (Black Mountain)
- Anouk Van de Velde (Black Mountain)
- Arne Daneels (LNE)
- Bart Verstraete (NAV)
- Bruno De Vocht (Isocell)
- Caroline Henrotay (BIM)
- Catherine Grimonpont (FOD Economie)
- Elie Mansour (Black Mountain)
- Eline De Rocker (OVAM)
- Emilie Snauwaert (West-Vlaanderen)
- Geert Saelens (Abriso)
- Georges Timmermans (CIR)
- Hans Delanoye (Thermohanf)
- Herman Raes (Recticel)
- Ilse Dries (DAR Vlaanderen)
- Jens Siems (Kronotex)
- Jeremy Boucher (Pavatex)
- Johan Van Der Biest (BMP / Wienerberger)
- Johan Van der Biest (BMP/Wienerberger)
- Johan Van Dessel (WTCB)
- Lieven De Boever (TCHN)
- Louis Sempels (Rockwool)
- Luc Dumont (VGI-FIV)
- Lutgarde Neirinckx (Styfabel)
- Mathias Kersschot (Isomo)
- Nele Defoirdt (UGent)
- Patricia Denis (SPW Wallonie)
- Peter Tulkens (Knauf Insulation)

- Petri Ven (Federplast)
- Piet Vitse (Pitt Corning)
- Pieter Van Laere (Saint Gobain Construction Products Isover)
- Quentin de Hults (BASF)
- Robin Zwarteveen (Pavatex)
- Rogier Van Mensvoort (Isovlas)
- Roos Servaes (OVAM)
- Rutten Caspar (Isocell)
- Shpresa Kotaji (Federplast / Huntsman)
- Stefaan Delorge (Doscha)
- Vincent Briard (Knauf Insulation)
- Vincent De Temmerman (Confederation Construction)
- Virginie Lambert (BIM)
- Virginie Lambert (BIM)
- Werner Huygens (Jackon Insulation)
- Wouter Kroon (Doscha BV)
- Wouter Kroon (Doscha)

ANNEX 2

Environmental impact categories

Environmental impacts expressed with impact categories of LCIA (CEN TC 350)		
Environmental impact	**unit**	**Impact assessment method**
Global warming potential, GWP;	kg CO_2 equiv	ReCiPe midpoint
Depletion potential of the stratospheric ozone layer, ODP;	kg CFC 11 equiv	ReCiPe midpoint
Acidification potential of soil and water, AP;	kg SO_2 equiv	ReCiPe midpoint
Eutrophication potential, EP;	kg (PO4)3- equiv	CML 2002
Formation potential of tropospheric ozone, POCP;	kg Ethene equiv	CML 2002
Abiotic depletion potential (ADP-elements) for non fossil resources[a]	kg Sb equiv	CML 2002
Abiotic depletion potential (ADP-fossil fuels) for fossil resources[a]	MJ, net calorific value	Cumulated energy demand

[a] *The abiotic depletion potential is calculated and declared in two different indicators:*

- *ADP-elements: include all non renewable, abiotic material resources (i.e. excepting fossil resources);*
- *ADP-fossil fuels include all fossil resources*

Additional environmental impact categories		
Environmental impact	**unit**	**Impact assessment method**
Land occupation	Species.yr	ReCiPe endpoint (interim)
Land transformatoin	Species.yr	ReCiPe endpoint (interim)
Marine ecotoxicity	kg 1,4 DB equivalent	ReCiPe midpoint
Freshwater ecotoxicity	kg 1,4 DB equivalent	ReCiPe midpoint
Terrestrial ecotoxicity	kg 1,4 DB equivalent	ReCiPe midpoint
Human toxicity (cancer)	DALY	ReCiPe endpoint
Human toxicity (non-cancer)	DALY	ReCiPe endpoint
Particulate matter formation	DALY	ReCiPe endpoint
Ionising radiation, human health	DALY	ReCiPe endpoint
Water depletion	m^3	ReCiPe endpoint

Global warming potential (GWP)

Unit: kg CO_2 (carbondioxide) equivalences

Description:

The global warming potential describes the insulating effect of greenhouse gases, such as CO_2 and methane, in our atmosphere, affecting our health and that of the ecosystem in which we live. These emissions are causing an increase in the absorption of radiation emitted by the earth, magnifying the natural greenhouse effect. The greenhouse effect is a natural process of global warming involved in the radiation balance of the earth. It is caused by greenhouse gas (GHG) emissions in the atmosphere, mainly water vapour (the main contributor to the greenhouse effect), carbon dioxide (CO_2) and methane (CH_4). Greenhouse gases absorb infrared radiation and thereby cause an in increase atmospheric temperature. This basically natural phenomenon is becoming a problem due to an increase in GHG emissions resulting from human activities. Each GHG has a different warming potential. This potential is calculated on the basis of a reference: the warming potential of CO_2. Each GHG is assigned a characterisation factor, which expresses how many times more important the warming potential of this greenhouse gas is compared to CO_2 (whose characterisation factor is by definition equal to 1). Climate change is a direct result of rising concentrations of greenhouse gases in our atmosphere. These gases let sunlight through, but capture the heat reflected from the earth and bounce it back. This phenomenon is known as the greenhouse effect. Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are some important greenhouse gases.

The concentration of greenhouse gases in our atmosphere has increased significantly since the beginning of the industrial era (1750). There is increasing evidence that the temperature increase that we observe the last fifty years is largely due to human activities (eg use of fossil fuels and deforestation).

Ozon depletion potential (ODP)

Unit: kg CFC-11 (trichloorfluormethaan) equivalences

Description: The ozon layer depletion potential describes the depletion of the ozone layer in the atmosphere caused by emissions of chemical foaming and cleaning agents which allows the passage of greater levels of UV from the sun, causing skin cancer and reducing crop yields. Ozon depletion potential is a measure of a substance's ability to destroy stratospheric ozone, based on its atmospheric lifetime, stability, reactivity and content of elements that can attack ozone, such as chlorine and bromide. The characterisation model is developed by the World Meteorological Organization (WMO) and defines ozone depletion potential of different gasses (kg CFC-11 equivalent/ kg emission). Stratospheric ozone depletion refers to the thinning of the stratospheric ozone layer as a result of anthropogenic emissions. This causes a greater fraction of solar UV-B radiation to reach the earth’s surface, with potentially harmful impacts on human health, animal health, terrestrial and aquatic ecosystems, biochemical cycles and materials. Stratospheric ozone depletion thus impinges on all four areas of protection: human health, the natural environment, the man-made environment and natural resources. The stratospheric ozone layer is at its lowest level since measurements began in 1970. The main reason is the increase of chlorine and bromine levels by the release of such CFCs. This caused the UV-B radiation to increase significantly in some areas, the most prominent increase of 130% at the height of Antarctica.

Acidification potential of land and water sources (AP)

Unit: kg SO_2 (sulfurdioxide) equivalences

Description: The acidification potential is a measure of emissions that cause acidifying effects to the environment. The acidification potential is assigned by relating the existing S-, N-, and halogen atoms to the molecular weight. Acidifying pollutants have a wide variety of impacts on soil, groundwater, surface waters, biological organisms, ecosystems and materials (buildings). Examples include fish mortality in Scandinavian lakes, forest decline and the crumbling of building materials. The major acidifying pollutants are SO_2, NO_x and NH_x. Areas of protection are the natural environment, the man-made environment, human health and natural resources.

Eutrophication potential (EP)

Unit: kg PO_4^{3-} (phosphate) equivalences

Description: Eutrophication results from over-fertilisation of water and soil by nutrients such as nitrogen and phosphorous from human activity, speeding up plant growth and killing off animal life in lakes and waterways. The eutrophication potential is a measure of emissions that cause euthrophying effects to the environment. The eutrophication potential is a stoichiometric procedure, which identifies the equivalence between N and P for both terrestrial and aquatic systems. Eutrophication covers all potential impacts of excessively high environmental levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In addition, high nutrient concentrations may also render surface waters unacceptable as a source of drinking water. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition (measured as BOD, biological oxygen demand). As emissions of degradable organic matter have a similar impact, such emissions are also treated under the impact category "eutrophication". The areas of protection are the natural environment, natural resources and the man-made environment. For most species there is a clear optimum concentration off nutrient in water needed. Any deviation from this optimum is negative for that plant species. This leads to a shift in species populations. This can result in an ascending or decreasing number of species.

Photochemical ozone creation (POCP)

Unit: kg C_2H_4 (ethene) equivalences

Description: The photochemical reaction of sunlight with primary air pollutants such as volatile organic compounds (VOCs) and nitrogen oxides (NO_x) leads to chemical smogs that affect our health and that of our ecosystem and food crops. Photochemical ozone creation is a measure of emissions of precursors that contributes to low level smog, produced by the reaction of nitrogen oxides and VOCs under the influence of UV-light. Photo-oxidant formation is the formation of reactive chemical compounds such as ozone by the action of sunlight on certain primary air pollutants. These reactive compounds may be injurious to human health and ecosystems and may also damage crops. The relevant areas of protection are human health, the man-made environment, the natural environment and natural resources. Photo-oxidants may be formed in the troposphere under the influence of ultraviolet light, through photochemical oxidation of Volatile Organic Compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NO_x). Ozone is considered the most important of these oxidising compounds, along with peroxyacetylnitrate (PAN). Photo-oxidant formation, also known as summer smog, Los Angeles smog or secondary air pollution, contrasts with winter smog, or London smog, which is characterised by high levels of inorganic compounds, mainly particles, carbon monoxide and sulphur compounds. This latter type of smog causes bronchial irritation, coughing, etc. Winter smog is part of human toxicity.

Abiotic depletion potential for non-fossil resources (ADP elements)

Unit: uitgedrukt in kg Sb (antimone) equivalences

Beschrijving: Over-extraction of minerals and other non-living, non-renewable materials leads to exhaustion of our natural resources. Abiotic depletion potential for non-fossil resources is a measure of the extractions of the non renewable, abiotic material resources except fossil resources. The indicator describing this impact category is subject to further scientific development. The use of this indicator can be adapted when a further advanced and commonly accepted scarcity related indicator is available.

Abiotic depletion potential for fossil resources (ADP fossils)

Unit: uitgedrukt in MJ, net calorific value

Description: Over-extraction of fossil resources can lead to exhaustion of our natural resources. Abiotic depletion potential for fossil resources is a measure of the extractions of the non renewable fossil resources.

Land use (occupation and transformation)

Unit: species.yr

Description: The land use impact category reflects the damage to ecosystems due to the effects of occupation and transformation of land. This category covers a range of consequences of human land use. A distinction is made between use of land as a resource, in the sense of being temporarily unavailable, and transformation of land due to harvesting biotic resources or the destruction or alteration of land (e.g. mining). Transformation of land can have impacts on the biodiversity and (human) life support functions. Although there are many links between the way land is used and the loss of biodiversity, generally two mechanisms are concentrated on:

1. occupation of a certain area of land during a certain time;

2. transformation of a certain area of land.

Both mechanisms can be combined, often occupation follows a transformation, but often occupation occurs in an area that has already been converted (transformed). In such cases the method does not allocate any of the transformation impact to the production system that occupies an area. Distinction can be made between natural land transformation, agricultural land occupation and urban land occupation.

Ecotoxicity (terrestrial, marine and freshwater)

Unit: kg 1,4 DB equivalenten of kg 2,4 D equivalences

Description: The characterisation factors of ecotoxicity accounts for the environmental persistence (fate) and accumulation in the human food chain (exposure), and toxicity (effect) of a chemical. Ecotoxicity covers a number of effects such as acute and chronic toxicity on different species in soil (i.e. terrestrial ecotoxicity) and water (i.e. fresh water aquatic and marine ecotoxicity). The area of protection is the natural environment and resources.

Human toxicity, cancer effects

Unit: DALYs (Disability Adjusted Life Years).

Description: Toxicological characterization factors for human health are calculated by taking into account the time integrated fate, exposure of a unit mass of chemical released into the environment (including, in many cases, the size of the exposed population), toxicological potency (a quantitative measure related to the dose–response of a chemical, such as the LOEL – the Lowest Observable Effect Level in a test) and toxicological severity (a measure or description, qualitative or quantitative, of the cancer effect incurred, such as bladder cancer).

Human toxicity, non-cancer effects

Unit: DALYs (Disability Adjusted Life Years).

Description: Toxicological characterization factors for human health are calculated by taking into account the time integrated fate, exposure of a unit mass of chemical released into the environment (including, in many cases, the size of the exposed population), toxicological potency (a quantitative measure related to the dose–response of a chemical, such as the LOEL – the Lowest Observable Effect Level in a test) and toxicological severity (a measure or description, qualitative or quantitative, of the non-cancer effect incurred, such as skin irritation).

Particulate matter / respiratory inorganics

Unit: DALYs (Disability Adjusted Life Years).

Description: Ambient concentrations of particulate matter (PM) are elevated by emissions of primary and secondary particulates. The mechanism for the creation of secondary emissions involves emissions of SO_2 and NO_x that create sulphate and nitrate aerosols. Particulate matter is measured in a variety of ways: total suspended particulates (TSP), particulate matter less than 10 microns in diameter (PM10), particulate matter less than 2.5 microns in diameter (PM2.5) or particulate matter less than 0.1 microns in diameter (PM0.1).

For respiratory inorganics, all available methods are de facto endpoint methods. It is advised to report both the number of cases of different diseases as well as the related Years of Life Lost, Years of Life Disabled and DALYs.

Ionising radiation, human health

Unit: DALYs (Disability Adjusted Life Years).

Description: The same framework for human toxicity and ecotoxicity applies for ionizing radiation: the modelling starts with releases at the point of emission, expressed as Becquerel (Bq), and calculates the radiative fate and exposure, based on detailed nuclear physics knowledge. For human toxicity, the exposure analysis calculates the dose that a human actually absorbs, given the radiation levels that are calculated in the fate analysis.

Ionising radiation, ecosystems

Unit: DALYs (Disability Adjusted Life Years).

Description: The same framework for human toxicity and ecotoxicity applies for ionizing radiation: the modelling starts with releases at the point of emission, expressed as Becquerel (Bq), and calculates the radiative fate and exposure, based on detailed nuclear physics knowledge. For ecosystem impacts, the ecotoxicity framework is based on the hazardous concentration affecting species and on the concept of the change in the potentially affected fraction of those species, adapted to radioactive substances.

Water depletion

Unit: m^3 of water consumed

Description: Water depletion is related to the quantity as well as the quality of the water. The governing principles for a consideration of water quantity are that (1) the water sources are renewable and sustainable and (2) the volume of water released are returned to humans or ecosystems for further use downstream. The governing principle for a consideration of water quality is that the utility of the returned water is not impaired for either humans or ecosystems downstream. Water quantity indicators are defined for water use, consumption, and depletion to reveal the sustainable or non-sustainable nature of the sources. Generally the following sources are taken into consideration: in-stream water (use), off-stream water (withdrawal), surface water and ground water.

Calculation methods

ReCiPe midpoint and endpoint

The ReCiPe method was created by RIVM, CML, PRé Consultants, Radboud Universiteit Nijmegen and CE Delft. In ReCiPe one can choose between indicators at two levels:

- Eighteen midpoint indicators
- Three endpoint indicators

Each method (midpoint, endpoint) contains factors according to the three cultural perspectives. These perspectives represent a set of choices on issues like time or expectations that proper management or future technology development can avoid future damages.

- Individualist: short term, optimism that technology can avoid many problems in future.
- Hierarchist: consensus model, as often encountered in scientific models, this is often considered to be the default model.
- Egalitarian: long term based on precautionary principle thinking.

For this project we will use the Hierarchist method.

More information is available on the website www.lcia-recipe.net.

CML 2002

The (Dutch) Handbook on LCA provides a stepwise `cookbook' with operational guidelines for conducting an LCA study step-by-step, justified by a scientific background document, based on the ISO Standards for LCA. The different ISO elements and requirements are made operational to be `best available practice' for each step (Guinée et al, 2002).

The life cycle impact assessment (LCIA) methodology is based on a midpoint approach covering all emission- and resource-related impacts, for which practical and acceptable characterisation methods are available. Best available characterisation methods have been selected based on an extensive review of existing methodologies world-wide. For most impact categories a baseline and a number of alternative characterisation methods is recommended and for these methods comprehensive lists of characterisation and also normalization factors are supplied. Ecotoxicity and human toxicity are modelled adopting the multi-media USES-LCA model developed by Huijbregts et al. (2000, 2002).

The CML baseline method elaborates the problem-oriented (midpoint) approach. The CML Guide provides a list of impact assessment categories grouped into

A: Obligatory impact categories (Category indicators used in most LCAs)

B: Additional impact categories (operational indicators exist, but are not often included in LCA studies)

C: Other impact categories (no operational indicators available, therefore impossible to include quantitatively in LCA)

In case several methods are available for obligatory impact categories a baseline indicator is selected, based on the principle of best available practice. These baseline indicators are category indicators at "mid-point level" (problem oriented approach)". Baseline indicators are recommended for simplified studies. The guide provides guidelines for inclusion of other methods and impact category indicators in case of detailed studies and extended studies.

Only baseline indicators are available in the CML method in the SimaPro software programme (based on CML Excel spreadsheet with characterisation and normalisation factors).

More information is available on the website http://www.leidenuniv.nl/cml/ssp/databases/cmlia/index.html