Rules and recommendations for the development of a national database of construction materials

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NOTE: This project has received funding from LIFE Programme under the Grant Agreement number LIFE 18 GIE/ES/000911 Life for LLL(s).

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Abstract

This document is the result of the development activities carried out within the B2 work package of the Life Level(s) project. The work package B2, specifically step 1 *Developing recommendations to drive uptake of EPD*, focuses on improving the quality and correct use of data in countries where Building level LCA is not yet mainstream, particularly, Croatia, Ireland, Italy and Spain. To this end, a review of the main European initiatives related to the LCA of construction materials and existing and developing legislation was carried out. Then, a proposal for the format, framework, data categorisation and methodology for the creation of a national database is presented.

Madrid, May 2021

How to cite: Ruiz Amador D., Tumini I. 2021. Rules and recommendations for the development of a national database of construction materials.

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Executive summary

This document is the result of the development activities carried out within the B2 work package of the Life Level(s) project. The main objective of this project is to mainstream sustainable buildings in Europe through greater awareness and use of the specified indicators within the framework of Level(s), a set of common EU indicators to address life cycle environmental performance of buildings. Another objective is achieving the greater sense among the main actors in the industry and government on the necessity of Level(s) and a life cycle approach framework in addressing climate and environmental risk.

This particular work package B2, specifically step 1 *Developing recommendations to drive uptake of EPD*, focuses on improving the quality and correct use of data in countries where Building level LCA is not yet mainstream, particularly, Croatia, Ireland, Italy and Spain.

Ecometro Mediciones Sl. in collaboration with CAR, was commissioned to develop the following tasks described in this document:

1. Part 1 and Part 2 - Develop national rules/recommendations for use of data and data categorisation.
2. Part 3 – Identify default data and categorise existing data for Spain.
3. Part 4 – Proposing the structure and methodology for developing a National Data base for Spain.

In chapter 1 a brief introduction to the topic of life cycle analysis in the construction sector, legislation and initiatives is presented.

Chapter 2 describes the different types of LCA data, their use and where they can be accessed. In particular, Table 2.2 lists the main European EPD systems and repository.

Chapter 3 describes three European NDBs: INIES (France), OKOBAÜDAT (Germany) and MMG (Belgium). These NDBs are free databases linked to a national certification system. Although their main use is national, NDBs are a reference for other European countries. For example, the OKOBAÜDAT is also used in Austria. Nevertheless, these systems use a different format, data categorization and methodologies, so it is interesting to analyse them and understand their advantages and weaknesses. In the conclusion of the chapter we present a series of summary tables useful for comparing the different NDBs and relating them to the Level(s) objectives.

Chapters 4 and 5 contain recommendations for the development of a national database. Specifically, Chapter 4 presents recommendations for a common format aligned with developing legislation and the Level(s) evaluation philosophy.

The main characteristics of format are resumed in the table bellow

Categorization of dataset	A- Specific data B- Average data C- Generic data or default data
Life cycle stage	Ideally the NDB should consider all stages included in the EN 15804, from A to D. In the initial phase of development, information should be limited for the stages A1-A3.
Building parts/elements	Ideally the NDB should consider all elements from shell, core and urban works (see table 4.2). Nevertheless, at an early stage of development of NDB the minimum information should include the Shell (substructure and superstructure) and Core limited ceiling, wall and ceiling finishes, floor coverings and finishes.

Building Model	The two common hierarchical classifications of building products are: • Decomposition based on **element method** proposed by PEF4Building**.** The model structure is based on a hierarchical subdivision of the building in smaller entities: building elements, sub-elements and materials (Figure 4.1).  • The classification proposed by the EN 15978:2011 and taken up by the Working Draft PrEN 15978-1:202x (Figure 4.2) These two types of structures are only indicative, NDBs can be organised according to a different hierarchy of products and use dictionaries to allow communication between them.
Life cycle impacts	The NDB should consider all impact categories included into the reference standards EN 15978 and EN 15804: • Global warming potential (GWP100) • Depletion potential of the stratospheric ozone layer (ODP) • Acidification potential of land and water (AP) • Eutrophication potential (EP) • Formation potential of tropospheric ozone photochemical oxidants (POCP) • Abiotic Resource Depletion Potential for elements (ADP element) • Abiotic Resource Depletion Potential for fossil fuels (ADP fossil). Considering EN 15804 updates and PEF recommendations, additional impact categories under consideration are: • Eco toxicity and human toxicity. • Particulate matter / respiratory inorganics (dust particles). • Ionising radiation. • Land use. • Water scarcity.

	• Use of renewable biotic resources. • Use of non-metallic minerals. However, in the early stages of NDB development, the Global Warming Potential (GWP100) is recommended as the minimum impact category.
Use of data	According to the proposed data categorisation and in line with the indications of Level(s) and prEN 15978 regarding the use of data, three cases can be distinguished: *Type 1 – assessment using a simplified building model* It is a simplified assessment limited to the main building elements (facades, masonry, structures, etc.). The use of category C-generic and default data is recommended for this type of assessment. *Type 2 – assessment using the as designed building model* this assessment can be made on the basis of a final project when most of the product are defined. The data used for this assessment is a mix of generic (category C) and specific data (category A and B) when available. *Type 3 – assessment using a fully detailed as designed or 'as built' building model* For this type of evaluation, the data requirement are as for a Type 2 assessment except that the design data shall be the final or as built' data.

Digitalization	To promote the digitalization and the easy communication among different systems, the NDB should follow the ILCD+EPD format

Chapter 5 presents the recommendations and methodological proposal for the generation of a consistent set of generic data for one of the most important parts of a national database, i.e., environmental data for the product stage (modules A1-A3). Successively, this database must be completed with use stage and end-of-life processes.

The working draft prEN 15941 states that "if no EPD according to EN15804+A2:2019 is available, or the EPD is not complete for the product which is used in the building, the product stage (modules A1-A3) information from available EPD, EPD according to ISO 21930 or a data set from an LCA database or from an LCA study to ISO 14044 of a similar product may be used and adapted to create a new data set to reflect the actual situation as closely as possible".

Ultimately, this statement establishes that, in the absence of specific data for the product stage (A1-A3) of a construction product (e.g. a specific EPD), different strategies can be addressed to generate data to fill this information gap. These strategies can be based on the adaptation of existing LCA data to the actual situation.

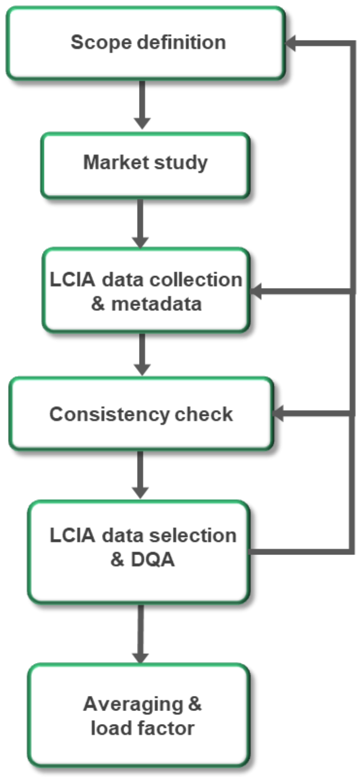
The existing LCA data to which the standard refers are mainly:

- LCA databases (i.e. LCI data)
- LCA studies (LCIA data)
- EPD (LCIA data)

First option requires an LCA expert as well as access to LCA tools that are in most cases under license. Without renouncing entirely to this option, it is advisable to address firstly the generation of generic LCA data from LCIA data already published.

In order to generate generic LCA data, a difference must be made between a "production mix" which is the effective production in the country and, a "consumption mix" which is the available mix in the country for consumption. The consumption mix is equal to the production mix plus the imported products minus the exported products. Therefore, carrying out a market study is crucial to determine the market shares of domestic producers as well as inflows and outflows of construction products.

The proposed methodology consists of different stages that are shown in following figure. The general idea is to collect existing LCIA data (preferably EPD data) for a previously defined construction product (or family products). This data collection should be oriented according to the information obtained from the market study for that product. After, a consistency and quality analysis of the data collected, averaging of LCIA data is performed in order to obtain the generic data. The generation of generic data is an iterative process and the milestones reached in intermediate stages of the methodology can cause the redefinition of the previous stages.



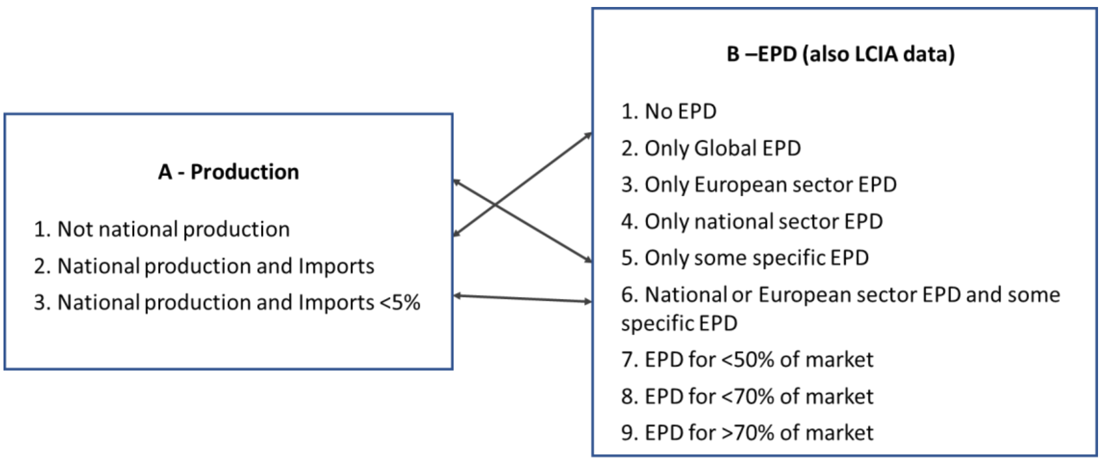
Scope definition: must be described the product or family of product under study, its physical, chemical and functional characteristics and other relevant specifications. It must also be defined the functional unit, i.e., the unit to which the environmental data to be collected and generated are referred, for example m2, kg, m3

Market study: study of the consumption mix of the product in the country (national production, imports and exports). It is intended to know the origin of the product sold in the country as well as market shares or production volumes of the different manufacturers and importers.

LCIA data collection & metadata: collection of LCIA data from both national manufactures and importers. Data should also be collected at the European and global level so that they can be compared with those that are candidates to be part of the generic data. LCIA data will be collected consulting EPD programs although published LCA studies could also be taken into account. Each LCIA data collected must be characterized by its metadata (a template is provided for this purpose).

Once the LCIA data collection has started, information gaps will soon be found. To these information gaps must be added those detected during the market study. The proposed methodology for the generation of generic data of the BDN tries to face the more than probable information gaps that its developers will encounter. The methodology allows the making of assumptions and the use of less representative data when those desirable data are not available.

The following figure proposes a classification for the multiple situations that can be found.



In the following table is shown the classification for products in Spain.

Product	A - Production	B – EPD
Brick	A2/A3	B6
Cement	A2/A3	B6
Glass	A2/A3	B6
Structural steel (long steel product)	A2/A3	B7/B8
Timber	A2/A3	B6
Aluminium	A2/A3	B6
Indoor ceramic finishing	A2/A3	B8/B9
Gypsum plasterboard	A2/A3	B6
External Thermal Insulation Systems	A2/A3	B6/B7
Mortars	A2/A3	B6/B7
Aluminium windows	A2/A3	B6
PVC windows	A2/A3	B5
Natural stone	A2/A3	B5
Rolled zinc	A2/A3	B5
Extruded polystyrene (isolation)	A2/A3	B5
Curtain walls	A2/A3	B5
External aluminium doors	A2/A3	B5
Mineral wool (isolation)	A2/A3	B5/B7
Glass wool	A2/A3	B5/B7

Consistency check: all LCIA data collected should pass a consistency check. The purpose of this stage is ultimately to detect significant differences between LCIA data collected. The consistency check can be performed in various ways, and even could depend on the product under study. Firstly, it is recommended to group the data under several criteria, e.g. geographical scope, types of product, relevant methodological issues, etc. Secondly, a simple statistical treatment of LCIA data in the same group must be performed, and a simple representation of LCIA data or charts where are shown correlation between two related impact values e.g. for mineral wood, climate change versus non-renewable primary energy or climate change versus abiotic depletion potential (fossil). Finally, comparison among statistical values for LCIA data groups can also be made, e.g. comparison of means and standard deviations for national manufacturers and the rest of Europe manufacturers.

LCIA data selection and DQA: selection of LCIA data that will be used to determine the generic LCIA data. Only LCIA data that show consistency with each other and, at the same time, are aligned with the scope and market analysis will be used for this purpose. For example, a LCIA data can be excluded because is outside the confidence interval - 95% - of its group, or because its carbon footprint/density ratio is inconsistent with that of the rest of LCIA data.

A data quality assessment is also conducted in this stage. As proposed in Annex E in EN 15804 +A2:2019, the data quality assessment must cover geographical, technological and time-related representativeness. Additionally, other issues dealing with the quality of a LCIA data can be proposed, as accuracy of LCIA data, review type for LCIA data and other. Finally, a data quality index (DQI) is obtained for each LCIA data.

Averaging and load factor: averaging of selected LCIA data and DQI of all of them to obtain the generic LCIA data and its corresponding DQI. According to information obtained in market study, generic LCIA data can be calculated by weighted average of LCIA data collected based on market shares or production volumes. If these figures are not available, an arithmetic average of selected LCIA data can be performed. In this step must also be measured the uncertainty associated with the averaging of LCIA data.

Regarding to data generation, the working draft prEN 15941 also states that “In making such adaptations, assumptions shall not simply default to the best case but shall conservatively represent a realistic condition”. Considering this conservative approach, the application of the worst-case scenario should take into account the level of uncertainty from generated LCA data.

Additionally, load factor or data penalization is a concept used in some National Databases, especially when this has regulatory purposes. The load factor depends on the uncertainty associated to generic data and tries to compensate its incompleteness and imponderability. If the load factor is applied should be attributed transparently and be separate to the data itself.

Data quality requirements

In the early development of the NDB, quality assessment of generated data is not aimed at the exclusion of a generic data in the NDB because it does not meet minimum quality level. Whatever the level of data quality, sufficient generic data should be guaranteed to perform a minimum comprehensive assessment based on a simplified building model (substructure, superstructure and finishes).

Therefore quality assessment serves to characterize the quality of the data generated after the application of different assumptions and/or the application of different less representative dataset. i.e., it can serve to elucidate the data with the highest quality available. And on the other hand, the quality assessment can also serve to substantiate the generation of a load factor to be applied to generic data or for the use of the NDB for regulatory purposes.

In future developments of the NDB, the minimum quality level that generic data must have to be part of the NDB should be defined, especially if is intended to be used them for regulatory purposes.

For assessment using a fully detailed or 'as built' building models, construction product LCA data may be a mixture of generic and specific data. Specific data should be used where it is available for the products used but may be generic where no specific data are available (prEN15978). The framework for quality assessment of the generic data can also be used to assess the quality of the specific data (for example the EPD of a manufacturer providing a specific construction product) when it is intended to replace the generic data. The specific LCIA data, should be as accurate and representative data as possible for the actual construction product installed. For this purpose, minimum quality requirements should be established for specific data to become part of the NDB.

Special materials

When collecting LCIA data, special attention must be paid to two groups of materials: bio-based materials and metals.

Carbon storage in products must be documented separately according to ISO 14067:2018 (carbon footprint of products), and according to EN 15804:2012+A2:2019, climate change impact must be reported broken down into fossil, biogenic and land use fractions. However, almost all EPD and LCA of construction products are published under EN 15804+A1:2013 standard. It is very common to find LCA data for bio-based product whose climate change values include the stored carbon, resulting in negative figures for the cradle to gate scope (modules A1-A2-A3). Carbon sequestration must only be taken into account when the EoL modules (specially C3 and C4) are included and the wood-based products originates from sustainable sources (certified by FSC, PEFC, etc.).

Another set of products to which special attention should be paid are metals products. Metals have the ability to be reused or recycled without altering their properties. This confers a high value to metal scrap that is the key incentive for the systematic dismantling, collection and recycling of metal products.

EN 15804 requires that the recycled content input is characterized in module A1 (recycled content approach). The recyclability of metals can still be accounted for through the use of module D, where credits can be applied to the system based on avoided burden (EoL recycling approach). Therefore the recycled content figure alone of modules A1 to A3 is not suited for the LCA of metal products. For that purpose, a full LCA including EoL recycling credits is the most appropriate approach.

1_LCA for construction sector Overview

The building sector has a major impact on the environment. In Europe, this sector is responsible for about 50% of the use of natural resources, 40% of the energy use and 16% of the water use. Buildings are furthermore responsible for 36% of the total CO_2 emissions in the EU (European Union, 2019). The state-of-the-art methodology to identify and analyse the most significant environmental impacts of a building is a Life Cycle Assessment (LCA). An LCA is a tool that enables the analysis of where and when selected environmental impacts may occur at the different stages along the life cycle of a building.

Analysis of several environmental impacts ensures that any trade-offs between different impacts, as well as between different life cycle stages, can be identified. This ensures a more thorough analysis of the improvement potential of design options, as well as helping to identify 'hot spots' of environmental impact along the life cycle of a building (European Union, 2019; Trigaux et al., 2020).

The Life Cycle Assessment for Construction Industry

The Life Cycle Assessment (LCA) is a methodology used to measure the environmental impact of a product, a component, or a building over a life cycle. The life cycle of a building is defined as all processes from the extraction of raw materials for the construction of the building until the end of its use, including disassembly and recycling (Figure 1.1). Hence, the LCA measures the environmental impacts at the different stages that are called collectively life-cycle.

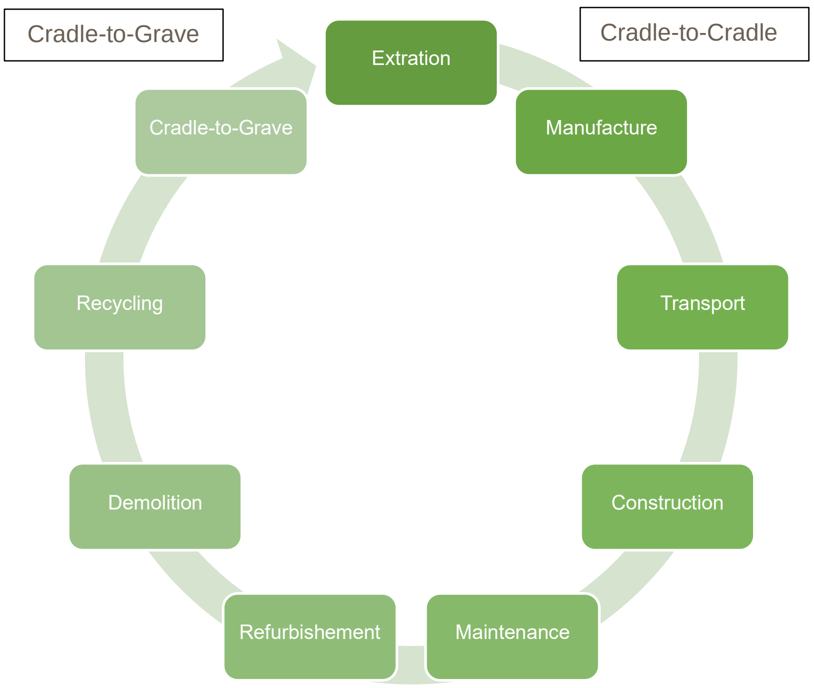


Figure 1.1. Life Cycle of a construction product. Source (Anderson & Thornback, 2012, p. 5)

Life Cycle Assessment is intended to report on all significant environmental impacts associated with a product or process. It therefore measures impact across a broad range of environmental issues such as impact on air quality, on water usage and water quality, on toxicity to human life and to ecosystem functioning, on impact on global warming and resource use.

One of the priority objectives of the LCA is the transparent, organised and comparable communication of environmental product information. For this reason, a common communication format called Environmental Product Declaration (EPD) has been adopted. The EPD provide environmental information from LCA studies in a common format, based on common rules, known as Product Category Rules (PCR). This format is regulated by a reference standard (ISO14425:2006, EN 15840:2012 and update versions) that sets out the requirements for the development and publication of an EDP.

The EPD is usually published by Program Operator (see the table 2.1), which also ensure the study compliance through a third-party verification. Construction product EPD are normally modular, so that an EPD for cement can be used with an EPD for Aggregate to produce an EPD for concrete (Anderson & Thornback, 2012).

Life Cycle Stages

The scope of different LCA studies can vary, but the manufacture of the construction product will always be included (cradle to gate). Some studies will, in addition, consider the transport to, and installation of the product on a construction site, its maintenance, and the impacts of disposal (cradle to grave), but because these can vary widely depending on the location and the way that the product is used, some LCA studies do not include these later stages.

Because of their use of a wide range of raw materials and the vastly different forms of processing used to produce final products and the different ways that they are used, construction products can be responsible for many environmental impacts at different stages in the life cycle. For instance:

- Extracting virgin resources: For materials such as aggregates, raw materials extraction will be one of the principal impacts, but for more highly processed materials the production impacts are likely to dominate.
- Manufacturing: The impact of manufacturing can be the major environmental impact especially if large amounts of energy are required as in the production of metals or cement.
- Packaging: The impact of packaging is usually small though too little packaging can increase product wastage. The disposal of packaging is often a big part of its impact.
- Transport: Transport impacts are generally small in comparison to other life cycle impacts. Even when construction products are moved globally, they are normally shipped which has a low environmental impact in comparison to road transport. The exception is for products such as aggregates and timber, which

have relatively low manufacturing impacts and therefore higher relative impacts from transport, though they are still small.

- Waste impacts: Waste can be generated at several different stages of the life cycle - during the manufacturing process, on construction sites and during maintenance, replacement and demolition.
- Site impacts: The IGT Final Report states that 10-15% of materials sent to a building site end up as waste – the impacts of producing these materials, that are then wasted, is a considerable impact associated with the construction site.
- Maintenance and refurbishment: The impact due to the replacement of materials and products due to maintenance activities (i.e. annual replacements) and refurbishment or replacement (i.e. replacement of windows).
- Demolition and disposal: Some products are unable to be reused or recycled and therefore end up as waste in landfill. Emphasis is now beginning to turn to consider end of life issues at the very start of the manufacture of a product so that it can be deconstructed and reused or recycled easily at the end of life.

(Anderson & Thornback, 2012)

The EN 15804 "Sustainability of construction works - Environmental product declarations the life cycle of building products - Core rules for the product category of construction products" describes which stages of a product's life cycle are considered in the EPD and which processes are to be included in the life cycle stages. According to it, the life cycle stages are organized as the figure bellow:

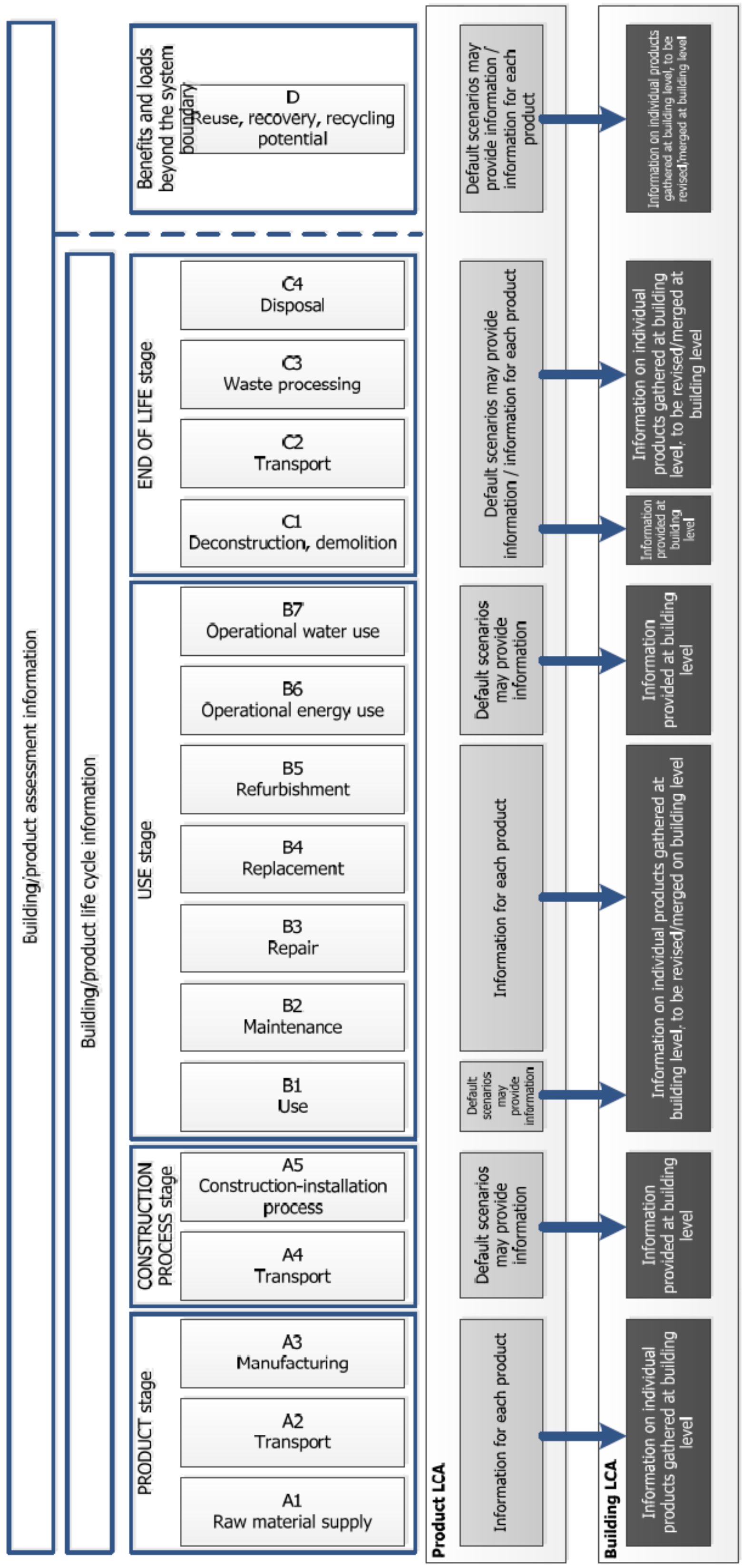


Figure 1.2 Relation between product LCA and building LCA along the life cycle modules. Figure based on EN 15804and EN 15978. Source: EeBGuide Guidance Document, (AA.VV., 2011, p. 17)

As stated above, the minimum scope for an EDP of a construction product should be that of production stage (A1-A3). The next stages that should be included are end-of-life (C1-C4) and benefits and loads beyond the system boundaries (D).

Steps for producing LCA

The process for developing an LCA goes through different steps as follows:

- **Goal and Scope**: The first step if the study is to be made public is to consider the goal and scope of the study. Examples of different studies include product comparisons or supply chain management.
- **Data collection**: The next step is to gather primary data on the manufacture of the product. This will cover the input materials and energy used and the product's waste and emissions produced. For this step, it is essential to compile an **inventory** of the system. The inventory is the list of resources used and the emissions to air, water and land produced from all the processes required to manufacture the product, including the raw materials used and the energy required (upstream processes) and the disposal of wastes (downstream processes). LCI data – the list of resources and emissions, is also provided by LCI databases (free or private) and is the basis of LCA databases. LCI data often includes several hundred separate resource or emission data and is very difficult to use without an LCA tool to evaluate the resulting environmental impacts.
- **Modelling**: The next step in the Life Cycle Assessment is to build a model of the process, and link this to existing LCA data sets for the upstream and downstream processes so that a complete system model is produced. Modelling is normally done using a tool designed for the purpose which includes information for materials, energy and waste.
- **Analysis**: The final stage is analysis using the results of the modelling in the context of the goal and scope of the study.
- **Critical review**: If the study is to make public comparison then a critical review

(AA.VV., 2011; Anderson & Thornback, 2012)

Impact categories

Life Cycle Assessment is intended to report on all significant environmental impacts associated with a product or process. It therefore measures impact across a broad range of environmental issues such as impact on air quality, on water usage and water quality, on toxicity to human life and to ecosystem functioning, on impact on global warming and resource use. These issues can change, and their importance increase or decrease over time as society's concerns and priorities change.

The EN 15840+A1:2013 states that information on environmental impact is expressed through the impact categories of Life Cycle Assessment (LCIA) using characterisation factors in a LCIA according to ISO 14044. The EPD shall contain a core set of pre-determined environmental impact indicators (Table 1.1). The EPD may also contain additional environmental impact indicators (Table 1.2).

Table 1.1 Core Environmental impact indicator

Impact categories	Indicator	Unit (expressed per functional unit or per declared unit)
Climate change-total	Global warming potential total(GWP-total)	kg CO2 eq.
Climate change-fossil	Global warming potential fosil fuel(GWP-fossil)	kg CO2 eq.
Climate change-biogenic	Global warming potential total biogenic(GWP-biogenic)	kg CO2 eq.
Climate change-land use and land change	Global warming potential total(GWP-total)	kg CO2 eq.
Ozone Depletion	Depletion potential of the stratospheric ozone layer (ODP)	kg CFC11 eq.
Acidification	Acidification potential, Accumulated Exceedance (AP)	mol H eq.
Eutrophication aquatic freshwater	Eutrophication potential, fraction of nutrients reaching freshwater and compartment (EP-freshwater)	kg PO4 eq.
Eutrophication potential aquatic marine	Eutrophication potential, fraction of nutrients reaching freshwater and compartment (EP-marine)	kg N eq.
Eutrophication terrestral	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	mol N eq.
Photochemical ozone formation	Formation potential of tropospheric ozone (POCP)	kg NMVOC eq.

Depletion of abiotic resources- fosil fuels	Abiotic depletion potential for non fossil resources (ADP-minerals&metals)	kg Sb eq.
Depletion of abiotic resources- mineral and metals	Abiotic depletion potential for fossil resources (ADP-fossil)	MJ
Water use	Water (user) deprivation potencial, deprivation-weighted water consumption (WDP)	m3 world eq. Deprived

Source: EN 15840 table 3

Table 1.2 Additional Environmental impact indicator

Impact categories	Indicator	Unit (expressed per functional unit or per declared unit)
Particulate Matter emissions	Potential incidence of disease due to PM emissions	Disease incidence
Ionizing radiation, human health	Potential Human exposure efficiency relative to U235	kBq U235 eq.
Eco-toxicity (freshwater)	Potential Comparative Toxic Unit for ecosystem	CTUe
Human toxicity, cancer effects	Potential Comparative Toxic Unit for humans	CTUh
Human toxicity, non-cancer effects	Potential Comparative Toxic Unit for humans	CTUh
Land use related impacts/Soil quality	Potential soil quality index	dimensionless

Source EN 15840 table 4

Contribution of LCA to the sustainable construction

As the operational impacts (primarily heating, cooling, ventilation and lighting) of buildings decrease through regulation of new build and retrofit of the existing stock, then the impact of the materials used to construct the buildings (the embodied impacts) becomes more important.

Until recently, there has been little focus on these embodied impacts, but interest is growing with a range of approaches being developed. With all approaches, the intention is first to quantify the impact, and then to provide information so that users can identify areas with the greatest potential for reduction and to evaluate reduction strategies. An EPD provides one mechanism to do that, by providing robust and consistent information that can be used to quantify the embodied impacts of a building over its life cycle.

The diagram (figure 1.3) shows several approaches to measuring the environmental impact associated with materials at the building level. Some approaches only measure carbon whilst others measure a wider range of embodied impact indicators provided within EPD and LCA databases. The approaches also cover different scopes, eg cradle to gate, or cradle to site, or cradle to grave.

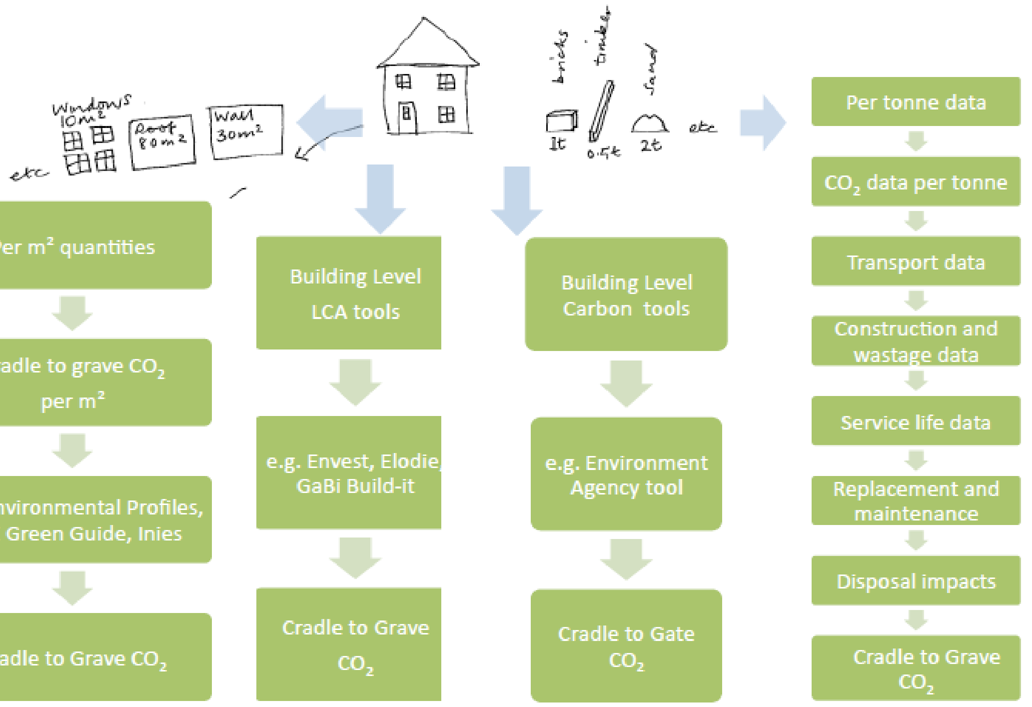


Figure 1.3 Carbon estimation flow at building level. Source: Anderson & Thornback, 2012, p. 21

Functional Unit or Declared Unit

The functional unit is a key element of LCA which has to be clearly defined. The functional unit is a measure of the function of the studied system and it provides a reference to which the inputs and outputs can be related. The functional unit provides the reference for combining the material flows attributed to the construction product and for summing up the environmental impacts in the life cycle stages of the construction product at the building level.

This enables comparison of two essential different systems. Definition of a functional unit could be difficult. The definition should be precise and comparable enough so that the unit can be used throughout the study as reference.

For example, the functional unit for a paint system may be defined as the unit surface protected for 10 years. A comparison of the environmental impact of two different paint systems with the same functional unit is therefore possible.

The functional unit used for a project should be determined though the elaboration of the collected data and study. Also, potential restrictions with respect to the depth of the study, the sources and quality of data are determined during the process of the study.

Thus, a construction product may have several possible functions. Depending on the objective of the EPD, the EPD may refer to a specific function and scenario. To normalize the calculation of inputs and outputs of a product along the different modules, the functional unit or declared unit is used as a common basis (AENOR, 2012; Life04 ENV/GR/110, n.d.).

LCA regulation

Since 1989, with the publication of Construction Product Directive (CPD), the European Union has promoted the creation of a common framework for building regulation. Subsequently, the European Committee for Standardisation (CEN), through product Technical Committees, promote the development of standards for each construction product. In 2011, the CPD was replaced by the Construction Products Regulation (CPR), which add the environmental sustainability as new requirement for construction sector. The biggest impact is that if an EU Member State wants to regulate in these areas of sustainability, it will have to do so in accordance with European standards.

With the aim of providing a common method for measuring the environmental impact at building level and reducing potential barriers among European countries, the EU Member States agreed to ask the CEN to develop a horizontal approach to the measurement of embodied and operational environmental impacts of construction products and whole buildings across the entire life cycle.

In 2004, the European Commission mandated the development of these new European Standards known as mandate M/350. The European Standards Technical Committee set up to do this called CEN/TC 350 and it is organized into six working groups:

- CEN/TC 350/ Task Group Framework
- CEN/TC/WG1 Environmental Performance Assessment of Buildings
- CEN/TC WG2 Building Life Cycle description
- CEN/TC WG3 Product Level (EPD, communication formats)
- CEN/TC WG4 Economic Performance Assessment of Buildings
- CEN/TC WG5 Social Performance Assessment of Buildings

The main reference standards for life cycle analysis of construction products and which have been developed under the umbrella of CEN TC 350 are:

- CEN/TR 15941:2010 Sustainability of construction works - Environmental product declarations - Methodology for selection and use of generic data.
- EN 15804:2012+A2:2019 Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products.
- EN 15978:2011 Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method (currently under review).

At international level, the reference standards for EPDs are:

- ISO 14044:2006 Environmental management — Life cycle assessment — Principle and Framework
- ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines
- ISO 14025:2006 Environmental labels and declarations — Type III environmental declarations — Principles and procedures

Eu initiative and projects

In addition to the standard development, several initiatives are carried out within the EU to create a common framework for the environmental assessment of buildings.

Among the numerous initiatives and projects, PEF4Building and Level(s) should be mentioned.

Product Environmental Footprints (PEF4Building)

The Product Environmental Footprints (PEFs) initiative originates from the European Commission's Single Market for Green Products initiative which proposed to look into the feasibility of an initiative on the Ecological Footprint of Products to address the issue of the environmental impact of products, including carbon emissions [and] explore possibilities for establishing a common European methodology to assess and label them (Recanati & Ciroth, 2019).

During several pilot projects, Product Environmental Footprint Category Rules (PEFCR) were developed for certain products. Among these products were the following construction products: thermal insulation, hot and cold-water supply piping systems, photovoltaic modules, metal sheets and decorative paints. The PEF4Buildings project aims at testing the applicability of the PEF method, and the PEFCRs of these construction products, at the building level instead of the product level.

Through the study of two office buildings, the following results were obtained:

1. To develop a possible approach to benchmark office buildings and to define classes of performance.
2. To carry out an assessment at building level. It provide a guidance on how to link the assessment of the environmental performance of construction products to the assessment of a building by using the PEF method.

As an additional outcome, the project team made the following recommendations:

- Defining a common EU methodology to calculate the environmental impact of buildings and a common EU methodology on how to define environmental benchmarks.
- Using a stepwise conservative approach, meaning that initially benchmarks are defined representing lower limit values and which gradually become more severe in time.
- The first conservative benchmark should be set to allow all office buildings that fulfill minimum legal requirements on energy, water, fire safety, etc. To define the environmental impact fulfilling the improvement or target value, this can be

based on best-practice buildings (experimental or demonstration projects) or based on virtual buildings with for example 30% less impact than the reference value (i.e. representing business-as-usual). In the second approach, the percentage reduction could either be based on a statistical analysis of building practice in the specific Member State or based on political targets set.

- The reference buildings for each building typologies, must be defined the building that represent the building practice in a specific Member State.
- To have one benchmark including both material and energy impact. However, taking practical implementations into account, it might be easier to separate both (in a first phase) because energy benchmarks are currently already established in the EU Member States.
- Defining clear and different calculation rules on how to calculate the impacts in the design and post-construction phase.
- Ensure data quality requirement.

Level(s)

With the aim to create a common assessment method and reporting system on the sustainability performance of building, the EU Commission promote the development of Level(s) as new European approach. Level(s) is based on life cycle thinking and circularity and it provide a framework for a common language for building sustainability, which can be used directly on building projects and portfolios, or as a basis for other initiatives, policies, schemes and actions.

Within the Level(s) framework, each indicator is designed to link the individual building's impact with sustainability priorities at the European level. This allows Level(s) users to focus on a manageable number of essential concepts and indicators that contribute to achieving EU and national environmental policy goals (European Commission, 2020).

Level(s) is intended to provide a valuable set of information and data which can enable to understand, improve and optimise the sustainability performance of a building. To report on the performance of a building project using Level(s) involves gathering, handling, and processing a wide range of data relating to the performance of a building. Some relevant data includes into Level(s) are described table below.

Table 1.3 Data point associated with building resource use and the indoor environment.

Resouces uses	Associated data points
Energy and water use	· Consumption (calculated and monitored) · Related CO2 equivalent emissions · Related costs
Building elements and materials	· Quantities (design and as-built) · Related CO2 equivalent emissions · Related costs · Related services life estimates
Building designs and structures	· Adaptability features (contributing to an overall score) · Deconstruction features (contributing to an overall score) · Related costs
Maintenance plans	· Maintenance and replacement cycles · Related costs
The indoor environment	· Ventilation rates (calculated and monitored) · Tested building product emissions (design and as-built) · Air quality monitoring and sampling results · Thermal conditions (calculated and monitored) · Lighting and visual comfort conditions · Noise levels and acoustic comfort conditions

Source: Level(s) – A common EU framework of core sustainability indicators for office and residential buildings, Dodd et all., 2020

Level(s) takes a whole life cycle approach to the sustainability of buildings. To fully support this approach, the evaluation is complemented by a full Life Cycle Assessment (LCA) of a building. By making a LCA, the environmental impacts associated with a building can be quantified and the most significant areas can be identified and used as the starting point for improving performance.

The common framework is organised into three levels. The levels provide a choice as to how advanced the reporting on sustainability for the project will be. The three levels represent the following stages in the execution of a building project:

- Level 1. The conceptual design for the building project – the simplest level as it entails early-stage qualitative assessments of the basis for the conceptual design and reporting on the concepts that have or are intended to be applied.
- Level 2. The detailed design and construction performance of the building – an intermediate level as it entails the quantitative assessment of the designed

performance and monitoring of the construction according to standardised units and methods.

- Level 3. The as-built and in-use performance of how the building performs after completion and handover to the client – the most advanced level as it entails the monitoring and surveying of activity both on the construction site and of the completed building and its first occupants.

The basic idea is that the levels represent a professional journey from the initial concept through design, construction and then, after handover, to the reality of the completed building. Progression up the levels also represents an increase in the accuracy and reliability of the reporting – the higher the level, the closer the reported results will be to providing you with data that reflects the performance of the building as-built and in-use (Dodd et al., 2020; European Commission, 2020; JRC, 2017).

Figure 1.4: The levels – from conceptual design to in-use performance. Source: Level(s) – A common EU framework of core sustainability indicators for office and residential buildings, Dodd et all., 2020

2_LCA Databases

Type of LCA data

LCA data can be presented in two ways: LCI data and LCIA data. Life cycle inventories (LCI data), consist in a list of inputs and outputs of elemental substances. The inputs refer to resources used by the system under analysis while the outputs refer to the substances that are released into the air, water or soil. All of them referenced to the functional unit (see Figure 2.1).

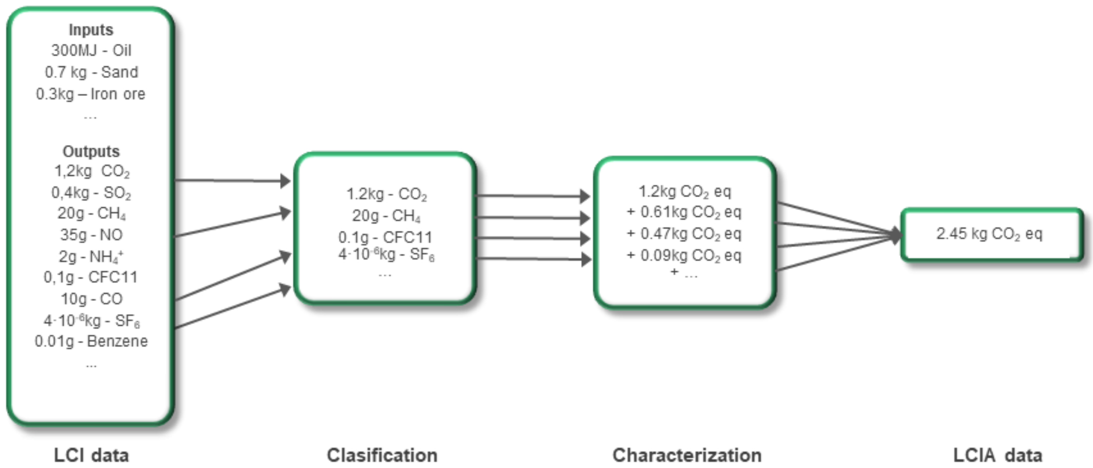


Figure 2.1: Differences between LCI data and LCIA data

To obtain the effects derived from LCI, it is necessary to evaluate the consequence that each substance has on a chosen environmental impact. This process is known as life cycle inventory assessment (LCIA). If we are interested in the climate change, firstly all substances that have effect on this impact must be chosen from LCI (classification). Secondly, the effect of these substances must be referred to a common unit of impact (characterization), for example methane causes 30.5 times more global warming potential than carbon dioxide itself. Finally, the impact value obtained as equivalent units of CO_2 is the sum of the contribution of all characterized substances. This value is known as LCIA data.

While LCIA data are ready to use in calculations, LCI data requires an expert user and in most cases LCA tools to obtain LCIA data. In Table 2.1 are shown main LCA data according to its origin.

Table 2.1 Type of LCA

LCA DATA	LCI	LCIA	EXPLANATION	EXAMPLES
LCA databases	X		Data are available under license. These data are used in EPD generation and LCA studies. To obtain LCIA data is necessary tools with database of category impact methods	Ecoinvent, Thinkstep, Umberto
EPD		X	EPD published that has suitable construction sector data	EPD programs
National database		X	Generic LCA data for key materials or processes in construction. In any case, data are mandatory for regulatory purposes or certification.	OKOBAUDAT, NMD and INIES databases

LCA databases

In order to develop a life cycle study, several quantitative data concerning the emissions and the resources use during the production process is needed. To facilitate this task, various organisations and companies have developed life cycle inventory databases.

They contain generic information and are used to calculate the impact of a specific product. Databases can be:

- inventory database with basic materials, including building materials. The most common are for purchase databases (GaBi, Ecoinvent, etc.), but there are also public databases (ELCD, PEF, etc.). All of them contain information on the input and output flows of a process, but the form of aggregation can be different.
- sectoral databases, which contain sector-specific information. For example, NEEDS is a database for the electricity sector, or Eurobitumen for bituminous materials.

EPD

These are databases that collect product-specific EPDs that may have been produced by a manufacturer (specific EPD) or by an association (sectoral EPD). The published data are public and must fulfil the requirements defined by the EPDs operator. Membership of an EPD programme ensure that the data has been calculated in accordance with the standard and has passed a review process.

EPD operators gather in associations created with the aim of coordinating the development and provision of credible and scientifically correct data from products. At European level, ECO Platform is the main association for EPDs in the construction and infrastructure sector.

ECO Platform also provides a digital ECO Portal where it is possible consult the EPDs from the different member operators. The exchange of data between operators is only possible thanks to the digitisation of information. The use of a common language is key for communication between the different operators.

In response to the need to find a common language and harmonise information for the construction sector, the InData Working Group was founded. It defined the ILCD+EPD as the data exchange format and it should be applied to different type of data (E. g. generic, product specific, producer, association, representative values).

The following table presents some of the most used EPD catalogues for the construction sector.

Table 2.2. Information about EPD programs

Acronomy	Designation of the EPD Program	Country	Webpage	Manager of the EPD Program	Availability of data (public/paid)	Scope
ASTM	ASTM International - EPD	International	astm.org			Cement and concrete
BAU EPD	Bau EPD GmbH	Austria	bau-epd.at	Austrian Sustainable Building Platform (ASBP)	Public	Construction products
B-EPD	Belgian EPD Programme	Belgium	health.belgium.be	Federal Public services Health, Food Chain Safety and Environment	Public	Construction products
GreenBookLive	Environmental Profile	United Kindom	greenbooklive.com	BRE Global	Public	Products and services
DAPc	DAPcons - Declaraciones Ambientales de Productos para la construcción	Spain	csostenible.net	CATEEB - Col.legi d'Aparelladors, Arquitectes Tècnics i Enginyers d'Edificació de Barcelona	Public	Construction products
DAP habitat	DAP Habitat System	Portugal	daphabitat.pt	Dep. Eng. Civil - Universidade de Aveiro	Public	Construction products
ECO Platform	ECO Platform	Europe	eco-platform.org	European EPD Programme Operators	Public	Construction products
GBCe Plataforma de Materiales		Spain	materiales.gbce.es	GBCe	Public	Construction products
epddanmark	EPD Danmark	Denmark	epddanmark.dk	Danish Technological Institute	Public	Construction products
EPD Ireland	EPD Ireland programme	Ireland	igbc.ie/epd-home	IGBC	Public	Construction products

EPD Italy	EPD Italy	Italy	www.epditaly.it	ICMQ S.p.a	Public	Construction products
INIES	FDES-Fiches de Déclaration Environnementale et Sanitaire Declaration Sheets + AFNOR	France	base.inies	Alliance HQE-GBC	Public	Construction products and Building Equipment
Global EPD	Global EPD - AENOR	España	aenor.com/declaraciones-ambientales-de-producto	AENOR	Public	Construction products
IBU	IBU.data	Germany	ibu-epd.com	Institut Bauen und Umwelt e. V.	Public	Construction products
inside inside	INSIDE INSIDE - EPD Database	Holanda	database.insideinside.nl	Dutch Green Building Council	Public	Interior products
JEMAI	JEMAI- Japanese Environmental Management Association of Industry	Japón	www.jemai.or.jp	Japan Environmental Management Association for Industry	Paid	
EPD Korea	EPD Korea	Corea	www.keiti.re.kr	KEITI - Korean Environmental Institute for Technology and Information	Paid	
MRPI	National Milieu Database	Netherland	milieudatabase.nl	MRPI Fundation	Public	Construction products
EPD Norge Digi	NEF - Norwegian EPD Foundation	Norway	digi.epd-norge.no	NEF - Norwegian EPD Foundation	Public	Generic product and services
PEP ecopassport	Product Environmental Profile ecopassport program	France	www.pep-ecopassport.org	Association P.E.P	Public	Construction products and Building Equipment
RTS EPDs	Rakennustieto - Environmental	Finland	cer.rts.fi	Building Information Foundation RTS	Public	Construction products

	Product Declaration					
EPD System	The International EPD System	Sweden	www.environdec.com	EPD International AB	Public	Generic product and services

National database

The National databases (NDB) are databases developed by a country which contain the environmental information of building materials representative for this region. Generally, the creation of an NDB is associated with a regulatory requirement, such as the incorporation of life cycle analysis of buildings into legislation. This is the case in France where the INIES database is mandatory for HQE certification or in Germany where the ÖKOBAUDAT database is used in the Assessment System for Sustainable Building (BNB). For more information see the next chapter.

Some Countries, which do not have their own NDB, use similar databases from other countries, such as Austria, which uses the ÖKOBAUDAT. Other Countries, such as Finland, are in the process of developing an NDB.

Some States without their own databases or access to other types of data often rely on more developed databases, such as INIES, despite the lack of representativeness of the data. This practice leads to a lack of data representativeness.

3_National Database

Inies

Overview

INIES is the French national reference database for environmental and health data on construction products and equipment. INIES offers Environmental and Health Declaration Sheets (EHDP) for construction products and Product Environmental Profiles (PEP) for building equipment, provided by manufacturers and trade associations in the format set out in European standard NF EN 15804 and its national supplement NF EN 15804/CN for construction products and standard NF XP C08-100-1 and PCR version 3 for equipment. The INIES database is run by the supervisory board and the technical committee. The supervisory board, chaired by the Alliance HQE-GBC, ensures that the database operates ethically and professionally. The technical committee oversees the collection and processing of data as well as database content updates (Association HQE, 2019).

A FDES is a standardised document that shows the results of a product's life cycle analysis as well as health information, used to calculate the environmental and health performance of an eco-design building.

The analysis is carried out according the EN 15804+A1 and NF EN 15804/CN, which they take the product's entire life cycle into account, from extracting the raw materials to the end of its life, no forgetting the inclusion of transport, implementation, and even the product's usage. FDES sheets thus constitute a major multi-criteria tool that helps professionals make choices that will make their building more sustainable, with limited impact on the environment, all while creating a healthy atmosphere for future users.

Methodology for Default Data (Donnée Environnementales par Défault-DED)

For the environmental performance assessment of new building (*Performance Environnementale des Bâtiments Neufs-PEBN*), it is required the use of specific environmental data of product or material installed in the building. In absence of specific data, it should be used a default data (DED) for the product or equipment used in the building.

In order to meet the objective of completeness of the building assessment, the DED should cover all construction products and equipment, i.e. at least one data item per line of the INIES nomenclature considered relevant (level 3 for construction products and levels 3 or 4 for equipment).

Categorisation

The INIES is composed by EHDP developed respecting the NF EN 15804 and NF EN 15804/CN standard, as well as French regulations:

- on environmental declarations (Decree No. 2013-1264 and ministerial order of 23 December 2013 relating to environmental declarations of construction products and decorative products intended for use in building works)
- on VOC emission declarations for the concerned products (Decree No. 2011-321 and et ministerial order of 19 April 2011 relating to labelling of construction products or floor and wall coverings or paints and varnishes about their emission of volatile pollutants and ministerial order of 20 February 2012 amending ministerial order of 19 Avril 2011).
- as well as verification by an independent third party (Ministerial order of 31 August 2015 relating to independent third-party verification of environmental declaration of construction products, decorative products and electric, electronic and HVAC equipment intended for use in building works)

EHDPs verified by a verifier, are called “configurable”. There are *mother* EHDPs which allow to generate *daughter* EHDPs. Both, mother and daughter EHDPs are registered independently of each other in the program.

Typologies of configurators rely on two main characteristics: the type of EHPD issued by the configurator and the method of parameter settings. Three types of configurators can be distinguished depending on the type of EHPD:

- collective EHPD
  - Configurators mainly working by extrapolation of the product size based on collective EHPD of a "model product" (for example main extrapolation by mass of the product)
  - Configurators allowing issuing of collective EHPD, but with parameter settings relating to sensitive parameters regarding elements of the process or the life cycle (product size, but also nature of material substrate like formulation of concrete, resin, specific surface treatment, colour …)
- individual EHPD
  - produced using a common base of collective and generic data and methodological assumptions: the responsible for placing the product on the market issues his individual declaration according to his own data restricted or not to sensitive parameters identified up- front. When issued, this "daughter" declaration must undergo a complementary verification to the one of the configurator (in particular on relevance of the chosen parameters and sensitive parameters).

Impact and module

The version PEP v3.0 consider the followed environmental indicators (Table 3.1)

Table 3.1: Environmental indicators used in INIES

Indicator	Unit
Indicators of environmental performance	
Global warming potential (GWP)	kg CO2 eq.

Ozone Depletion Potential (ODP)	kg FCF11 eq.
Acidification potential (AP)	kg SO2 eq.
Eutrophication potential (EP)	kg PO4(-3) eq.
Photochemical Ozone Creation Potential (POCP)	kg C2H4 eq.
Abiotic depletion potential for non-fossil resources (ADPE)	kg Sb eq.
Abiotic depletion potential for fossil resources (ADPF)	MJ
Air pollution	m3
Air pollution	m3
Indicators of resources depletion consumption	
Use of renewable primary energy (PERE)	MJ
Primary energy resources used as raw materials (PERM)	MJ
Total use of renewable primary energy resources (PERT)	MJ
Use of non-renewable primary energy (PENRE)	MJ
Non-renewable primary energy resources used as raw materials (PENRM)	MJ
Total use of non-renewable primary energy resources (PENRT)	MJ
Input of secondary material (SM)	kg
Use of renewable secondary fuels (RSF)	MJ
Use of non-renewable secondary fuels (NRSF)	MJ
Use of net fresh water (FW)	m3
Indicators of the waste categories description	
Dangerous waste	kg
Non-dangerous waste	kg
Radioactive waste	kg
Indicators of the exit flow description	
Components for the reuse	kg
Recyclable materials	kg
Materials for the energy recuperation (incineration excluded)	kg
Energy from the exterior	Mj

Source: (Ministère du logement et de l’Habitat Derable & Ministere de l’Environnement de l’Energie et de la, 2019)

Module

The module considered in the environmental analysis are the production A1-A3, construction A4-A5 and end of life C1-C4.

(Association HQE, 2019, 2020)

Ökobaudat

Overview

ÖKOBAUDAT is a platform with data, information and links related to the life cycle assessment (LCA) of construction works.

At the platform's core is the online database with LCA and EPD datasets on building materials, construction, transport, energy and disposal processes. ÖKOBAUDAT is provided as a standardized database for life cycle assessment of construction works by the Federal Ministry of the Interior, Building and Community and is the mandatory database for the Assessment System for Sustainable Building (Bewertungssystem Nachhaltiges Bauen, BNB).

The datasets are in compliance with DIN EN 15804 "Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products" and are subject to strict quality requirements. They can be used in many different building assessment systems.

ÖKOBAUDAT is the mandatory database for assessing global environmental effects in the Assessment System for Sustainable Building (Bewertungssystem Nachhaltiges Bauen, BNB). It provides data for the calculation of life cycle assessments of buildings or constructions, using the online software eLCA. To ensure consistency, BNB-compliant data must be based on the background database GaBi. The ÖKOBAUDAT platform also offers datasets based on ecoinvent background data.

ÖKOBAUDAT Format

The ÖKOBAUDAT adopted the ILCD data format[1], with extensions for EPD data that cannot be presented in the ILCD format. This adapted ILCD format is called "ILCD+EPD data format". A detailed description of the data fields in the ILCD+EPD

[1] ILCD: https://eplca.jrc.ec.europa.eu/LCDN/developerILCDDataFormat.xhtml

data format can be found in “Table of definitions, ILCD+EPD Data format”[2] at ÖKOBAUDAT webpage.

The ILCD+EPD format can be generated using the EPD Editor, an independently executable software tool available at the ÖKOBAUDAT webpage.

Data Categories

The ÖKOBAUDAT Dataset are organized into 3 categories, from A to C depending on its origin.

Category A data (EPDs with programme operation)

Data in Category A is life cycle assessment data in accordance with EN 15804 from environmental product declarations (EPDs). Behind the EPD is a programme that operates in accordance with EN ISO 14025. The programme instructions and product category rules (PCRs) must be available for the public to be read and must have been compiled in accordance with EN 15804 and EN ISO 14025.

Category B data (Verified EPDs/life cycle assessment data in accordance with EN 15804)

Data in Category B is not generated as part of an EPD programme that operates in accordance with EN ISO 14025 (Category B1) or is not published as part of an EPD (Category B2). However, it has been externally verified/subject to a critical review like the Category A data.

Submitting Category B data requires coordination with the ÖKOBAUDAT Users' Advisory Group. Here the respective requirements for the submission of data to ÖKOBAUDAT are set out depending on the requirements, including the origin of the data. In principle, proof of compliance with EN 15804 must be provided separately for the respective datasets via an external verification process (**Category B1**) or critical review (**Category B2**) by the applicant or supplier of life cycle assessment data. The critical review must be in the form of an “external review”, which has to be carried out analogously to verification according to EN ISO 14025.

[2] https://www.oekobaudat.de/en/service/downloads.html

Category C data ("generic datasets")

Data in Category C is generated based on EN 15804, but is not subject to an external review by an independent third party. Category C data includes replacement data that ÖKOBAUDAT provides for product categories for which no Category A or Category B data is available ("generic data"). This life cycle assessment data is provided with uncertainty margins of 10 % to 30 % when the data is generated. Generic datasets are commissioned by the BBSR where necessary and prepared in accordance with uniform, consistent procedures audited by independent third parties. They correspond to the requirements for modelling and calculation of LCA data formulated in the ÖKOBAUDAT principles.

Other datasets of Category C are not included in ÖKOBAUDAT.

Dataset Types

To express the representativity of life cycle assessments, ÖKOBAUDAT differentiates between five dataset types:

- specific dataset – manufacturer/manufacturing company-specific dataset for a specific product
- average dataset – average datasets provided by industrial associations, several companies, or several works (i.e. on the basis of data on the industrial production of companies)
- representative dataset – data that is representative for a country/region (for example average for Germany)
- template dataset – unspecific datasets for specific products created on the basis of a "template EPD"
- generic dataset – generic data in accordance with EN 15804 and other data that is not modelled on the basis of industrial data (for example on the basis of literature, expert knowledge, etc).

The ÖKOBAUDAT can be also divided into construction products and other life cycle data. The possible variation of dataset type occurring in ÖKOBAUDAT are showed in the Table 3.2

Table 3.2 Data categorisation and dataset type in ÖKOBAUTDAT.

Group	Data category	Description	Database	Conformity check	Dataset type (subtype)
Construction product dataset	A	Construction product EPD in programme operation	Manufacturer, works location	Independent external verification via programme operation	Specific dataset
			Association, country		Average dataset
					Template dataset
	B1	Construction product EPD without programme operation	Manufacturer, works location	Independent external verification without programme operation	Specific dataset
			Association, country		Average dataset
					Template dataset
	B2	Construction product dataset (no EPD)	Manufacturer, works location	Independent external critical review	Specific dataset
			Representative data for a country/region		Representative dataset
Construction product datasets	C	Construction product dataset (no EPD)	Replacement data for a country/region	NO	Generic dataset
Other life cycle data		Transport processes			
		Use processes			
		General end-of-life processes			
		Energy supply			

Source: ÖKOBAUTDAT. Basis for the building life cycle assessment, p.32.

Hierarchical Frame

The datasets must be allocated to one of the given product categories. The current product categories can be found on the ÖKOBAUDAT website[3]. The product categories are organized according to the example (Table 3.3):

Table 3.3: Example of product categories in ÖKOBAUDAT.

1. Mineral building product
1.1 Binder
1.1.01 Cement
1.1.02 Lime
1.1.03 Gypsum
1.1.04 Clay

Source: ÖKOBAUTDAT. Basis for the building life cycle assessment, p.33.

[3] https://www.oekobaudat.de/fileadmin/downloads/20201012_Produktkategorien_Uebersetzung.pdf

Impact

The impact and environmental indicators assessed by ÖKOBAUDAT are in accordance with the EN 15804. All indicators that are assessed on the BNB must be calculated in all cases. The impacts of the module A1-A3 (product stage) may be indicated individually and/or in aggregated form; all other modules must be presented individually. The total of A1 to A3 must be calculated from the individual values A1 to A3. The mandatory indicators are showed in the Table 3.4

Table 3.4 Impact categories in ÖKOBAUDAT

Indicator	Unit
Indicators of Life cycle	
Use of renewable primary energy (PERE)	MJ
Primary energy resources used as raw materials (PERM)	MJ
Total use of renewable primary energy resources (PERT)	MJ
Use of non-renewable primary energy (PENRE)	MJ
Non-renewable primary energy resources used as raw materials (PENRM)	MJ
Total use of non-renewable primary energy resources (PENRT)	MJ
Input of secondary material (SM)	kg
Use of renewable secondary fuels (RSF)	MJ
Use of non renewable secondary fuels (NRSF)	MJ
Use of net fresh water (FW)	m3
Indicators of the impact assessment	
Global warming potential (GWP)	kg CO2 eq.
Ozone Depletion Potential (ODP)	kg R11 eq.
Photochemical Ozone Creation Potential (POCP)	kg Ethene eq.
Acidification potential (AP)	kg SO2 eq.
Eutrophication potential (EP)	kg Phosphate eq.
Abiotic depletion potential for non fossil resources (ADPE)	kg Sb eq.
Abiotic depletion potential for fossil resources (ADPF)	MJ

Source: ÖKOBAUT

Uncertainty and Penalties for generic data

ÖKOBAUDAT provides generic data for the calculation of life cycle assessments of buildings or constructions, which can be used in the planning phase if the specific products are not yet known or if no specific data is available.

In ÖKOBAUDAT, an uncertainty penalty is added to the indicator values for the product stage (modules A1-A3) of the generic datasets. These uncertainty penalties shall give a conservative estimate of the environmental impact, assuming worst case conditions and compensating for uncertainties in data quality. In order to determine these uncertainty margins, the datasets are classified into three levels regarding completeness of the model and representativeness (in terms of technology, time and geography; see Table 3.5). Depending on the completeness and representativeness of data, uncertainty penalties of 10 %, 20 % or 30 %, respectively, are added (see Table 3.5). Datasets that do not meet the requirements of level 3 in terms of completeness and representativeness cannot be accepted in ÖKOBAUDAT or have to be improved.

Table 3.5: Classification of dataset regarding completeness and representativeness.

Level	Completeness	Representativeness
1	**Product system largely complete**	**Representative** (in term of technology, time and geography)
2	**Few processes / flows are missing** The generator of the dataset has documented during modelling that not all products / processes have been completely recorded (e.g. use of auxiliary materials or supplies, in-house transports, small parts of system products, packaging estimated) or not all flows have been fully captured (e.g. certain emissions into waste water or air are incomplete, waste quantities are not fully recorded). In principle, errors that arise should be less than 5% deviation from a complete	**Partly representative** (in terms of technology, time and geography) For the system model either only the technological, only the temporal or only the geographical representativity can be documented. For instance, the very latest data of one plant with one type of production may be available for a product. Or a country's technology mix for a production type is used, but it's outdated. In principle, it should be ensured that no significant deviations (less than 10% in environmental impacts) can be expected from more up-to-date

	modelling and occur at most twice in a system model.	data, other types of production / technologies or geographical details (e.g. import mixes). The assessment is usually done by experts only.
3	**Important processes / flows are missing** The generator of the dataset has documented during modelling that due to lack of information, processes relevant for the results (with regard to mass and environmental indicators) were ignored or result-relevant flows in air, water or soil are missing. Even though important processes or flows are missing in the system model, the resulting error should be less than 10% deviation from a complete modelling and should occur at most twice in a system model.	**Ignorance of representativeness** Neither technology nor currentness nor geographical representation of the situation can be assessed. Deviations should be within the range of less than 20% with regard to environmental impacts. This classification is usually done by experts only.

Source: ÖKOBAUDAT

Table 3.6: Uncertainty penalties

Uncertainty penalty		Classification completness		
		Level 1	Level 2	Level 3
Classification representativness	Level 1	10%	20%	30%
	Level 2	20%	20%	30%
	Level 3	30%	30%	30%

Source: ÖKOBAUDAT

The uncertainty penalties are determined by the data provider (thinkstep) and are already included in the indicator values in ÖKOBAUDAT. The level of uncertainty penalties, including an explanatory statement for uncertainty penalties of 20% or 30%, is documented in the corresponding datasets. There are no uncertainty penalties imposed on data for scenarios (modules B, C and D)

(Federal Institute for Research on Building et al., 2020; IBO – Österreichisches Institut für Bauen und Ökologie GmbH, 2020)

Environmental Profile of building elements (Milieugerelateerde materiaalprestatie van gebouwelementen - MMG)

Overview

The MMG is a methodological framework for calculation and communication of Environmental Performance of Materials used on Building Elements for the Flemish construction sector. The assessment framework has been developed by The Public Waste Agency of Flanders (OVAM), the principal authority in the Belgian region of Flanders for sustainable management of waste, materials and soils. With the objective to develop a transparent and specifically related to the Belgian construction industry assessment methodology, OVAM, together with Service Public Wallonie and Brussel Environment took in 2014 the initiative to work towards the development user-friendly tool for decision makers.

In the period covering February 2011 through August 2012, by order of the OVAM the project team comprising VITO, KU Leuven (ASRO) and BBRI developed an expert calculation model (including assessment framework) for the quantification of environmental performance of building elements. The model served as the basis for a limited database of 115 building element variants that is representative of the Belgian construction industry (Servaes, 2012). The expert calculation model has been further developed since 2013. The methodology has been updated to follow amendments within European standardisation and the developments regarding the European Product Environmental Footprint (PEF).

Furthermore, the database has been extended to almost 500 building element variants. The extension was also done as data input for the online tool (hereinafter called 'tool') based on MMG that was made publicly available in 2018. With the tool, decision-makers will have a user-friendly calculation tool in which they can calculate the environmental impact of their building choices.

MMG Assessment Framework

The MMG method has been developed in line with the European harmonised standards for the assessment of environmental performance of buildings, which have recently been developed in CEN/TC 3502:

- EN 15804:2012+A1 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products (CEN 2013)
- EN 15978 Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method (CEN 2011a)
- EN 15643-2 Sustainability of construction works - Assessment of buildings - Part 2: Framework for the assessment of environmental performance (CEN 2011b)
- TR 15941 Sustainability of construction works - Environmental product declarations – Methodology for selection and use of generic data (CEN 2010)

Environmental Indicator

The assessment method considers the impact categories included in the CEN/TC 350 as well as the additional impact categories recommended in relevant documents such as PEF Guide (Spirinckx et al., 2018), national legislation of some member countries, and Technical Report of CEN/TC 350 (2016). The final list of impact assessed in the MMG is:

- global warming
- ozone depletion
- acidification for soil and water
- eutrophication
- photochemical ozone creation
- depletion of abiotic resources: elements

- depletion of abiotic resources: fossil fuels
- human toxicity (cancer effects and non-cancer effects)
- particulate matter
- ionising radiation: human health effects
- ecotoxicity: freshwater
- water resource depletion
- land use: occupation (soil organic matter and biodiversity)
- land use: transformation (soil organic matter and biodiversity)

Table 3.7 Selected CEN environmental indicators including units and selected impact method for individual environmental scores

Environmental indicator (CEN)	Unit	Selected impact method
Global warming	Kg CO2 eq.	EN 15804+A1 (2012)
Ozone Depletion	Kg CFC11 eq.	EN 15804+A1 (2012)
Acidification for soil and water	Kg SO2 eq.	EN 15804+A1 (2012)
Eutrophication	Kg (PO4)2 eq.	EN 15804+A1 (2012)
Photochemical Ozone creation	Kg ethene eq.	EN 15804+A1 (2012)
Depletion of abiotic resources elements	Kg Sb eq	EN 15804+A1 (2012)
Depletion of abiotic resources, fossil fuel	MJ, net calorific values	EN 15804+A1 (2012)

Table 3.8 Selected CEN+ environmental indicators including units and selected impact method for individual environmental scores.

Environmental indicator (CEN+)	Unit	Selected impact method	In line with
Human toxicity, cancer effects	CTUh	Resenbaum et al., 2008	PEF
Human toxicity, non-cancer effects	CTUh	Resenbaum et al., 2008	PEF
Particulate matter	Kg PM2.5 eq	Rabl & Spandaro, 2004	PEF
Ionising radiation, Human health effects	kgU235 eq	Frischknet et al., 2000	ILCD
Ecotoxicity: freshwater	CTUe	Rosenbaum et al, 2008	PEF
Water resources depletion	M3 water eq.	Frischknet et al., 2008	PEF
Land use occupation: soil organic matter	Kg C deficit	Milá I Canals et al., 2007	PEF

Land use occupation: biodiversity	PDF* m2yr	Köllner, 2000	_52
Land use transformation: soil organic matter	Kg C deficit	Milá I Canals et al., 2007	PEF
Land use transformation: biodiversity	PDF* m2	Köllner, 2000	_53

Data Selection

The data are obtained from the Swiss LCI database ecoinvent version 3.3, harmonised as much as possible into the Belgian construction sector. In the scope of the MMG research project in the period 2010-2013, a few proactive materials manufacturers and industry organisations offered their own specific environmental data of building products, which provided for an interesting comparison with the generic ecoinvent data.

Monetisation of impact

To allow for a decision-oriented selection of materials solutions, the characterisation values for each individual environmental indicator were optionally aggregated by means of the environmental external cost method. For each individual environmental indicator, the characterisation values are multiplied by a monetisation factor (e.g.: X kg CO2 equivalents times Y €/kg CO2 equivalents). This factor indicates the extent of the damage to the environment and/or humans, expressing it in a financial amount for the purpose of avoiding potential damage or settling any damage incurred.

Hierarchical structure

The calculation model is built up according to a hierarchical structure and distinguishes four levels of analysis: building, building element, work sections (i.e. building products), and materials (see figure 4.2). Each higher level is based on the previous level. Thus, a building is built up of a number of building elements (such as floors, external walls, internal walls, roof, etc.), which in turn consist of several work sections (e.g. a masonry wall). The work sections are again built up of different building materials (e.g. hollow brick and mortar).

MMG methodology

Functional Units

The functional unit for the calculation model is defined as 1 m^2 of an element (in case of elements that have a geometry of a surface and a thickness, e.g. 1 m^2 of exterior or interior wall or 1 m^2 of floor) as built in practice and that does not score identically for all possible performances.

Service Life

Specific requirements for the service life of the building are in most cases defined by the client. In the absence of such requirements, the general assessment method works with a standard assessment period of 60 years for homes, offices, schools and shops. The average life expectancy of buildings is usually longer than 60 years, but it is assumed that after 60 years, the building will most likely be renovated so thoroughly that, apart from the structure, relatively few of the original materials will still be present.

System Boundaries

The System Boundaries is based on the European standard EN 15804 that divide the Life Cycle of building into several stage or module (see figure 4.1). The basic rule here is that an impact is assigned to the stage in which it occurs. However, the MMG assessment method departs from these boundaries for practical reasons or else we have given our own interpretation owing to a lack of clarity or to contradictions in the standards. The scenarios and conditions considered for the MMG tool are:

A1-A3 Production stage

Specific Belgian environmental product declarations (EPDs) from the Federal database are not included yet in the first version of the tool and only generic LCI data can be used. In the recent update of MMG assessment framework, market and transformation processes were introduced. The market processes include inputs from production in several countries as well as inputs of transport processes.

A4-A5 Construction stage

The construction process stage mainly consists in the transportation of building materials from factory to building site, as well as a standard % of construction waste that is produced on the building site. A limited number of construction activities (e.g. excavation, energy related processes, and specific emissions at the construction site) are included in Module A5.

B1-B7 Use stage

Cleaning and planned servicing related to preventative and regular maintenance are included in Model B2. Corrective, responsive or reactive maintenance actions that should be considered in Module B3 are excluded, as these are related to user specific scenarios for which no general data are available.

The operational energy consumption (B6) for heating is calculated using the equivalent degree-day method.

C1-C4 End-of-Life stage

The composition of the materials and the method of connecting with other materials/ work sections determined the type of demolition process which could also lead to no environmental impacts. With the exception of soil, all construction and demolition waste, whether or not sorted on site, is transported from the construction/demolition site to a sorting facility/ collection point (e.g. metal dealer or crusher) and from there it is eventually further dispatched to recycling, reuse facility, incineration, energy recovery or landfill.

(OVAM, 2018)

Conclusions

As conclusions, some comparative table on the most important aspects of NDB format and contents are presented below.

Environmental Indicators

The three Database use the CEN/TC 350 as the main reference for the methodological approach, although there are some differences between them. The Environmental indicators are compared with the complete list of EN 15840+A1:2013 Core and Additional Environmental impact indicators.

Table 3.8 Environmental Impact Indicators of EN 15840+A1:2013, Inies, Ökobaudat and MMG.

Impact categories	EN 15840+ A1:2013	Inies	Ökobaudat	MMG
Climate change-total	X	X	X	X
Climate change-fossil	X			
Climate change-biogenic	X			
Climate change-land use and land change	X			
Ozone Depletion	X	X	X	X
Acidification	X	X	X	X
Eutrophication aquatic freshwater	X	X	X	X
Eutrophication potential aquatic marine	X			
Eutrophication terrestral	X			
Photochemical ozone formation	X	X	X	
Depletion of abiotic resources- fosil fuels	X	X	X	X
Depletion of abiotic resources- mineral and metals	X	X	X	X
Water use	X			
Particulate Matter emissions	X			X
Ionizing radiation, human health	X			X
Eco-toxicity (freshwater)	X			X
Human toxicity, cancer effects	X			X
Human toxicity, non-cancer effects	X			X
Land use related impacts/Soil quality	X			
Land use occupation: soil organic matter				X
Land use occupation: biodiversity				X
Land use transformation: soil organic matter				X
Land use transformation: biodiversity				X
Air pollution		X		

Use of renewable primary energy (PERE)	X	X
Primary energy resources used as raw materials (PERM)	X	X
Total use of renewable primary energy resources (PERT)	X	X
Use of non-renewable primary energy (PENRE)	X	X
Non-renewable primary energy resources used as raw materials (PENRM)	X	X
Total use of non-renewable primary energy resources (PENRT)	X	X
Input of secondary material (SM)	X	X
Use of renewable secondary fuels (RSF)	X	X
Use of non-renewable secondary fuels (NRSF)	X	X
Use of net fresh water (FW)	X	X
Dangerous waste	X	
Non-dangerous waste	X	
Radioactive waste	X	
Components for the reuse	X	
Recyclable materials	X	
Materials for the energy recuperation (incineration excluded)	X	
Energy from the exterior	X	

Module

Table 3.9 LCA Module assessed in Inies, Ökobaudat and MMG.

LCA Module	Inies	Ökobaudat	MMG
A1-A3	X	X	X
A4-A5	X	X*	X
B1-B7		X*	X
C1-C4	X	X*	X
D		X*	

X*: The values must be presented individually and penalties are not applied.

Data categories

The three databases do not use a common categorisation, but there are differences between them.

Inies only accepts data from EPDs developed according to respecting the NF EN 15804 and NF EN 15804/CN standard and French regulations and distinguishes between two types of data: collective and individual.

Okobaudat uses a categorisation of type A, B and C where A is data from EPDs, B is data from verified sources and C is generic data.

In contrast, MMG only uses generic data from the Swiss ecoinvent database version 3.3.

Table 3.10 Data categorisation in Inies, Ökobaudat and MMG.

Type of data	Inies	Ökobaudat	MMG
Specific from EPD	X	X	
Collective form EPD	X	X	
Generic		X	X
Verified LCA		X	

4_Recommendation for National Database development

For the realisation of the different NDBs of materials for the Level(s) project, it is recommended that the format, the structure, and type of data follow the following principles:

- Aligned with current legislation and the recommendations of international working groups.
- Common format and agreed between Level(s) users.
- Interoperability between different NDBs.
- Oriented towards digitisation and the use of BIM.
- The flexible format, to allow the adaptation to regulatory changes and the addition of information as the sector develops more knowledge.
- Accessibility, it must have a friendly and intuitive interface for the user.
- Sufficient coverage, it should contain a minimum amount of information sufficient to carry out an exhaustive evaluation of the building, including the different phases from design to execution and maintenance of the building.
- Reliability of the data, there must be mechanisms for review by third parties to guarantee the veracity of the information.

The main characteristics that an NDB should have and that should be the subject of discussion between the agents concerned are detailed below.

It is important to keep in mind that the field of LCA of construction materials is on going development, so the legislation and tools proposed here may soon be obsolete.

Categorization of dataset

Consultation of different NDBs has shown that there is no common format for the data type. In general, 3 types of data can be distinguished:

A- Specific data: obtained from a specific product produced by a specific manufacturer (e.g. specific EPD).

B- Average data: is a representative value of a specific product obtained by combining specific data or other average data. The aaveraging process may be applied to technologies, products, sites, countries and time-scale. EN 15804 and TR 15941 define them as “data combined from different manufacturers or production sites for the same declared unit”.

C- Generic data: or default data usually representing different producers and building products/ commercial references. Default data can be defined as “a surrogate data used if no specific data are available”.

System Boundaries

Life cycle stage

the level(s) structure encourages a complete life cycle analysis of a building. In the life cycle, it refers to the cradle to cradle and includes all phases, from material extraction, production, transport, use, disassembly and eventually reuse and recycling. For this reason, it is necessary that NDBs aspire to contain information related to building materials in the different phases.

In EN 15804 the life cycle of building products is divided into modules A to D (figure 4.1)

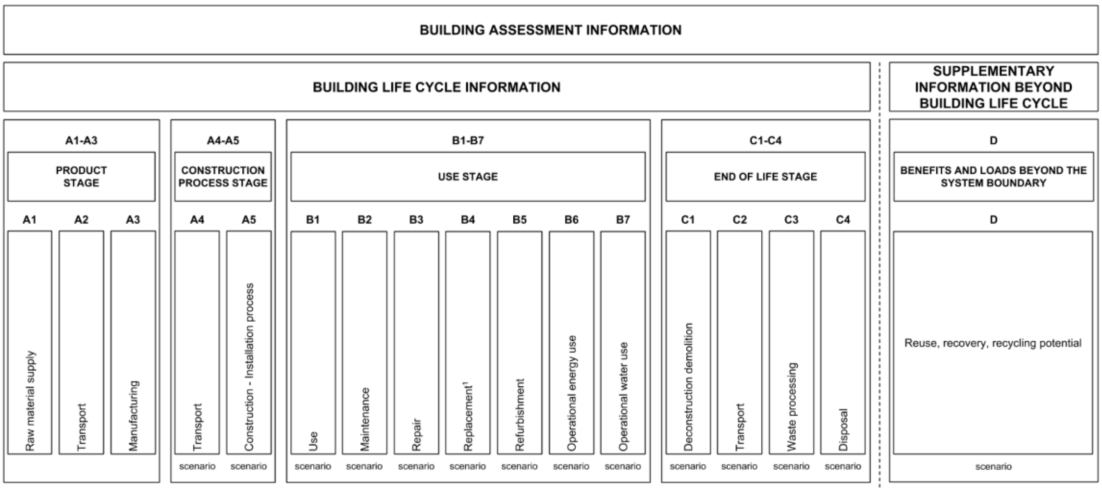


Figure 4.1 Life Cycle stages. Source: EN 15804

The objective of the building environmental assessment should be to consider all phases of the life cycle. However, the lack of information about all phases can be an obstacle to the creation of a comprehensive database.

For this reason, in the beginning of NDB development and according to simplified reporting option 1 for Level(s) (Dodd et al., 2017), it should be required only the assessment of A1-A3 module, the product production phase. The subsequent phases may be an optional information.

However, it should be borne in mind that the draft of EN 15978 and the simplified reporting option 2 for Level(s) envisages extending the mandatory minimum analysis to phases end of life (C1-C4) and the benefit and loads beyond the system boundaries (D). Therefore, EPDs considering these stages will be available in the short term. The NDB should be developed with a flexible format that allows the future incorporation of the other phases.

Table 4.1 Simplified reporting options in Level(s)

Simplified reporting option 1: 'incomplete life cycle: product stage, calculated energy performance and projected service life	• The product stage (A1-3) • The use stage (B4, B5, B6)
Simplified reporting option 2:	• The product stage (A1-3) • The use stage (B6) • End of life stage (C3-4)

'incomplete life cycle: product stage, calculated energy performance and the building material bank'	• Benefits and loads beyond the system boundary (D)

Source: Level(s)-A common EU framework of core sustainability indicators for office and residential buildings, Dodd el all, 2017

Building parts/elements

According to Level(s) framework, the minimum scope for Building part and element is detailed in the table 4.2.

Table 4.2 Building parts as described in Level(s)

Building parts	Related Building elements
Shell (substructure and superstructures)	
Foundations (substructure)	· Foundations (substructure) · Piles Basements · Retaining walls
Load bearing structural frame	· Frame (beams, columns and slabs) · Upper floors · External walls · Balconies
Non-load bearing elements	· Ground floor slab · Internal walls, partitions and doors · Stairs and ramps
Facades	· External wall systems, cladding and shading devices · Façade openings (including windows and external doors) · External paints, coatings and renders
Roof	· Structure · Weatherproofing
Parking facilities	Above ground and underground (within the curtilage of the building and servicing the building occupiers)
Core (fittings, furnishings and services) Fittings	
Fittings and furnishings	· Sanitary fittings · Cupboards, wardrobes and worktops (where provided in residential property) · Ceilings Wall and ceiling finishes · Floor coverings and finishes
In-built lighting system	· Light fittings · Control systems and sensors
Energy system	· Heating plant and distribution · Cooling plant and distribution · Electricity generation and distribution
Ventilation system	· Air handling units · Ductwork and distribution
Sanitary systems	· Cold water distribution · Hot water distribution · Water treatment systems

	· Drainage system
Other systems	· Lifts and escalators · Firefighting installations · Communication and security installations · Telecoms and data installations
External works	
Utilities	· Connections and diversions · Substations and equipment
Landscaping	· Paving and other hard surfacing · Fencing, railings and walls · Drainage systems

Source: Level(s)-A common EU framework of core sustainability indicators for office and residential buildings (Dodd et al., 2017)

The NDB should provide sufficient data to carry out a full building assessment, especially for a level 3 assessment.

However, at an early stage of development of NDB the minimum information should include the Shell (substructure and superstructure) and Core limited ceiling, wall and ceiling finishes, floor coverings and finishes.

Building model

Hierarchical classifications of building products are commonly used to offer users a way to navigate within a larger amount of data. However, no common hierarchy frame has been established for existing databases. We can distinguish two main structures:

- Decomposition based on **element method** (Spirinckx et al., 2018)**.**

The model structure is based on a hierarchical subdivision of the building in smaller entities: building elements, sub-elements and materials (Figure 4.1).

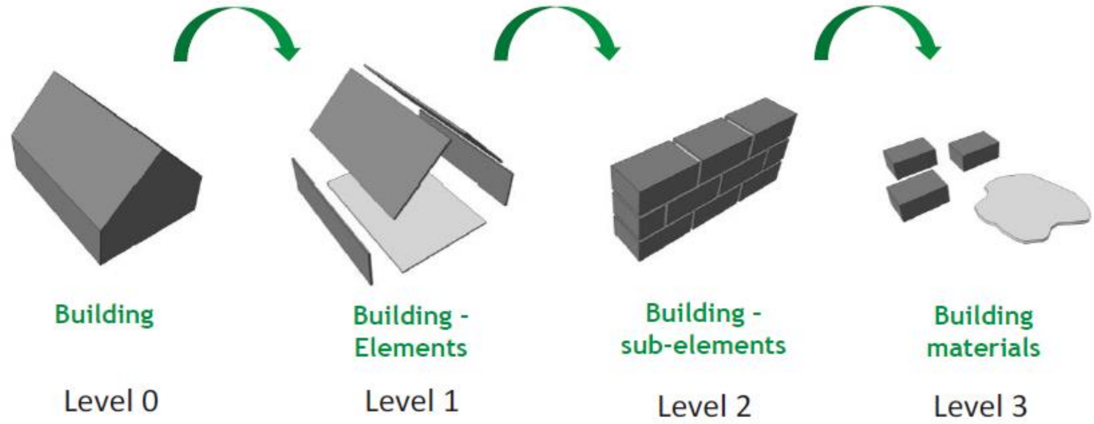


Figure 4.2. Hierarchical de-composition of Building. Source: PEF4Building, 2018, pag.15.

For distinction and detailed analysis of the different building elements and sections of the building the tree-like building element classification system of OmniClass (2015) is used in compliance with ISO 12006-2 (International organization for Standardization, 2015) (Spirinckx et al., 2018).

The OmniClass™ Construction Classification System, which is a system for organizing and retrieving information specifically designed for the construction industry. It is especially used to organise the libraries of Building Information Modelling (BIM) systems. OmniClass™ is designed to provide a standardized basis for classifying information created and used by the North American architectural, engineering and construction (AEC) industry, throughout the full facility life cycle from conception to demolition or reuse, and encompassing all of the different types of construction that make up the built environment.

More information about the OmniClass classification can be found on the web page https://www.csiresources.org/home.

- The classification proposed by the EN 15978:2011 and taken up by the Working Draft PrEN 15978-1:202x (Figure 4.2) (AENOR, 2012)

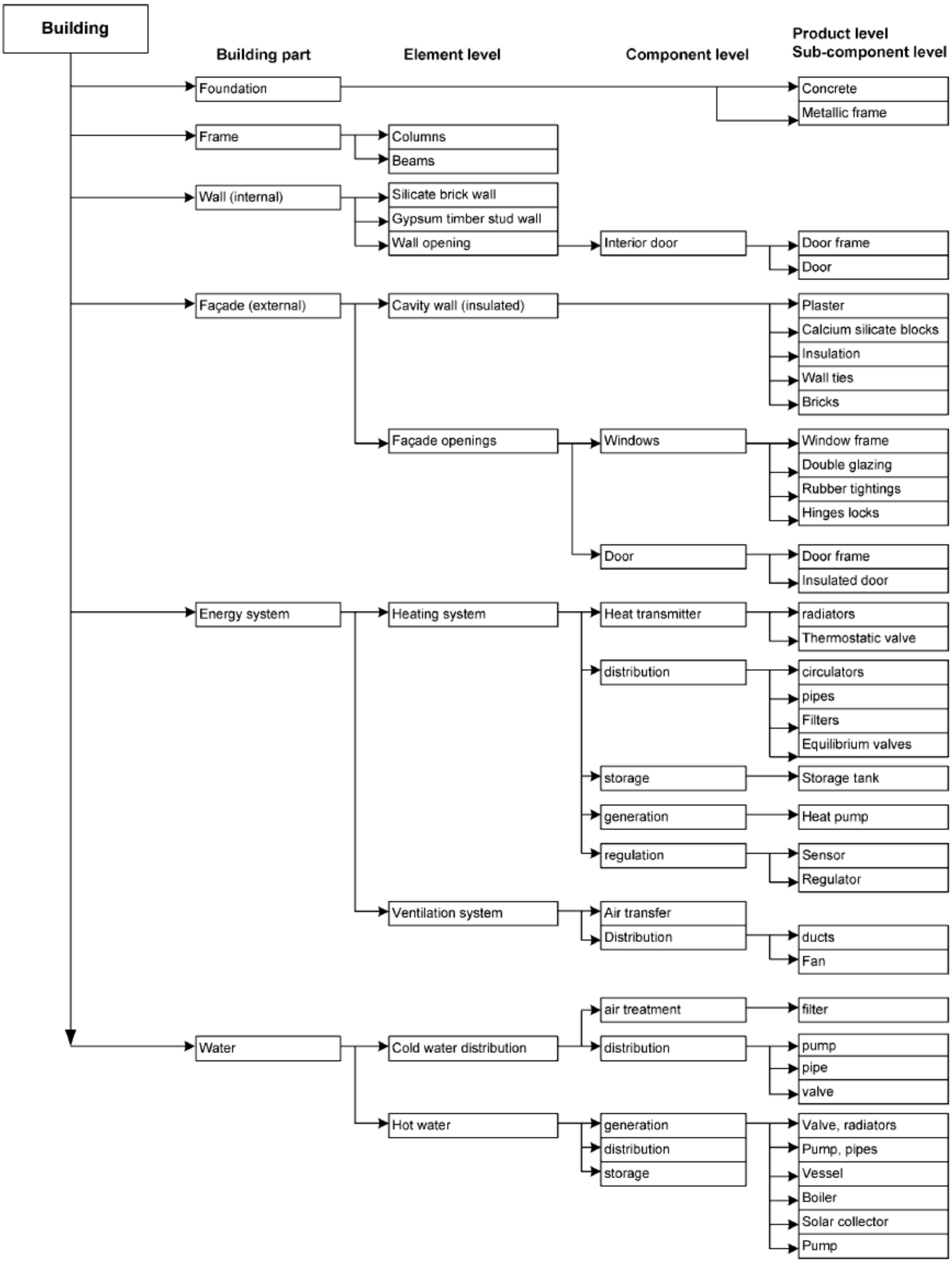


Figure 4.3. Example of a structuring of building information using the different level of aggregation. The figure not cover all products and elements embedded in the building. Source: Working Draft PrEN 15978-1:202x, Annex A.

It should be considered that different regions might use a different hierarchy, which normally refers to the organisation of national databases of construction materials. In such cases, dictionaries may be used for translation from one system to another.

Life Cycle Impacts

According to Level(s) recommendation, the environmental impacts of a building shall be assessed through quantification and reporting on the following environmental impact category indicators (reference standards EN 15978 and EN 15804):

- Global warming potential (GWP100)
- Depletion potential of the stratospheric ozone layer (ODP)
- Acidification potential of land and water (AP)
- Eutrophication potential (EP)
- Formation potential of tropospheric ozone photochemical oxidants (POCP)
- Abiotic Resource Depletion Potential for elements (ADP element)
- Abiotic Resource Depletion Potential for fossil fuels (ADP fossil).

Considering EN 15804 updates and PEF recommendations, additional impact categories under consideration are:

- Eco toxicity and human toxicity.
- Particulate matter / respiratory inorganics (dust particles).
- Ionising radiation.
- Land use.
- Water scarcity.
- Use of renewable biotic resources.
- Use of non-metallic minerals.

However, in the early stages of NDB development, information on all impact categories may not be available. Therefore, the Global Warming Potential (GWP100) is recommended as the minimum impact category, allowing other categories to be easily added in the future.

Use of data

The NDB should include different types of data that can be used depending on the stage of the project and the level of the evaluation. In relation with Level(s) framework, the use of different type of data is explained bellow:

Level 1

With the aim to encourage design professional to start using LCA since the beginning of the project, Level(s) allow to perform an incomplete LCA, limiting the assessment to a reduced number of life cycle stages. For the level 1, a simplified method and data source should be provided to perform an estimation of overall environmental performance of building.

Therefore, the NDB should contain enough generic data covering the different categories of construction products to carry out a simplified reporting option. According to Level(s), the minimum building scope for the level 1 includes shell and core elements of building and the A1-A3 stage module. As with the generic data, the representative data can be used to carry out a simplified evaluation when no generic data exists for any particular product.

Level 2

For a comparative performance assessment, Level(s) framework recommends the use of specific data. The building elements as minimum building scope are shell and core, excluding external works, and the analysis should consider all life cycle stages, unless for the simplified reporting option. according to Level, and for executive projects, when the different products for the building elements have been selected, the type of data to be used should be:

- Specific EPD for a specific product and one manufacturer.
- Average data for a family of product and one manufacturer.
- Generic or representative data can only be used if the specific data or average data for a particular product is not available.

Level 3

For the optimisation assessment level, the complete cradle-to-cradle LCA for a building should be carried out. For this level, simplified report option is not allowed. Thus, the minimum building scope include all material listed for shell, core and external works, and the analysis should consider all life cycle stages. The type of data to be used should be:

- Specific EPD for a specific product and one manufacturer.
- Average data for a family of product and one manufacturer.
- Generic or representative data can only be used if the specific data or average data for a particular product is not available.

Nevertheless, taking into account the level of complexity that the NDB will have, especially in the initial phase of development, and the type of building information available at the different stages of the project, it is recommended to follow the indications of prEN 15978:

Type 1 – assessment using a simplified building model

For a Type 1 assessment, element level LCA and design data may be used, including for major components (e.g. complete walls, floors, roofs). Construction product LCA data may be generic.

Type 2 – assessment using the as designed building model

For a Type 2 assessment, element level LCA and design data should be avoided where sufficient product level LCA and design data are available. Construction product LCA data may be a mixture of generic and specific data. Specific data should be used where it is available for the products used but may be generic where no specific data are available.

Type 3 – assessment using a fully detailed as designed or 'as built' building model

For a Type 3 assessment, the data requirement are as for a Type 2 assessment except that the design data shall be the final or as built' data.

Format of NDB and Digitalization

With the aim to facilitate the seamless flow of information between different actors, the International Life Cycle Data System (ILCD), a machine-readable format has been developed by the European Platform on Life Cycle Assessment (EPLCA). Within the ILCD format, we can find the EPD extension as a specific format to describe EPD data, complemented by additional EPD specific information that was not foreseen in the original ILCD format, as shown in the chart below (Figure 4.3).

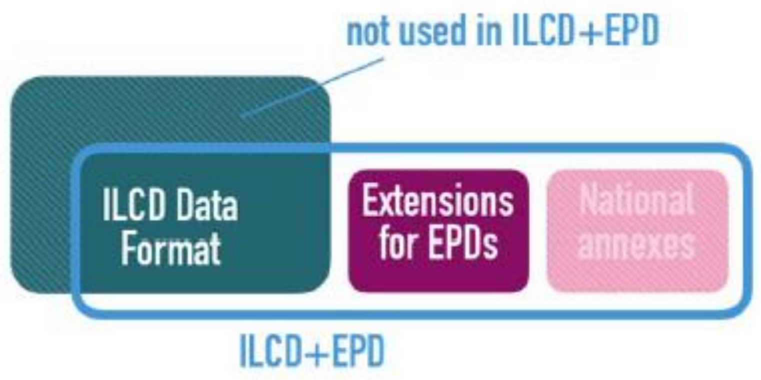


Figure 4.4: Scheme of ILCD+EPD format, Source: FAQ for InData Compliance CPEN2018, (InData, 2019, p. 2)

ILCD+EPD consists of several documents and tools to help LCA practitioners develop of software-independent LCA models and databases. It is an XML-based format with eight available dataset types for the elements in the database.

5_NDB development

According to what was explained previously, the generation of a national database is a complex task that must be approached in stages. This chapter presents the recommendations and methodological proposal for the generation of a consistent set of generic data for one of the most important parts of a national database, i.e., environmental data for the product stage (modules A1-A3). Successively, this database must be completed with use stage and end-of-life processes. In this way, increasingly comprehensive environmental assessments of buildings can be carried out.

In the context of the environmental assessment of building, the recommendations and proposed methodology have as a starting point a statement of the future standard prEN 15941: “If no EPD according to EN15804+A2:2019 is available, or the EPD is not complete for the product which is used in the building, the product stage (modules A1-A3) information from available EPD, EPD according to ISO 21930 or a data set from an LCA database or from an LCA study to ISO 14044 of a similar product may be used and adapted to create a new data set to reflect the actual situation as closely as possible. Such a new data shall be made only on the basis of suitably reliable and accurate information”.

Ultimately, this statement establishes that, in the absence of specific data for the product stage (A1-A3) of a construction product (for example a specific EPD), different strategies can be addressed to generate data that cover this information gap. These strategies are based on the adaptation of existing LCA data to the actual situation in which is developed the analysis to be carried out. In the context of a national database, this reality would be the consumption of construction products in the country.

The existing LCA data to which the standard refers are mainly:

- LCA databases (i.e. LCI data)

- LCA studies (LCIA data)

- EPD (LCIA data)

As it was commented before, first option requires an LCA expert as well as access to LCA tools that are in most cases under license. Without renouncing entirely to this option, it is advisable to address firstly the generation of generic LCA data from LCIA data already published for the product under analysis. The information reported in an EPD is verified by a third party according to the EN 15804/ISO 21930 standard within an EPD program. Therefore, this data source is preferable over LCA studies even though they may be critically reviewed according to ISO 14044 or EN 15804.

Another important question refers to ”consumption” of construction products. The ILCD Handbook provides some guidance for the development of generic LCA data. A difference is made between a “production mix” which is the effective production in the country and, a “consumption mix” which is the available mix in the country for consumption. Obviously they do not represent the same reality. The consumption mix is equal to the production mix plus the imported products minus the exported products. Therefore, it follows that it is of vital importance to carry out a market study in order to determine not only the market shares of national manufacturers but also the input and output flows of the construction products. Although the ILCD Handbook proposes the weighted averaging of LCI data for the generation of generic LCA data, these guidance can also be applied to LCIA data.

As a continuation of the quote from prEN 15941, the working draft also states that “In making such adaptations, assumptions shall not simply default to the best case but shall conservatively represent a realistic condition”. This can be interpreted as that a conservative approach has to be applied regardless of the method by which the new LCA data is generated. In principle the generic data should be as representative as possible. However, the process to generate them can have two sources of uncertainty: one of them is due to the lack of information that must be completed with assumptions and less representative data, and the second one due to all data averaging carries an inherent interval of uncertainty. Considering the conservative approach mentioned in prEN 15941, the application of the worst case scenario should take into account the level of uncertainty from generated data.

Introduction

The proposed methodology consists of different stages that are shown in Figure 5.1. The general idea is to collect existing LCIA data (preferably EPD data) for a previously defined construction product (or family products). This data collection should be oriented according to the information obtained from a market study for that product. After a consistency and quality analysis of the data collected, averaging of LCIA data is performed in order to obtain the generic data. As can be seen in Figure 5.1 the generation of generic data is an iterative process which is reflected by the feedbacks between stages. This means the milestones reached in intermediate stages of the methodology cause the rethinking of the previous stages. The proposed methodology takes as a starting point the works of (Erlandsson, 2018; Silvestre et al., 2015).

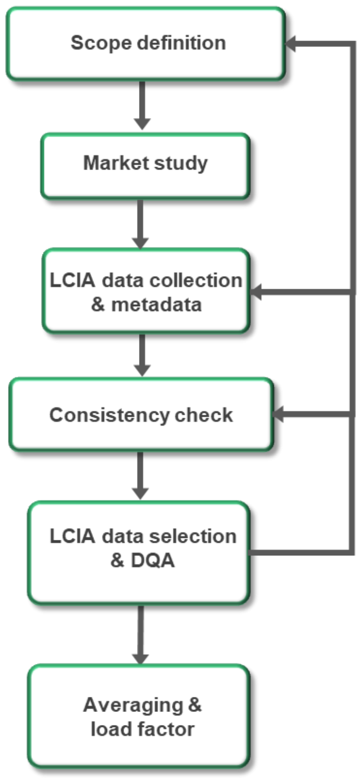


Figure 5.1: Methodology flowchart

Scope definition

In the scope definition must be described the product or family of product under study, its physical, chemical and functional characteristics and other relevant specifications. It must also be defined the functional unit, i.e., the unit to which the environmental data to be collected and generated are referred, for example m2, kg, m3.

Methodological issues related to core rules, as for example the fulfillment of complementary product category rules, must be defined in this stage. However, the environmental impacts indicators, life cycle stages (information modules A, B, C, D) and other methodological issues must be determined at the NDB level in order to be consistent for all construction products included in the NDB.

Preferably LCIA data from EPD will be collected but LCIA data from LCA studies can also be consulted. Decisions made in this regard should also be reflected in the scope definition.

Market study

This step corresponds to the study of the consumption mix of the product in the country (national production, imports and exports). It is intended to know the origin of the product sold in the country as well as market shares or production volumes of the different manufacturers. To obtain this information is essential the participation of manufacturers associations, interest groups and other stakeholders related to the family of products under study. During the development of this stage, possible information gaps will begin to be detected.

LCIA data collection & metadata

Once the market study has been completed, it is necessary to collect LCIA data from both national manufactures and importers. Data should also be collected at the European and global level so that they can be compared with those that are candidates to be part of the generic data. LCIA data will be collected consulting EPD programs (see Table 2.1). Published LCA studies could also be taken into account in this stage.

Each LCIA data collected must be characterized considering its metadata and all relevant information describing how the LCA on which it is based was conducted. A template is provided for metadata reporting for each LCIA data collected (see Annex A).

Once the LCIA data collection has started, information gaps will soon be found. To these information gaps must be added those detected during the market study. The casuistry can be very diverse in this sense and the methodology aims to face any intermediate situation between two unlikely extreme scenarios:

a) All the manufacturers that market the product in a country are known, their market shares are also known and specific or average LCIA data for their products are available for all of them.

b) All data described in a) are complete unknown,

To address the lack of information, both in terms of market shares and LCIA data, less representative data can be used, or assumptions can be made. For example:

- If the market shares are unknown, the LCIA data can be averaged based on production volumes. Ultimately, an arithmetic average of all LCIA data collected can be made if production volumes are also unknown.
- If some national manufacturers (or none) do not have an EPD for their products, data from an industrial sector EPD of that country could be used to represent their contributions to the consumption mix.
- An industrial sector EPD of a second country could be used to represent data for products imported by a manufacturer from that country.
- An average of EPDs from several European manufacturers could represent all imports from Europe that arrive in a country.

All these decisions should be consistent with:

- the scope defined for the product,
- the market study of product,
- the methodological issues followed by all data as a whole, and

- the rest of LCIA data.

Consistency check

Before starting the generic data calculation process, all LCIA data collected should pass a consistency check. The aim of this stage is to identify those LCIA data that are no obtained under the same conditions or whose results differ greatly from the rest of LCIA data (even when the same premises are given). The consistency check can be performed in various ways, and even could depend on the product under study. Here are some recommendations that can be used by itself or as a starting point to develop consistency checks for specific circumstances.

Firstly, LCIA data can be grouped according to different criteria:

- geographical scope, e.g., data from national production, from foreign production (only imports), Europe or the rest of the world;
- different types of product, e.g. in cements, CEM, CEM II, CEM III, CEM IV or white cements;
- any issue/factor with an important contribution to LCA results, e.g. recycled content, biogenic/fossil carbon segregation, product density, production technology, etc.
- several criteria can applied for grouping, e.g. white cement from national manufacturers.

For each LCIA data group:

- first averaging of LCIA data – simple statistical treatment of LCIA data (arithmetic average and standard deviation), and/or
- LCIA data representation – graphs where are shown or collated the LCIA data, and/or
- charts where are shown correlation between two related impact values, e.g. for mineral wood, climate change versus non-renewable primary energy or climate

change versus abiotic depletion potential (fossil); for metal products, climate change versus recycled content.

Finally, comparison among statistical values for LCIA data groups can also be made, e.g. comparison of means and standard deviations for national manufacturers and the rest of Europe manufacturers. The purpose of this stage is ultimately to detect significant differences between LCIA data collected.

LCIA data selection and DQA

In this stage are selected the LCIA data that will be used to determine the generic LCIA data. Only LCIA data that show consistency with each other and, at the same time, are aligned with the scope and market analysis will be used for this purpose. For example, a LCIA data can be excluded because is outside the confidence interval - 95% - of its group, or because its carbon footprint/density ratio is inconsistent with that of the rest of LCIA data. It is advisable to investigate the reasons why the LCIA data present inconsistencies and explain in a transparent way the reasons why they are discarded.

Once the LCIA data has been chosen, a data quality assessment is also conducted in this stage. This assessment must take into account the representativeness of the data and but also other issues that influence in the quality. In this way, a Data Quality Index (DQI) of the LCIA data can be defined as the average of two intermediate DQI.

$$DQI_{LCIA\ data} = \frac{DQI_{represetativeness} + DQI_{\text{other quality issues}}}{2} \qquad [1]$$

Below is explained in detail how to deal with these two DQI.

Representativeness

As proposed in Annex E in EN 15804 +A2:2019, the data quality assessment of each selected LCIA data shall cover the following factors dealing with representativeness:

- TiR: time-related representativeness

- GR: geographical representativeness

- TeR: technological representativeness

Also according to this standard, it can be applied one of the two mandatory assessment methods developed by the UN (Ciroth et al., 2015) or Product Environmental Footprint (PEF) initiative (EC, 2017). In these recommendations the PEF method has been chosen, in which each individual representativeness factor is evaluated in a scale with 5 quality ratings (very good, good, fair, poor and very poor according to the **Error! Reference source not found.** Annex B).

For each representativeness factor, is assigned a value according to the quality rating (very good 1, good 0.9, fair 0.8, poor 0.65 and very poor 0.5).

In this assessment process, it must be taken into account that the quality of LCIA data is a relative concept, e.g. an EPD of a manufacturer in a country might have very good quality in terms of the product it represents but it is not so representative if with this EPD is intended to characterize the imports from several manufacturers in that country. Therefore, the data quality of a LCIA data must be referred to its representativeness in the national context for which the generic data is obtained.

Assuming that time-related, geographical and technological representativeness are equally important, DQI for representativeness of the underlying LCIA data can be expressed as follow:

$$DQI_{represetativeness} = \frac{TiR + GR + TeR}{3} \quad [2]$$

Other quality factors

Additionally to representativeness for a LCIA data, other issues dealing with the quality of a LCIA data can be proposed, as:

- accuracy

- review type

- contribution of specific data sources to results

- methodological issues, for example, biogenic carbon dioxide is included in results, is not declared the recycled content of the product, the period of core process inventory on which the results are based is less than 1 year, fulfilling with complementary product category rules, other assumption unspecified in EN 15804, etc.

This document illustrates the application of accuracy and review type issues in the DQA, although it can be designed to consider more quality factors.

Accuracy. If a LCIA data declares a calculated uncertainty alongside results (expressed as percentage, e.g. coefficient of variation), this value will be used to determine its accuracy factor, P=1-uncertainty(%)/100. If the LCIA data does not declare the uncertainty in its published result, the accuracy factor will be based on values in Table 5.1.

Table 5.1. Accuracy factor for several LCIA data

LCIA data		P
One Manufacturer	One product - one facility	0.9
	Several products or several facilities	0.75
	Several products and several facilities	0.6
Sector		0.4

The value of P in the case of one product/one facility comes from a conservative assumption that assumes that the default uncertainty is 10% for LCIA data with no reported uncertainty.

Review type. The review type factor is defined in Table 5.2.

Table 5.2. Review type factor for several LCIA data

LCIA data	R
Verified EPD (EN15804)	1
Third part review (EN15804)	0.85
Rest of cases	0.4

These two factors can be grouped in $DQI_{\text{other quality issues}}$, and assuming the same weight for them:

$$DQI_{\text{other } quality\ issues} = \frac{P + R}{2} \qquad [3]$$

Averaging and load factor

From the previous stages, selected LCIA data and the DQI of all of them are available in this point. The averaging of these values will allow obtaining the generic LCIA data and its corresponding DQI.

LCIA data averaging

Generic LCIA data can be calculated by weighted average of LCIA data collected based on market shares (MS) or production volumes (PV):

$$Generic\ LCIA\ data_{average} = \frac{\sum MS_i(or\ PV_i) \cdot LCIA\ data_i}{\sum MS_i(or\ PV_i)} \qquad [4a]$$

If MS or PV figures are not available, an arithmetic average of selected LCIA data can be performed:

$$Generic\ LCIA\ data_{average} = \frac{\sum LCIA\ data_i}{n} \qquad [4b]$$

In the same way, DQI for the Generic LCIA $data_{\text{average}}$ can also be calculated with expressions similar to [4a] and [4b] (as long as the figures for MS or PV are not subject to uncertainty), i.e.,

$$DQI_{generic\ LCIA\ data} = \frac{\sum MS_i(or\ PV_i) \cdot DQI_{LCIA\ data_i}}{\sum MS_i(or\ PV_i)} - A \qquad [5a]$$

and for arithmetic averages,

$$DQI_{generic\ LCIA\ data} = \frac{\sum DQI_{LCIA\ data_i}}{n} - A \qquad [5b]$$

Where a factor of extra quality loss, A, is applied. The A value can depend on the type of average applied as proposed in **Error! Reference source not found.**.

Table 5.3. Extra quality loss depending on averaging

Average		A
Weighted	Market share > 70%	0
	Market share ≤ 70% >50%	0.05
	Market share ≤ 50%	0.1
	Production volumes > 70%	0.1
	Production volumes ≤ 70%	0.15
Arithmetic		0.2

The values proposed for loss quality by accuracy (Table 5.1), by review type (Table 5.2), by averaging (Table 5.3); as well as the weights given to these different factors in [1], [2] and [3] are just a proposal to illustrate the application of the methodology. These quality factors can be designed at the NDB level ensuring the consistency between them.

Uncertainty

The uncertainty associated with the averaging of LCIA data has two clearly differentiated sources:

Basic uncertainty, U_b, inherent to the statistical treatment of LCIA data, that can be calculated with the coefficient of variation of the weighted or arithmetic averages, i.e., with mean and standard deviation,

$$U_b = CV = \frac{\sigma}{\mu} = \frac{\sigma}{Generic\ LCIA\ data_{average}} \quad [6]$$

Quality uncertainty, U_q, derived from the quality lack of the Generic LCIA $data_{average}$. It can be calculated by:

$$U_q = 1 - \mathrm{DQI}_{generic\ LCIA\ data} \quad [7]$$

The final uncertainty of the Generic LCIA $data_{average}$ must takes into account these two uncertainty sources. It can be proposed:

$$U_{max} = Max[U_b, U_q] \quad [8a]$$

These uncertainties can be also combined using the root mean square method:

$$U_{rms} = \sqrt{{U_b}^2 + {U_q}^2} \quad [8b]$$

Load factor

The load factor or data penalization is a concept used in some NDB, especially when this has regulatory purposes. The load factor depends on the uncertainty associated to generic data and tries to compensate its incompleteness and imponderability. If the load factor is applied should be attributed transparently and be separate to the data itself.

In either case shown in [8a] and [8b], upper bound of the $\pm U$ range is the worst scenario for the generic data generated. As a conservative approach derived from prEN 15941, the application of the load factor could be done as follows:

$$Generic\ LCIA\ data = Generic\ LCIA\ data_{average} \cdot (1 + U) \quad [9]$$

Data quality requirements

The proposed methodology for the generation of generic data of the BDN tries to face the more than probable information gaps that its developers will encounter. The methodology allows the making of assumptions and the use of less representative data when those desirable data are not available. These strategies imply a loss of the quality of the data generated.

The quality assessment proposed in the methodology has two main functions. On the one hand, it serves to characterize the quality of the data generated after the application of different assumptions and/or the application of different less representative dataset, i.e., it can serve to elucidate the data with the highest quality available. And on the other hand, the quality assessment can serve to substantiate the generation of a load factor to be applied to generic data or for the use of the NDB for regulatory purposes.

The quality assessment proposed is not aimed at the exclusion of a generic data in the NDB because it does not meet minimum quality level. In the early development of the NDB sufficient generic data should be guaranteed to perform a minimum comprehensive assessment based on a simplified building model. The minimum scope of building parts must include the shell (substructure and superstructure) as defined in Level(s) framework (see section 4.5). At present, an increasing number of EPD can already be found for practically all the elements included in this scope. This is not the case with the core scope, for which it can be found numerous EPD of finishes for ceilings, walls and floors, but not for services (energy, lighting, ventilation, sanitary and other systems). For these construction products (substructure, superstructure and finishes), generic data can be generated with more or less success in relation to its quality and representativeness. In future developments of the NDB, the minimum quality level that generic data must have to be part of the NDB should be defined, especially if is intended to be used them for regulatory purposes.

For assessment using a fully detailed or 'as built' building models, construction product LCA data may be a mixture of generic and specific data. Specific data should be used where it is available for the products used but may be generic where no specific data are available (prEN15978). The scheme proposed in section 5.6 for quality assessment of the generic data can also be used to assess the quality of the specific data (for example the EPD of a manufacturer providing a specific construction product) when it is intended to replace the generic data. The specific LCIA data, should be as accurate and representative data as possible for the actual construction product installed. For this purpose, minimum quality requirements should be established for specific data to become part of the NDB, for example “the DQI for the EPD must be higher than 0.85”. The scheme proposed in section 5.6 covers important quality aspects as representativeness, accuracy and review type. But it can be designed to include other specifications when evaluating specific data to be included in the NDB, such as compliance with complementary product category rules and others relevant methodological issues.

Special materials

When collecting LCIA data, special attention must be paid to two groups of materials: bio-based materials and metals.

The reporting of biogenic carbon contained in bio-based products as wood/plants-based products is a controversial matter. Biogenic carbon refers to the carbon absorbed from the atmosphere and stored in a growing plant or tree via photosynthesis. The accumulation of stored carbon is known as carbon sequestration and is an often-claimed benefit of using bio-based products in construction.

However, carbon stored can be released back into the atmosphere depending on the selected disposal route of the construction product. For example, if this product is buried in landfill, carbon stored can break down into carbon dioxide or even methane.

For this reason, carbon storage in products must be documented separately according to ISO 14067:2018 (carbon footprint of products), and according to EN 15804:2012+A2:2019, climate change impact must be reported broken down into fossil, biogenic and land use fractions. However, almost all EPD and LCA of construction products are published under EN 15804+A1:2013 standard. It is very common to find LCA data for bio-based product whose climate change values include the stored carbon, resulting in negative figures for the cradle to gate scope (modules A1-A2-A3). Carbon sequestration must only be taken into account when the EoL modules (specially C3 and C4) are included and the wood-based products originates from sustainable sources (certified by FSC, PEFC, etc.).

Another set of products to which special attention should be paid are metals products used in structure, reinforcement, cladding, roofing, window frames, plumbing, heating equipment and in many other applications.

Metals have the ability to be reused or recycled without altering their properties. This confers a high value to metal scrap that is the key incentive for the systematic dismantling, collection and recycling of metal products. For example, for alluminium products used in building, more than 96% is selectively collected and sent to recycling (TU Delf and EAA, 2004) while for steel sections this value reaches 99% (Sansom and Avery, 2014). By other hand, metal recycling provides energy savings of between 60% and 95% compared to primary production.

However, the inclusion of recycling aspects in LCA studies generates much debate due to the coexistence of various methodological approaches to attribute environmental burdens between the original product and second product that receives secondary material from the first one. Two contrasting approaches are generally used to tackle recycling: the recycled content and the EoL recycling approaches.

The recycled content approach (also known as the cut-off approach or 100:0) considers that:

- secondary materials that are input to a process have zero attached environmental burden except for energy use of transport, collection, sorting, recycling, etc.;

- secondary materials on the output leave the first product system without any further environmental burden (energy use for transport, collection, sorting and recycling) as well as the avoided burden derived from the substitution of virgin material production. These environmental burdens (positives and negatives) go entirely to second product.

The EoL recycling approach (also known as the avoided burden approach or 0:100) considers that:

- secondary materials that are input to a process have the same attached environmental burden as virgin materials;

- secondary materials on the output side leave the product system causing extra environmental burden (energy use for transport, collection, sorting and recycling) as well as the avoided burden derived from the substitution of virgin material production. These environmental burdens (positives and negatives) go entirely to first product.

These two extreme situations meet in the reality of metal products. The life cycle of metal products is generally not "cradle to gate" or "cradle to grave", but rather "cradle to cradle". In practice, the life cycle of a metal product usually ends when the recycled metal is rendered in a form usable for a new product.

EN 15804 requires that the recycled content input is characterized in module A1 (recycled content approach). The recyclability of metals can still be accounted for through the use of module D, where credits can be applied to the system based on avoided burden (EoL recycling approach). In order to avoid double-counting of recycling benefits from both recycled content and EoL recycling, the avoided burdens are calculated in module D based on the net flow of secondary materials (i.e., metal scrap) exiting the product system. Therefore, the recycled content figure alone of modules A1 to A3 is not suited for the LCA of metal products. For that purpose, a full LCA including EoL recycling credits is the most appropriate approach.

Case study

This section presents the application of the proposed methodology for a specific case. Conducting a market study of any construction product is outside the scope of this document. Therefore, the market shares/volumes of national production as well as imports and exports are unknown in the case study presented. Although this situation could itself be a scenario derived from the market study.

Thus, the methodology will be applied to obtain representative data for a part of the consumption mix present in a country. The case study focuses on obtaining a representative impact on climate change (kg CO_2 eq.) of the Spanish production of ceramic tiles. This data could in turn serve to generate:

- the consumption mix in Spain when the origin, volume and LCIA data of imports are known,
- the consumption mix in other countries for which Spain is an importer of ceramic tiles.

The standard EN 14411 classifies ceramic tiles according to the production route:

- A, for tiles obtained by extrusion,
- B, for those obtained by dry pressing.

In turn, EN 14411 carries out a secondary classification for the water absorption capacity of ceramic tiles:

- I, low absorption, in turn divided into Ia and Ib
- II, average absorption, in turn divided into IIa and IIb
- III, high absorption

In LCIA data search, 58 EPDs were obtained from various Spanish manufacturers. These EPD are published in two Spanish EPD program, GlobalEPD and DAPcons, and all are available on the web pages of these EPD programs. The products declared in all of them can be grouped into:

- 22 EPD for ceramic tiles (floor finishing), class BIa and BIb
- 26 EPD for porcelain tiles (floor and wall finishing), class BIa and AI
- 10 EPD for ceramic tiles (wall finishing), class BIII

For each EPD a file was made according to Table 5.1 with all their meta information. The functional unit common to all of them is $1m^2$. Each EPD was achieved using PCR (EN 15804), and cutoff and allocation rules, assumptions, methods and models are consistent among them. All EPD were verified by the program in which they are published. Most of the EPDs report average data of several commercial series of products. Only two EPD report data for specific products (both for porcelain tiles).

Figure 5.2 shows the graph for consistency check of EPD collected grouped in ceramic tiles, porcelain tiles and ceramic tiles for wall. Global warming is represented vs. density and also vs. the total of non-renewable primary energy (PENRT). All data collected shown good correlation. For porcelain tiles, two EPD have been discarded since they represent specific product with very high density values (≈38 kg/m^2) compared to the rest of the EPD (≈23 kg/m^2).

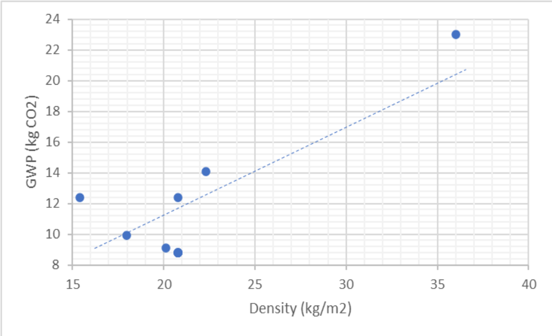
Although generic data is obtained from EPD with good time, geographical and technological representativeness, the quality loss of the average data ($DQI_{average}$) is derived from the fact that an arithmetic averaging has been performed.

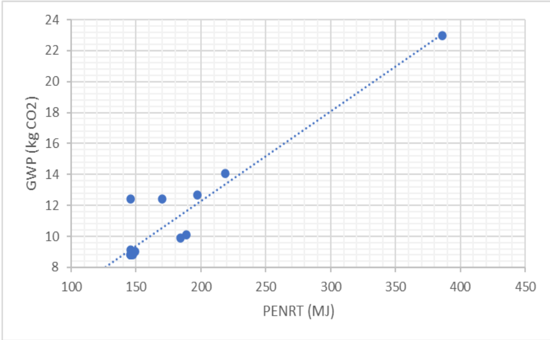
Table 5.4 shows the Generic LCIA $data_{average}$ (GWP) obtained from [4b], $DQI_{average}$ from [5b], U_b from [6] and U_q from [7] for the 3 products under study.

Table 5.4. Generic data - GWP, DQI and uncertainty for ceramic and porcelain tiles

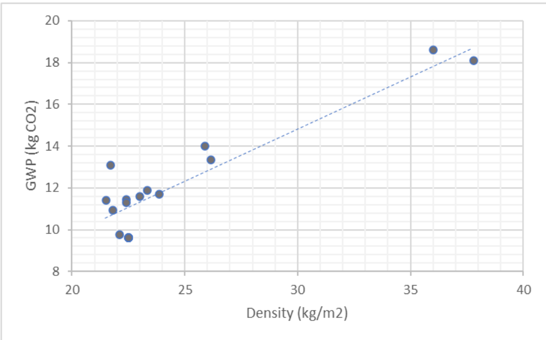
	Generic $GWP_{average}$	σ	$DQI_{average}$	U_b	U_q
	Kg CO_2 eq	Kg CO_2 eq	[0-1]	[0-1]	[0-1]
Ceramic tiles	9.38	1.98	0.75	0.21	0.25
Porcelain tiles	10.85	1.44	0.73	0.13	0.27
Ceramic tiles (wall)	9.40	1.59	0.75	0.17	0.25

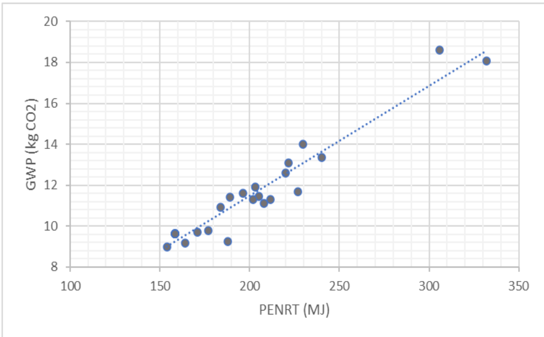
Ceramic tiles



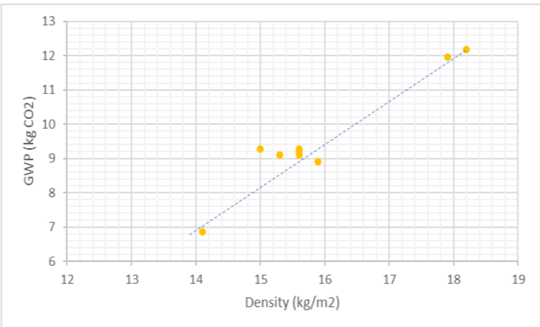


Porcelain tiles





Ceramic tiles (wall)



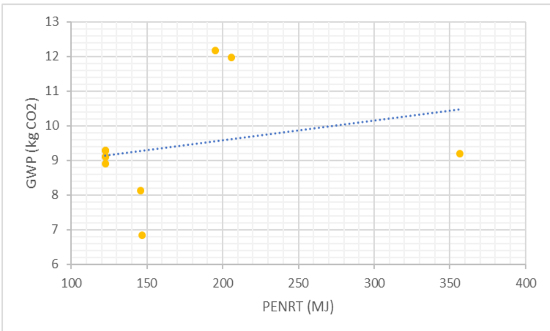


Figure 5.2: GWP vs density, and GWP vs PERNT for all EPD collected

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Annex A. Template for metadata reporting

The different parts of the template for the collection of LCIA metadata reporting are described below.

Hierarchical classification	This information refers to the product family according to the type of hierarchical structure chosen by the NDB. E.g. Mineral Building Products / Binder / Cement
LCIA Data	
LCIA data code	Identification of LCIA data assigned, e.g. in EPD case, the code given by EPD program
Product	Name of product
Product classification	E.g. for cements (CEM II 32.5) or for ceramic tiles (group BIII according to ISO 13006). There may be more than one type of classification. For example, a window may have a classification for permeability and another related to wind load resistance.
LCIA data source	indicate whether it is an EPD or another source such as LCA study
Owner of LCIA data/Manufacturer	Name of manufacturer
Name of EPD Program	If applicable. E.g. GlobalEPD, International EPD System, etc.
Type of review	If is verified or critically reviewed (or not), e.g. verified according to 15804.
Type of LCIA data	Specific dataset, average dataset, generic dataset
Averaging process	In case of average data, number of products/manufacturers/production sites and averaging process
Product description	
Product composition	indicate the composition of the material, especially if using products other than those commonly used for that product or family
Functional Unit/declared unit	Indicate the Functional Unit/Declared Unit used in the EPD or LCA study, e.g. $1m^2$, $1m^3$, 1kg.
Relevant physical properties	indicate those characteristics y that are relevant for the data screening, especially those related to the performance of the product, e.g. bulk density or thermal transmittance in case of isolation materials

Conversion factor	Conversion factor to other units of interest, e.g. for surface or lineal products, kg/m2 or kg/m respectively
Recycled content (%)	Describe the amount of recycled material as a differential characteristic for data screening
Methodological Issues	
Information modules (EN 15804)	E.g. A1-A2-A3, C3-C4
PCR followed	Including complementary category rules if applicable
Reference Service Life	Service life of the product
Biogenic carbon treatment	For materials with biogenic origin, if biogenic carbon is reported independently or not
Allocation Rules	Indicate what are the allocation rules applied
Cut-off	Indicate what are the cutoff rules applied
Contribution of specific data sources to results	
Source of background data	Source of secondary data used for the calculation of the EPD or LCA study,e.g. Ecoinvent, GaBi, other databases
Variability/uncertainty of results	If are reported in EPD or LCA study, numerical expression of the variability/uncertainty of results
If relevant, other methodological issues	Indicate methodological issues if relevant.
Production volume or market share	Indicate if the study report information about the market
Representativeness	
Publication date	Indicate the data of publication. To determine time representativeness
LCIA data validity	Indicate the data of validity. To determine time representativeness
Location	To determine geographic representativeness
Technology description	Information that allows the product to be distinguished from the product group to which it belongs
Data quality	
TiR	see Annex B
GR	see Annex B
TeR	see Annex B
P	see Table 1
R	see Table 2
DQI	See equations [1], [2] and [3]
Environmental parameters (A1-A3)	

GWP (kg CO_2 eq)	Impact value
ODP (kg CFC-11 eq)	Impact value
AP (kg SO_2 eq)	Impact value
EP (kg $(PO_4)^3$ eq)	Impact value
POCP (kg C_2H_4 eq)	Impact value
ADPE (kg Sb eq)	Impact value
ADPF (MJ)	Impact value
Other	Impact value
Use of resources parameters (A1-A3)	
PENRT (MJ)	Indicator value
Other	Indicator value

Annex B. Data quality assessment from PEF initiative

Quality level	Geographical representativeness	Technical representativeness	Time representativeness
Very good	The processes included in the data set are fully representative for the geography stated in the “location” indicated in the metadata	Technology aspects have been modelled exactly as described in the title and metadata, without any significant need for improvement	Data are not older than 0 years as expressed in the ILCD field (“data set valid until” and the difference between the “valid until” and the “reference year” is not higher than 8 years
Good	The processes included in the data set are well representative for the geography stated in the “location” indicated in the metadata	Technology aspects are very similar to what described in the title and metadata with need for limited improvements. For example: use of generic technologies’ data instead of modelling all the single plants.	Data are not older than 3 years as expressed in the ILCD field (“data set valid until” and the difference between the “valid until” and the “reference year” is not higher than 8 years
Fair	The processes included in the data set are sufficiently representative for the geography stated in the “location” indicated in the metadata. E.g. the represented country differs but has a very	Technology aspects are similar to what described in the title and metadata but merits improvements. Some of the relevant processes are not modelled with specific data but using proxies.	Data are not older than 6 years as expressed in the ILCD field (“data set valid until” and the difference between the “valid until” and the “reference year” is not higher than 8 years

	similar electricity grid mix profile		
Poor	The processes included in the data set are only partly representative for the geography stated in the "location" indicated in the metadata. E.g. the represented country differs and has a substantially different electricity grid mix profile	Technology aspects are different from what described in the title and metadata. Requires major improvements.	Data are not older than 10 years as expressed in the ILCD field ("data set valid until" and the difference between the "valid until" and the "reference year" is not higher than 8 years, confirmed by the reviewer(s)
Very poor	The processes included in the data set are not representative for the geography stated in the "location" indicated in the metadata.	Technology aspects are completely different from what described in the title and metadata. Substantial improvement is necessary.	Data are older than 10 years as expressed in the ILCD field ("data set valid until" and the difference between the "valid until" and the "reference year" is not higher than 8 years

Annex 1 Template for the data collection

The different parts of the template for the collection of metadata related to the environmental information of products (EPD, LCA studies, etc.) are described below.

Hierarchical classification: This information refers to the product family according to the type of hierarchical structure chosen by the NDB.

LCIA Data: Information about the product under analysis

LCIA data code: Identification of LCIA data assigned for internal use, e.g. in EPD case, the code given by EPD program

Product: Name of product

Product classification: Classification allowing identification of the product or product family to which the product under consideration belongs. E.g. for cements (CEM II

32.5) or for ceramic tiles (group BIII according to ISO 13006). There may be more than one type of classification. For example, a window may have a classification for permeability and another related to wind load resistance.

LCIA data source: indicate whether it is an EPD or another source such as LCA study

Owner of LCIA data/Manufacturer: Name of manufacturer

Production plant: For the specific EPD indicate the name of production plant of the product under consideration if there are more than one production plants.

Name of EPD Program: indicate the name of EDP programme if applicable.

Type of review: indicate if the information has been audited through external review or not.

Type of LCIA data: the type of data recommended for the NDB are

- Specific dataset - specific data for a specific product from one production site;
- Average dataset - average from multiple manufacturers, multiple production sites and/or multiple products (even for only one manufacturer);
- Representative dataset - data that is representative for a country or region;
- Generic dataset - generic data acc. to EN 15804 and data based on other non-industry data sources (e.g. literature, expert knowledge)

Averaging process: In case of average data, indicate the number of products/manufacturers/production sites and averaging process.

Product Description: Information about the product under consideration, indicate information that may be relevant for data screening.

Product composition: indicate the composition of the material, especially if using products other than those commonly used for that product or family.

Functional Unit/Declared Unit: Indicate the Functional Unit/Declared Unit used in the EPD or LCA study.

Relevant physical properties: indicate those characteristics y that are relevant for the data screening, e.g. bulk density and thermal transmittance in case of isolation materials

Conversion factor: Conversion factor to other units of interest, e.g. for surface or lineal products, kg/m2 or kg/m respectively

Recycled content: Describe the amount of recycled material as a differential characteristic for data screening.

Methodological Issues: Information on the methodology used in carrying out the EPD or LCA study. This information is relevant for the calculation of the load factor.

Information modules (according to EN 15804): indicate the module calculated in the EPD or LCA study.

PCR followed: Including complementary category rules if applicable.

Reference Service Life: indicate the reference service life used in the EPD or LCA study.

Biogenic carbon treatment: For materials with biogenic origin, indicate its treatment if biogenic carbon is reported independently.

Allocation Rules

Cut-off: Indicate the cutting conditions that were used in the calculation of inflows and outflows

Contribution of specific data sources to results: Indicate all those conditions that give information on the origin of the information for carrying out the calculation.

Source of background data: Source of secondary data used for the calculation of the EPD or LCA study.

Variability/uncertainty of results: Indicate the variability or uncertainty factor if it is indicated in the study. This value, if not indicated in the study, can be calculated as an additional loading factor. If maximum and minimum values are presented in the study (especially for the average data), the variability is calculated as the maximum and minimum differential from the mean value in percentage. The uncertainty is the larger value between the maximum and minimum.

If relevant, other methodological issues: indicate methodological issues if relevant.

Production volume or market share: If the study present information about the market, indicate it.

Representativeness: This information is necessary to determine the representativeness of the data.

Publication date: Indicate the data of publication.

LCIA data validity: Indicate the data of validity.

Location: indicate the location

Technology description: Information that allows the product to be distinguished from the product group to which it belongs.

Public consultation with stakeholders

Within the framework of the Life Level(s) project, GBCe, in collaboration with Ecómetro mediciones, has carried out a consultation process with experts and stakeholders of the construction industry to find out their opinion and, above all, to achieve an agreement on the steps to follow for promoting the LCA in buildings dissemination.

To this end, different stakeholders, experts, and scientists in LCA (see list of invited guests) were contacted to attend 3 sessions organised as follows:

Session 1 (60 min):

- Welcome and introduction to the public consultation.
- Presentation of Life Level(s) project.
- Presentation of Life Level(s) results.
- Public discussion.

Session 2 and 3 (120 min)

- Introduction to the session.
- The moderator introduces different question for the discussion among guests.
- Conclusion of the session

Then, the shared opinions are shown below as conclusions of the process.

Promoting the ACV mainstreaming in the building environmental assessment

There is widespread agreement on the need to encourage the decarbonization of the construction sector through the LCA of buildings as reliable and objective environmental information. Despite, there are few and not homogeneous available data.

The sector regrets that this is because there is little demand for data. Imposing a regulatory requirement would increase the demand for data, but at the same time it is impossible impose a requirement if there is no data available. It is a vicious circle.

A first proposal is to provide generic data on the main materials, even if imprecise, to allowing for building analysis. This would have the following outcomes:

- To boost the LCAs of buildings and thus create reference values for the generation of standards and regulations.
- Promoting the demand for more and more accurate data.
- Disseminating LCA as a tool for comparison and user information on building quality.

There is a common agreement to collect, and exploit works already carried out in this area. There are many experiences at international and national level that should be taken advantage of. The work developed for the Life Level(s) has analysed the experiences of national databases in use in other countries (INIES, Ökobaudat and MMG), the current regulations, the development of technical groups such as the standardization groups (TC...) and In-Data, and previous experiences in Spain such as OpenDap, Sofia, ArCO2, Ecómetro ACV, etc.

Common Aims

- Promote LCA for assessing the quality of a building and for supporting the decision making on environmental impact reduction.
- Transparency of the whole process, in accordance with EN15804.
- Encouraging collaboration between agents
- Responsibility of the sector
- Focusing on a complete LCA analysis of the building, extending the information at all stages (cradle-to-cradle, cradle-to-cradle).
- To pursue quantification of environmental characteristics of the building, including all impact categories and not limited to the carbon footprint.
- Universal accessibility to data, information should be open, interoperable, flexible, adaptable and easy to understand.
- Ensuring reliable benchmarking through the use of quality-verified data, harmonised with the current regulations and regularly updated.

- Following the principle of Material Neutrality, the data should not be an element of discrimination, therefore it should be objective, include all stages and specify the functional unit.
- Applicability (in the future) to civil works

Common opinions

- Seek the Spanish Government commitment for promoting the sector transformation using LCA as a tool for information, comparison and support in decision-making. The Next Generation funds are an opportunity to finance initiatives such as:
  - Carrying out LCAs for all product families, from "traditional" to "innovative" and green products, supporting especially SMEs.
  - To generate a national, open and friendly database, based on existing experiences (e.g. OpenDap), providing generic data and increasingly complex specific data, including all phases of the Life Cycle.
  - Implementing virtuous mechanisms to boost LCA of buildings, such as fiscal incentives for producers who develop LCAs, for buildings that have an LCA, to require LCA for new public buildings, etc.
- Relaunch the development of all previous national and international initiatives.
- Proposing the maturation of OpenDAP into a LCA database.
- To create a working group that could putting together the stakeholders proposals and put forward to the Government (for example, CTN198, although not a forum with this objective, brings together profiles that could form this group).
- To look the possibility of developing market studies by product/sector (whenever possible) in order to be able to weight the values according to national production/importation. Currently there are not information about production vs importation market, so it would be useful make a review of the state of the art on the situation in other countries, national markets (steel and cement sectors have market data, other sectors do not), or by group of manufacturers, whichever is available.

Guest List

Guest	Company
Alejandro Payán de Tejada Alonso	
Aitor Dominguez	IDAE
Albert Cuchí	UPC
Alejandro López Vidal	ANDECE
ARTURO ALARCON	IECA
Bea de Diego	GBCe
borja izaola	GBCe
Celia Puertas	Arup
Diego Ruiz	Ecómetro
Elena Gracia	hispalyt
Enrique Larrumbide	ietcc.csic
Felipe Romero Salvachúa	ICCL
Giorgos Tragopoulos	Ecómetro
Javier Pérez	
José Antonio Tenorio	ietcc.csic
Josep Giner	REMA
LAETITIA BOUCHER	Interface
Lucia Mielgo	
Manuel Enríquez Jiménez	byearquitectos

Mariana Palumbo	UPC
Mario Trujillo Gómez	juntaex
Miguel García Tejera	CEPCO
Miguel Segovia	GBCe
Mónica Herranz	Afelma
Natalia Bielsa CSCAE	cscae
Paula Rivas	GBCe
Xabat Oregi	EHU
Yago Masso	ATEDI