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ADVANCE

ACCOMPANYING MEASURE FOR DISSEMINATION, VALORISATION AND COLLABORATIVE EXPLOITATION OF CIRCULARITY OF CONSTRUCTIONAL STEEL PRODUCTS

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LCA mobile application

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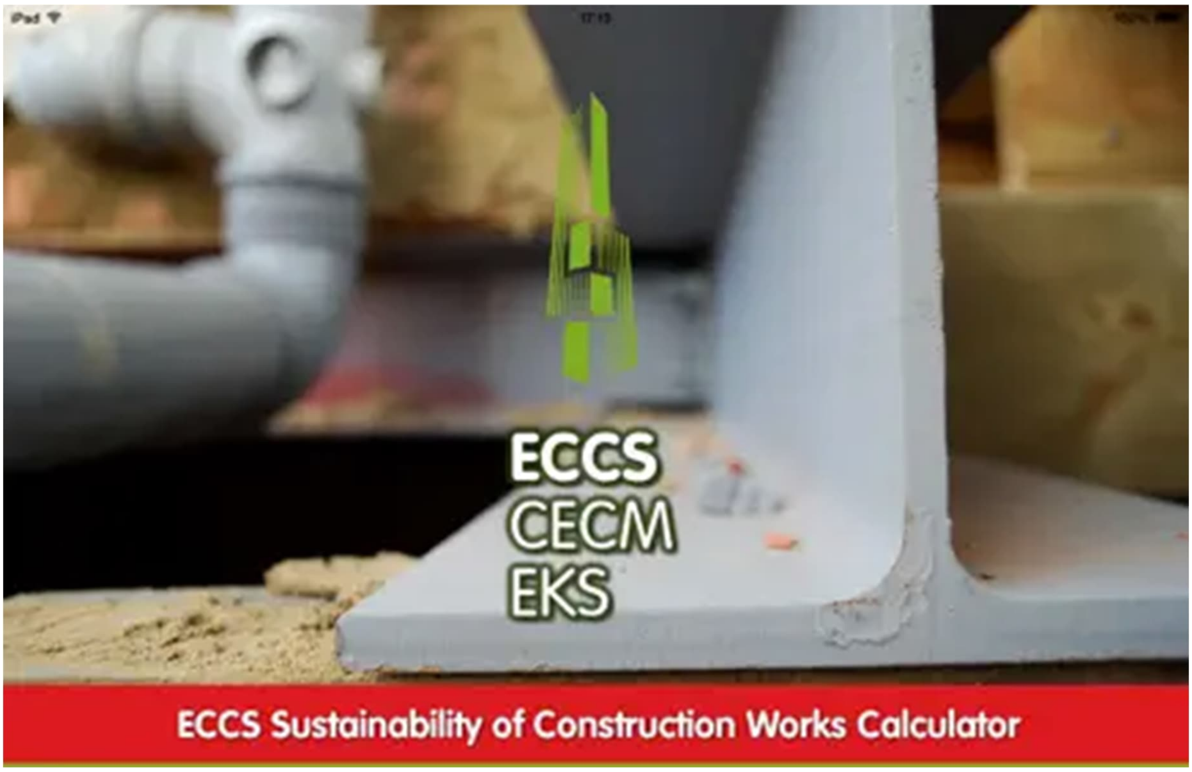

Deliverable: D 4.2 LCA mobile application

Confidentiality: Public

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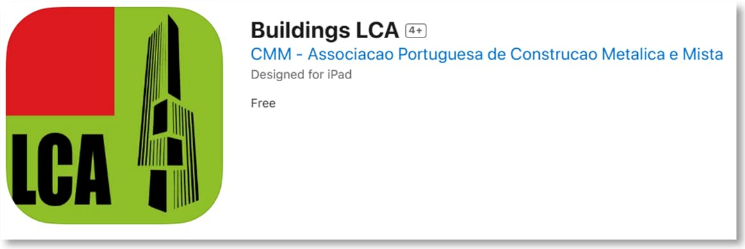
Executive summary

This report provides a description of the mobile tool 'Buildings LCA' developed in the scope of the RFCS project SB STEEL and upgraded in the scope of ADVANCE project.



The original tool was freely available for smartphones and tablets and could be downloaded from the App Store or the Google Store. The updated version is also freely available for smartphones and tablets, and a new version is also available online. The implementation of ADVANCE LCA methodology was verified by VTT.

The main upgrades of the current tool are:

- Implementation of the LCA approach for the reuse of steel products (as described in Deliverable D4.1);
- Additional macro-components for industrial buildings;
- Development of the online tool, which additionally allows for the creation of BIM objects of the macro-components, including the environmental LCA data.

This report covers the first two updates, while the latter is covered in Deliverable D4.3.

Contents

1. Introduction

In the project ADVANCE, the ‘Buildings LCA’ tool developed in the scope of the RFCS project SB STEEL was upgraded. The updated dashboard of the tool is illustrated in Figure 1. The original tool was developed to provide a simplified and quick evaluation of the sustainability of steel-framed buildings in the early stages of design, considering the life cycle environmental performance of the building. The adopted approach was based on a macro-component approach to cope with the lack of data in the early stages of building design [1].

Figure 1. Main dashboard of the updated tool.

The original tool was freely available for smartphones and tablets and could be downloaded from the App Store or the Google Store. The updated version is also freely available for smartphones and tablets, and a new version is also available online.

The main upgrades of the current tool are:

- Implementation of the LCA approach for the reuse of steel products (as described in Deliverable D4.1);
- Additional macro-components for industrial buildings;
- Development of the online tool, which additionally allows for the creation of BIM objects of the macro-components, including the environmental LCA data.

This report covers the first two updates, while the latter is covered in Deliverable D4.3.

2. Use of the tool

The tool is very user-friendly and the LCA calculation is made according to the flowchart represented in Figure 2:

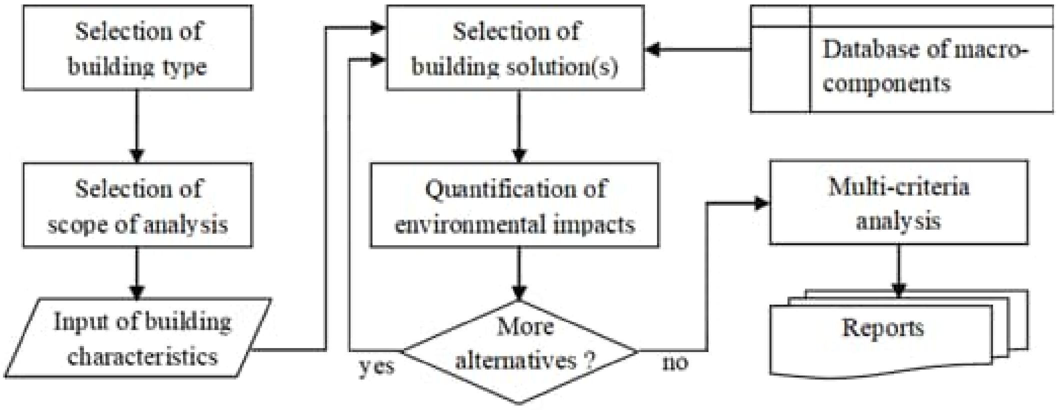


Figure 2. Flowchart of the LCA calculation.

As previously referred, this tool aims to provide a quick evaluation, in the early stages of design, of the sustainability of steel-framed buildings, considering the life cycle environmental performance of the building.

In the early stages of design, a building designer often faces different challenges in relation to the selection of the best environmental construction solutions when building data is often scarce (e.g.: which structural system to adopt, solutions for the building envelope, etc.).

Naturally, this is a challenging procedure as each question has a wide range of different alternatives that globally will lead to an even wider range of different solutions. In addition, from the point of view of the environmental assessment, the problem is more complex as one constructional solution may be beneficial in some environmental categories and simultaneously be very harmful in others.

To cope with the above problem, macro-components were developed, which consist of predefined solutions for each building component. Each macro-component is composed of different materials and includes the LCA of each solution. Therefore, the LCA of the building may be carried out based on the selection of a macro-component for each building component. The details of the LCA of each macro-component are given in Section 3 of this report.

2.1 Goal and scope of the LCA

The goal of the tool is to quantify the environmental impacts of buildings or building components (in m^2), using predefined macro-components. Moreover, the approach enables the assessment to be made at three different levels: (i) the material level (e.g.: a steel beam with 10 m); (ii) the component level (single macro-components); and (ii) the building level.

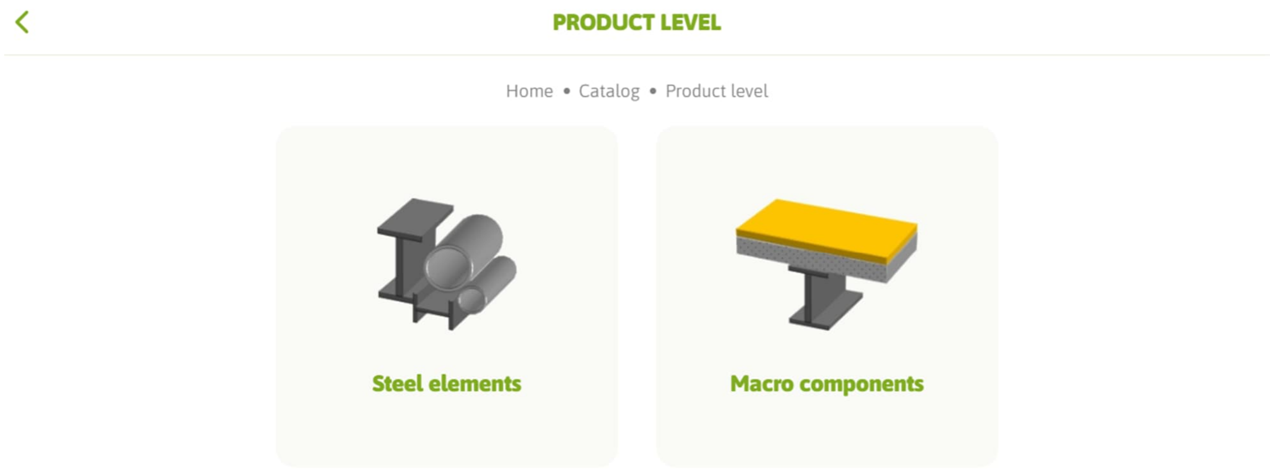


Figure 3. Product level (i) elements, and (ii) macro-components.

The two main levels are further described in the following paragraphs.

2.2 Material level

2.2.1 Functional unit

At the material level, the declared unit is a unit of steel (e.g.: 1 kg, 1 tonne, etc.). It may also refer to the total amount of a steel structure.

2.2.2 System boundaries

The life cycle environmental analysis comprehends three main calculations: (i) a cradle-to-gate analysis (Modules A1-A3); (ii) a cradle-to-date analysis plus end-of-life stages (Modules A1-A3, plus C1-C4 and D); and (iii) a cradle-to-grave analysis, including all modules.

When the end-of-life is included, the user may define a recycling rate and/or a reuse rate. Additionally, for Modules A1-A3, it is possible to define reused content (in % of the amount of steel).

2.2.3 Life Cycle Inventory

In the updated version, environmental datasets for steel products are provided from the database of the software 'LCA for Experts' (2025).

2.2.4 Life Cycle Impact Assessment

The environmental categories selected to describe the environmental impacts of the building are indicated in Table 1 and correspond to the environmental categories recommended in the European standards for the assessment of environmental performance of buildings (EN 15804 [2] and EN 15978 [3]).

Table 1 Core environmental impact indicators [2]

Climate Change - total	Global Warming Potential total (GWP-total)	kg CO_2eq.
Climate Change, fossil	Global Warming Potential fossil fuels (GWP-fossil)	kg CO_2eq.
Climate Change, biogenic	Global Warming Potential biogenic (GWP-biogenic)	kg CO_2eq.
Climate Change, land use and land use change	Global Warming Potential land use and land use change (GWP-luluc)	kg CO_2eq.
Ozone depletion	Depletion potential of the stratospheric ozone layer (ODP)	kg CFC-11 eq.
Acidification	Acidification potential, Accumulated Exceedance (AP)	Mole of H+ eq.
Eutrophication, freshwater	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	kg P eq.
Eutrophication, marine	Eutrophication potential, fraction of nutrients reaching marine end compartment (EP-marine)	kg N eq.]
Eutrophication, terrestrial	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	[Mole of N eq.
Photochemical ozone formation	Formation potential of tropospheric ozone (POCP)	[kg NMVOC eq.
Depletion of abiotic resources, mineral and metals	Abiotic depletion potential for non-fossil resources (ADP-minerals & metals)	kg Sb eq.
Depletion of abiotic resources, fossils	Abiotic depletion for fossil resources potential (ADP-fossil)	MJ, net calorific value
Water use	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	m^3 world eq. deprived

As already mentioned, the standard modular concept was adopted in the approach. Therefore, the output of the life cycle environmental analysis of the building is provided per module.

2.3 Building level

2.3.1 Functional unit

At the building level, the functional unit is a building with a defined typology (e.g. residential, office, etc) designed for a predefined period of life (e.g. 50 years) fulfilling all the standard requirements.

At the level of a building macro-component, the functional unit (in m^2) is a building component with a defined typology (e.g. external wall, internal slab, etc) used for a period of life (e.g. 50 years). In this case, the function of the building component may be included or not (in case of comparative assertions, then the function of the building component should be included).

2.3.2 System boundaries

The life cycle environmental analysis comprehends three main calculations: (i) a cradle-to-gate analysis (Modules A1-A3); (ii) a cradle-to-date analysis plus end-of-life stages (Modules A1-A3, plus C1-C4 and D); and (iii) a cradle-to-grave analysis, including all modules.

2.3.3 Life Cycle Inventory

In the updated version, environmental datasets are provided from the database of the software 'LCA for Experts' (2025).

2.3.4 Life Cycle Impact Assessment

The environmental categories selected to describe the environmental impacts of the building are indicated in Table 1.3 and correspond to the environmental categories recommended in the European standards for the assessment of environmental performance of buildings (EN 15804 [2] and EN 15978 [3]).

Likewise, the output of the life cycle environmental analysis of the building is provided per module.

In the current version of the tool, the life cycle environmental analysis of each macro-component was performed by 'LCA for experts' software.

3. Macro-components approach

Macro-components were defined for different building components according to the UniFormat classification scheme [4]. The following categories are considered: (A) Substructure, (B) Shell and (C) Interiors. Each main category is further sub-divided. The detailed classification scheme is represented in Table 2.

Table 2 Building component classification scheme [4]

<table>
<tr><td>(A) Substructure</td><td>(A40) Slabs-on-grade</td><td>(A4010) Standard slabs-on-grade</td><td></td></tr>
<tr><td rowspan="10">(B) Shell</td><td rowspan="4">(B10) Superstructure</td><td rowspan="2">(B1010) Floor construction</td><td>(B1010.10) Floor structural frame</td></tr>
<tr><td>(B1010.20) Floor decks, slabs and toppings</td></tr>
<tr><td rowspan="2">(B1020) Roof construction</td><td>(B1020.10) Roof structural frame</td></tr>
<tr><td>(B1020.20) Roof decks, slabs and sheathing</td></tr>
<tr><td rowspan="4">(B20) Exterior vertical enclosures</td><td rowspan="2">(B2010) Exterior walls</td><td>(B2010.10) Ext. wall veneer</td></tr>
<tr><td>(B2010.20) Ext. wall construction</td></tr>
<tr><td>(B2020) Exterior windows</td><td></td></tr>
<tr><td>(B2050) Exterior doors</td><td></td></tr>
<tr><td rowspan="2">(B30) Exterior horizontal enclosures</td><td>(B3010) Roofing</td><td></td></tr>
<tr><td>(B3060) Horizontal openings</td><td></td></tr>
<tr><td rowspan="4">(C) Interiors</td><td>(C10) Interior construction</td><td>(C1010) Interior partitions</td><td></td></tr>
<tr><td rowspan="3">(C20) Interior finishes</td><td>(C2010) Wall finishes</td><td></td></tr>
<tr><td>(C2030) Flooring</td><td></td></tr>
<tr><td>(C2050) Ceiling finishes</td><td></td></tr>
</table>

Within each building component, the corresponding macro-components have the same function and have similar properties. The functional unit of each macro-component is 1 m^2 of a building component with similar characteristics, to fulfil a service life of 50 years.

3.1 Illustrative example of the LCA of a macro-component

In the following, an illustrative example of a macro-component LCA calculation is provided. It is noted that, in some cases, in order to fulfil the function of a building component, different macro-components have to be considered simultaneously. The following example refers to the interior slab of a residential building, as illustrated in Figure 4.

The interior slab indicated in Figure 4 is composed of the following elements:

- ✓ a OSB plate with 18 mm;
- ✓ a layer of wood fiber insulation with 40 mm;
- ✓ a gypsum board with 15 mm;
- ✓ a density of cold-formed steel of 14 kg/m^2.

It is noted that the quantities of each macro-component are fixed, except the thickness of the insulation layer, which may be specified by the user.

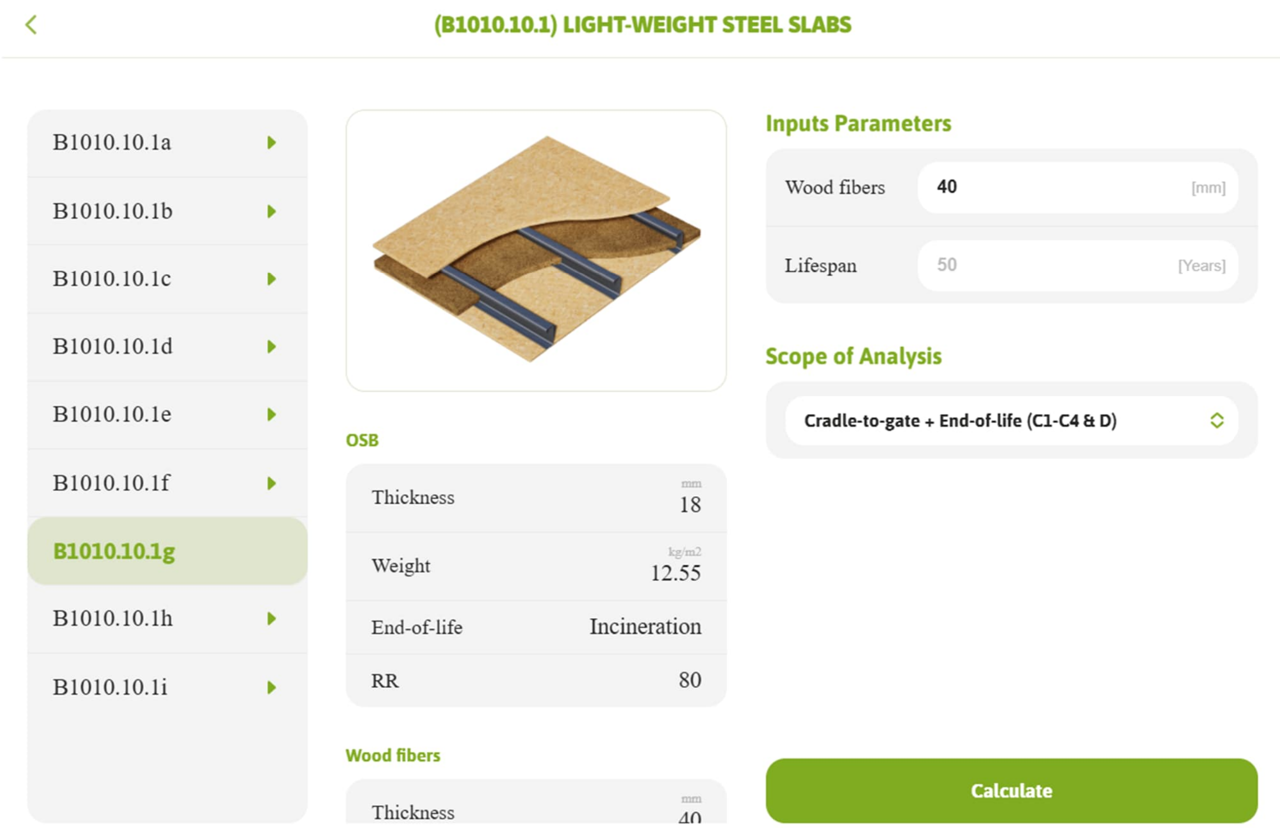


Figure 4. Main dashboard of the tool

The functional unit of the building component is an interior slab (per m^2) of a residential building, with a required service life of 50 years. The selected macro-component(s) must fulfil the same functional unit of the building component. Therefore, the estimated service life of the different materials must be considered.

Furthermore, to fulfil the environmental information in all modules, scenarios and assumptions are needed. All the scenarios are set in accordance with the rules provided in EN 15804 and EN 15978.

3.1.1 Scenarios for the transportation of materials (Modules A4 and C2)

When a cradle-to-grave analysis is selected, the transportation distances between the production plants to the construction site (module A4) and the distances between the demolition site and the respective recycling/disposal places (module C2) are assumed, by default, to be 20 km and the transportation is made by truck with a payload of 22 tonnes. However, the designer is able to specify other distances, enabling sensitivity analysis to be made in relation to the transportation of different materials.

3.1.2 Scenarios for the end-of-life stage (Modules C1:C4) and recycling (Module D)

Different end-of-life scenarios are specified for the materials according to their inherent characteristics, as indicated in Table 3. Thus, OSB is considered to be incinerated (80%) in a biomass power plant, and credits are given to energy recovery. Steel is recycled, assuming a recycling rate of 90%, and credits are obtained due to the net scrap at the end of the life-cycle process. Likewise, wood fibers are considered to be recycled (80%). However, due to the lack of data of the recycling process, no credits are obtained apart from the reduction of waste sent to landfill.

Table 3 EOL options for materials

Material	Disposal/Recycling scenario	Credits
Gypsum plasterboard	Landfill (100%)	-
Wood fibers	Recycling (80%) + Landfill (20%)	-
OSB	Incineration (80%) + Landfill (20%)	Credit due to energy recovery
Light-weight steel	Recycling (90%) + Landfill (10%)	Credit due to net scrap

3.2 Environmental analysis

The results of the macro-component are illustrated in Figure 5, which is a print-screen of the PDF report created by the tool.

LCA Results

LCA of 1m² of a weight steel slabs macro-component

Indicators describing environmental impacts

Indicator	Unit	A1-A3	A4	A5	C1	C2	C3	C4	D1.1	D1.2	D1	TOTAL
GWP-total	[kg CO2 eq.]	3.34e+1	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-1.38e+1	0.00e+0	-1.38e+1	1.96e+1
GWP-fossil	[kg CO2 eq.]	3.34e+1	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-1.38e+1	0.00e+0	-1.38e+1	1.96e+1
GWP-biogenic	[kg CO2 eq.]	-6.14e-2	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	8.20e-2	0.00e+0	8.20e-2	2.06e-2
GWP-luluc	[kg CO2 eq.]	5.27e-3	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-1.84e-3	0.00e+0	-1.84e-3	3.42e-3
ODP	[kg CFC-11 eq.]	-6.21e-13	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	1.87e-11	0.00e+0	1.87e-11	1.81e-11
AP	[Mole of H+ eq.]	7.89e-2	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-3.40e-2	0.00e+0	-3.40e-2	4.49e-2
EP-freshwater	[kg P eq.]	1.35e-5	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-3.23e-6	0.00e+0	-3.23e-6	1.03e-5
EP-marine	[kg N eq.]	1.69e-2	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-5.45e-3	0.00e+0	-5.45e-3	1.14e-2
EP-terrestrial	[Mole of N eq.]	1.82e-1	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-4.88e-2	0.00e+0	-4.88e-2	1.33e-1
POCP	[kg NMVOC eq.]	6.64e-2	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-2.22e-2	0.00e+0	-2.22e-2	4.43e-2
ADP-minerals&metals	[kg Sb eq.]	8.48e-6	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-7.88e-5	0.00e+0	-7.88e-5	-7.03e-5
ADP-fossil	[MJ]	3.82e+2	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-1.38e+2	0.00e+0	-1.38e+2	2.43e+2
WDP	[m³ world equiv.]	-1.01e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	0.00e+0	-9.29e-1	0.00e+0	-9.29e-1	-1.94e+0

Figure 5. Life cycle environmental analysis of macro-components (per m^2).

All macro-components are computed in a similar way, and the LCA of the building is assembled based on the different macro-components selected for each building component.

References

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[2] CEN (2019). EN 15804:2012 + A1:2019, *Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products*. European Committee for Standardization, Brussels, Belgium.

[3] CEN (2011). EN 15978. 2011. *Sustainability of Construction Works — Assessment of environmental performance of buildings — Calculation method*. European Committee for Standardization, Brussels, Belgium.

[4] UniFormat™: A Uniform Classification of Construction Systems and Assemblies (2010). The Constructions Specification Institute (CSI), Alexandria, VA, and Construction Specifications Canada (CSC), Toronto, Ontario. ISBN 978-0-9845357-1-2.