EnviBIM: Environmental data module for BIM library of construction elements

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Abstract. BIM has become widely used and preferred in building design. The benefits of this model can also be used to calculate the environmental impact of buildings. This paper presents the acquisition and implementation of environmental data to the existing and growing BIM library of building materials. The library contains specific (non-generic) elements, and its content is focused on conventional solutions used in Czech Republic. Environmental impacts associated with the production of building materials and elements (cradle-gate) were added to the BIM library and were expressed by 14 indicators. Generic environmental data were used. Linking them with specifics products demand high expertise and a lot of time. By designing methodology and specific guidelines, this process is speeded up, simplified, and future update and extend of resulting tool is enabled. Resulting tool (EnviBIM) will provide quantification of embodied environmental impacts of each single building part directly in the BIM model.

1. Introduction

LCA is the most commonly used method for assessing the environmental impact of buildings. It is also used to optimize the design of buildings from an environmental perspective. LCA was originally designed to design environmentally friendly products. Buildings are a very special product - they have a long lifetime, consist of a large number of products and the boundaries of the system in terms of LCA are unclear [1]. Thanks to the complexity and flexibility of the LCA method, it can be used for such a complex product as a building, but it requires a lot of time, high expertise and a lot of data, which are sometimes difficult to access. The results of such LCAs are often difficult to compare because LCA practitioners can make different decisions on different issues during the assessment, use different simplifications, system boundaries, data etc. To speed up, simplify and unify LCA of buildings, many tools have been developed to make LCA more accessible to stakeholders. Their overview can be found in [2] and [1].

The benefits of using BIM in building design are in particular in the possibility of effective collaboration between designers and other stakeholders, and its use is, therefore, becoming more common. The concept of its implementation was in 2018 accepted by the Czech Government as a national strategy.

The aim of the research is the development of the EnviBIM. This tool will provide quantification of embodied environmental impacts of each single building part directly in the BIM model, using a BIM
Building Product Library (hereinafter referred to as Building Library). This paper presents methodologies and guidelines developed for the implementation of environmental data into the Building Library.

1.1. Link to UN SDG(s)

EnviBIM is a simple tool that allows quantification of the carbon footprint of building parts and facilitates optimization of buildings towards their lower impact on climate change (SDG goal 13 Climate action). Quantification of environmental impacts of Building Library elements will help designers choose sustainable building materials. Thus EnviBIM supports responsible consumption and production (SDG goal 12).

2. Methods

2.1. Databases

The BIM Building Product Library (Building Library) contains building materials, products, assembled compositions and building systems of different manufacturers. It is designed as an universal and ever-expanding database of all kinds of construction products. It can be used through the BIM DEKSOFT plugin installed in the BIM tool or through a web interface. The great asset of the library for the designers is mainly the amount of information given with the items - technical information, links to assembly instructions, price, and soon also embodied environmental impacts.

In the Building Library the price of products is provided by linking its items with the cost estimation database. This cost estimation database is widely used in Czechia in early and advanced design phases. It contains all common construction products used in Czechia, in all variants, and with detailed descriptions. Using this database it is possible to compile a complete budget for almost any construction in Czechia.

Previous research proved, that the Czech cost estimation database can be linked with environmental database Ecoinvent in order that construction budget and cradle-to-gate environmental impact assessment can be made in one step [3].

Ecoinvent is the most frequently used environmental database in Czechia for LCA of construction and it was identified as the most applicable database in purpose to be linked with cost estimation database. Ecoinvent is a generic environmental database, covering more or less all commonly used construction products. However, its use for LCA of a building is not simple and straightforward since many elements need to be modelled using basic processes and material items. The modeling process takes a lot of time and each LCA expert can approach it differently, which in turn leads to different and incomparable results of environmental impacts.

2.2. Development of EnviBIM

Previous research has shown that for each item of cost estimating database it is possible to find or model appropriate cradle-to-gate environmental data in Ecoinvent database. However, to ensure the consistency of selection and modeling environmental data for each item, to simplify and speed up this process and to allow the update, detailed guidelines are needed. Therefore, the development of the EnviBIM module mainly involves the creation of these guidelines.

Work on the development EnviBIM runs on five levels:

- General methodology: A fixed methodological framework for EnviBIM. It is based on a thorough study of relevant standards and literature on LCA in construction sector.
- Creation of environmental data for EnviBIM
- Detailed guidelines and tools
- Case studies to assess the relevance of environmental outputs o EnviBIM.
3. Results

3.1. Detailed guidelines for interconnection of costing estimation and environmental database

For the new environmental module for the Building Library (EnviBIM) the method of linking the generic environmental database Ecoinvent 3 with the very detailed and partially specific Czech cost estimation database, was chosen. Given the size of the cost estimation database (37,731 items for construction materials), it is necessary to look for the possibility of automation and where this is not possible at least a detailed guidelines for the work with data, which will be applicable to a defined group of items. There are three main methods applied for obtaining the corresponding environmental data for specific elements (in a detailed guideline, these rules are modified for each specific group of materials).

3.1.1. Method 1: Group of costing item – one single Ecoinvent item

- **Description of the method:** For a group of products contained in the cost estimation database and differing only in dimensions or weight, the method identifies one single material item from Ecoinvent. These are mostly the products comprising only one material. In some cases method also tells which should be the source of data for unit conversion.
- **Automation of the process:** Automation is possible and simple. Excel sheet, where only dimensions or weight should be filled for each product.
- **Limitations of the method:** Within the product group, their manufacturing process of different products may vary, but as such differences are below the resolution level of Ecoinvent database, they are neglected.

3.1.2. Method 2: Combination of several material items of Ecoinvent database

- **Description of the method:** For a group of products that consist of the same materials but proportion of materials varies for each product (e.g. plastic windows), the method determines the corresponding materials items in Ecoinvent. It provides an eventual method of unit conversion, as well as a recommended source of information about products.
- **Automation of the process:** Automation is possible. For some groups of materials, an excel sheet is created, where the quantities of individual materials should be manually filled for each product and in some cases the selection of appropriate material from the menu is needed. However, it is necessary to manually assess whether the product actually belongs to the group for which the sheet is created.
- **Limitations of the method:** Environmental impacts of the process of assembling the product from individual materials is neglected. However, if this process appears to have too much environmental impact and if relevant environmental data are available, it is recommended to apply method 3.

3.1.3. Method 3: Combination of materials and process items from Ecoinvent

- **Description of the method:** The method is analogous to the method. For the group of products, however, it determines also the corresponding items of the manufacturing process. The instructions for working with data are more complicated in. It shall include a determination of the method of production of the products and, where appropriate, describe how the production method should be determined. This method is applied for instance for metal products, where data are combined from one ore more materials items – metal- and one or more metal processing items.
- **Automation of the process:** Automation is possible, but as the work with environmental items is quite complicated, and groups of the products with the same data modeling process are small, automation is realized only for several groups at the moment.
- **Limitations of the method:** Obtaining relevant information on manufacturing processes and technologies is often difficult and time-consuming. There is, therefore, a high risk that an error will be introduced into the method.
3.2. EnviBIM – environmental module in the Building Library

Environmental data are implemented to the Building Library in quite differentiated form as they are linked to the cost estimation items. However for users of the Building Library environmental data are displayed only on the level of the whole library element. Figure 1 shows an example of quite complex item – masonry wall with ETICS and all related components (anchors, moldings etc.) accessed through the web interface. On the left side there are layers of the structure with some possibilities to change their thickness, on the right side there are environmental impacts expressed by fourteen indicators. Thirteen of them correspond to the EPD standard EN 15804, the fourteenth is the single-score indicator ReCiPe.

![Example of environmental data for wall composition in EnviBIM web interface.](image)

4. Discussion and conclusion

EnviBIM tool aims to give designers the ability to easily identify the embodied impacts of construction products, directly in the BIM environment. The disadvantage, however, is that this option is limited to only one specific library of building elements, the scope of which is still limited. In the EnviBIM project a methodology and guidelines is being developed for linking the environmental database with the Czech cost estimation database that BIM Building Library uses for pricing. In the following years, the methodology and guidelines will be expanded, allowing the linking of environmental impacts to every single element of the entire extensive and comprehensive cost estimating database, so that the cradle-to-gate environmental impacts of buildings will be quantified simply along with the price.

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