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Envimat.cz - Online Database of Environmental Profiles of Building Materials and Structures

Julie Hodková[1], Antonín Lupíšek[1], Štěpán Mančík[1], Luděk Vochoc[1], Tomáš Žďára[2]

[1] Faculty of Civil Engineering, Department of Building Structures, Thákurova 7, 166 29 Praha 6, Czech Republic

[2] Faculty of Electrical Engineering, Department of Computer Graphics and Interaction, Karlovo náměstí 13, 121 35 Praha 2, Czech Republic

{julie.hodkova, antonin.lupisek, stepan.mancik, ludek.vochoc}@fsv.cvut.cz

Abstract. Envimat.cz is a new online catalogue of environmental profiles of building materials and structures localized for the Czech Republic. It allows users to compare, model and edit chosen elements. One of the main objectives is to help architects and designers to choose appropriate materials for their building and provide information on its environmental impacts. Information from the catalogue can also play a significant role for developers and their customers. Initial data are derived from the Swiss database Ecoinvent but the goal is to replace them continuously with more accurate, localized data coming from Environmental Product Declarations provided by Czech building industry producers. Envimat.cz brings multiple benefits, especially for the following stakeholders: it gives better information to the building owners; architects can easily choose solutions that are environmentally friendly; efficient producers can make profit from their advantage and Czech construction industry as whole is shifted to higher environmental friendly standard.

Keywords: online database, environmental profiles, building materials, constructions, embodied energy, primary energy, embodied emissions.

1 Introduction

In recent years the technical design of buildings has significantly improved. This led to a sound reduction of environmental impact during the operational stage of their life cycle. So far in the background, however, remained the problem of the construction stage impact. This impact is represented especially by energy consumption, atmospheric emissions and solid waste, but also by depletion of non-renewable sources of raw materials and water consumption during the production phase of materials.

Energy consumption and emissions produced during the life cycle of any structural element are two of the principal parameters used to select environmentally efficient solution. Wider utilization of materials with low values of embodied energy and embodied $CO_{2,eq.}$ or $SO_{2,\ eq.}$ emissions indicates better environmental quality.

As more low-energy and passive houses are established, the ratio between the construction and operational stage impacts is decreasing, and the consumption of

primary energy for construction and related emissions are gaining in importance (see Figure 1).

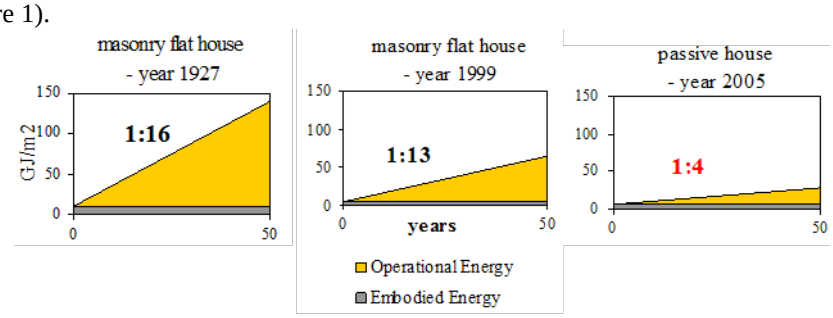

Fig. 1. The ratio between embodied and operational energy consumption [1]

Although the demand for detailed information on products and materials in Czech practice is growing, summary of environmental profiles of materials and structures has not been yet freely available.

With the support of SGS grant of Faculty of Civil Engineering of the Czech Technical University in Prague a web-based catalogue of materials and structures for new buildings and renovations - called Envimat – has been developed. It includes not only their technical but also their environmental parameters.

Fig. 2. Logo of Envimat

Provision of support to compare the environmental quality of several alternatives of proposed structures motivates designer or user of the building to choose the "greener" one and thus could reduce the impact of construction on the environment.

1.1 General methodology

The basic methodology for evaluation of the environmental impact of buildings is generally Life Cycle Assessment - LCA. The methodology is applicable to any product or process of human activity, including construction materials. All currently used methods for environmental quality assessment of building are based on LCA. They differ primarily by chosen system boundaries, data resources and time of data acquisition.

Correctly, the data from entire life cycle should enter into the assessment of "buildings fabrication" impact. This approach uses the system boundaries "Cradle to Grave", which includes all product life cycle stages from extraction of primary raw materials, through production, transport, application, use and final disposal. More

recently, even a "Cradle to Cradle" approach appears, which means a closed life cycle of products including their recycling.

In reality, it is quite difficult to quantify the product life cycle stages between transport to the site and disposal or recycling, because it always means some kind of future prediction. While counting of estimated or average values, large deviations can occur in the results.

Therefore the web-based catalogue Envimat uses data assessed with system boundaries "Cradle to Gate" that include only the initial stages from raw material extraction to production at a plant.

One more important stage of LCA is the impact of transportation from factory to building site, which can be substantial, too. It can be calculated with sufficient accuracy for specific cases, and so will form a separate part of environmental assessment (the boundaries "Cradle to Site" are used though).

1.2 Evaluated parameters

The substantial parameters of environmental impacts of materials and structures that will be evaluated in Envimat are Primary Energy Input [MJ], Global Warming Potential [$kgCO_{2,eq.}$] and Acidification Potential [$gSO_{2,eq.}$] – i.e. primary energy consumption and related emissions in „Cradle to Gate“ system boundaries. The catalogue contains also general building physical characteristics of the constructions as heat transfer coefficient (U [W/m^2K]), weight (m [kg]) or acoustic transmission loss (Rw [dB]).

1.3 Existing databases

The results of the LCA of materials and structure, with different system boundaries, form the content of many existing databases. The most important of them are listed below:

- Ecoinvent – Swiss Centre for Life Cycle Inventories - up-to-date LCI data
- EPD (Environmental Product Declarations) – www.environdec.com
- INIES – CSTB (Centre Scientifique et Technique du Bâtiment) - French database of EPDs, www.inies.fr
- IBO Baustoffdatenbank – IBO (Austrian Institute for Healthy and Ecological Building) – data of GWP, AP, PEI, EP of materials
- ICE database - Department of Mechanical Engineering, University of Bath - PEI and GWP of a large number of building materials.
- Bauteilkatalog www.bauteilkatalog.ch – SIA (Swiss Society of Engineers and Architects) - data of GWP, PEI, AP of building structures etc., www.bauteilkatalog.ch
- Ökobau.dat - German Institute Bauen und Umwelt (bau-umwelt.de) - German database of EPDs

1.4 Differences among various databases

The resulting differences that can occur in assessment of one building while using various databases are shown at the following charts. IBO and ICE databases (see previous paragraph) were used here for a case study.

It is evident especially in the comparison of embodied emissions of CO_2. While IBO assessed the wooden construction as environmentally extremely friendly the ICE methodics presents this construction on similar level with IBO assessment of brick construction. In this case, the difference between two assessments of one building by two different databases is massive.

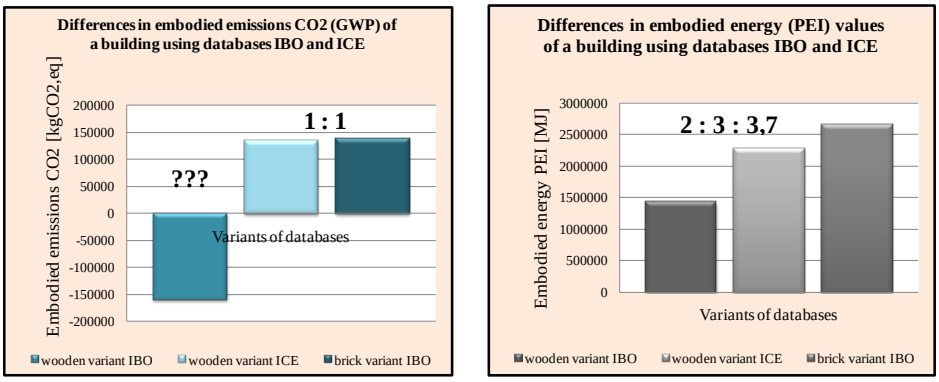

Fig. 3. Differences in embodied energy and carbon of building evaluated with IBO or ICE database [2]

There can be several reasons for such results as different system boundaries in the methodology (what life cycle stages are included, what processes enter the assessment etc.), data sources (from manufacturers or from secondary sources) or age of the data (modern versus older technologies).

2 Methodology of Envimat

The catalogue uses one of the largest international database of building materials Ecoinvent, developed in Switzerland. The database includes pieces of European mean data, but often it offers only Swiss data. To be closer to real conditions, the energy related data were recalculated for the Czech fuel mix in electricity network.

The major aim of Envimat development is to cooperate with local Czech manufacturers to obtain accurate data corresponding to the Czech conditions. Future material database used for Envimat will contain data obtained using EPD - Environmental Product Declaration (see below) or equivalent methodology. It will allow the manufacturers to provide their data and fill them in the database.

2.1 EPD

The Environmental Product Declaration – EPD is defined as "quantified environmental data for a product with pre-set categories of parameters based on the ISO 14040 series of standards, but not excluding additional environmental information"[6]. It measures energy and water consumption, waste production, impact on climate change, eutrophication, destruction of the ozone layer, etc. throughout the life cycle. The EPD document containing this information must be publicly accessible and the data contained therein must be verifiable. It is in fact a detailed "certificate" on the product's environmental impact[3].

In the EPD method every type of material has clearly established the so-called product category rules (PCR), i.e. a set of required parameters with defined system boundaries that must be evaluated in order to maintain the comparability of the results needed. It is important to realize that being labeled by EPD does not mean that the product is "ecological" or "green", if the EPD results cannot be compared to another product and if the benchmarks are not established.

The overall goal of the EPD is to enable companies to show the environmental performance of their products in a credible and understandable way. The main principles of EPDs are objectivity, credibility, neutrality, comparability and universality. This is achieved by processing the EPD by an independent organization according to prescribed PCR - Product Category Rules. This PCR contain guidelines for LCA of each product group (e.g. building products, concrete, etc.) and so ensure common and harmonized calculations and comparable results. The PCR are elaborated by professional institutions cooperating with trade industry organizations and before the official release of the final version, the PCR draft must go through the process of international reviews and comments

For end customers and consumers, the EPD forms a credible document that allows them to choose the most suitable product. As it is elaborated according to unified international methodology, the parameters of the products of the same type from different parts of the world are comparable. This implies also an advantage for producers and EPD publishers, since the declaration of their products are accepted worldwide [3].

2.2 Goals and objectives of Envimat

The goal was to create an online tool for evaluating and comparing the building structures and components according to their environmental and physical profiles with regard to the purpose and use of such element.

A missing database of building materials and structures localized for the Czech Republic is prepared. It is focused on embodied energy and CO_2 emissions. It will be available to the professional public and will also be suitable for teaching about these issues at specialized schools.

The tool will allow users to select or edit existing structures, create new structure or the possibility of expanding the database with new structures and materials.

It will be possible to compare, sort and filter the selected structures, using the fuzzy multi-criteria evaluation based on user preferences.

The producers will have an option to import data of their products.

3 Envimat architecture

The following Figure 3 shows the class model, which serves as a starting point for creating the Envimat database application.

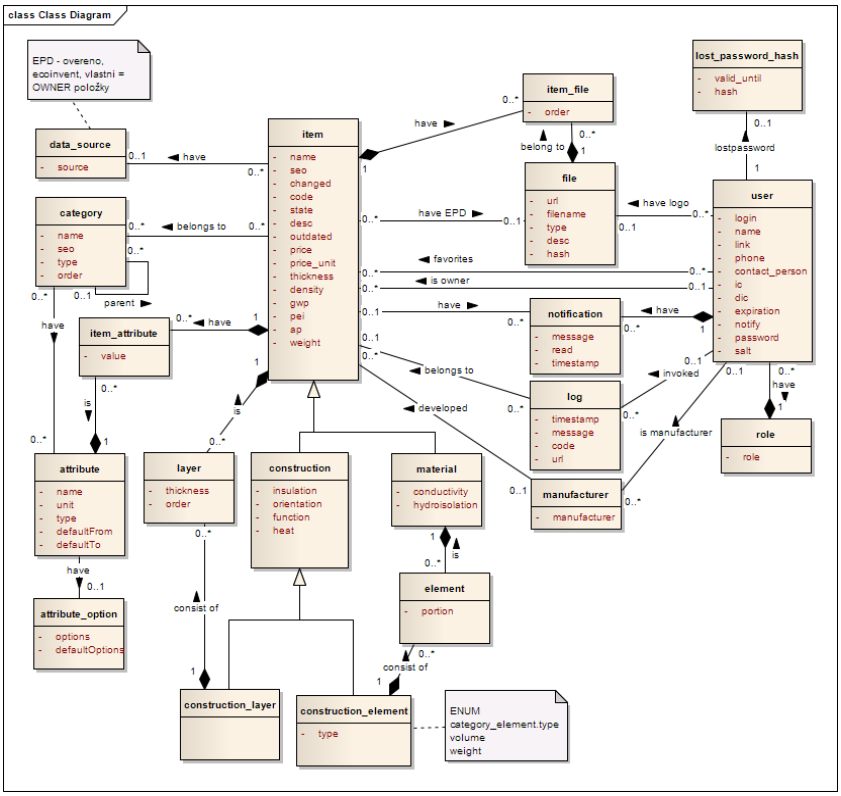

Fig. 4. Envimat database class model [7]

3.1 Envimat interface

The structure of the web catalogue is as follows:

- Main page with the methodology and links to additional information
- Part A : Catalogue of materials
  - Option 1 – Search in the material database and filtering of the materials according to their paramters and typology
  - Option 2 – Comparison of chosen materials

- Part B : Catalogue of existing structures
  - Option 1 – Structures ranked according to one parameter - Environmental (PEI, GWP...); Technical (U, Rw...)
  - Option 2 – Detailed search according to users criterion preferences – individual weighting of different criteria (under preparation)
  - Option 3 – Comparison of chosen structures
  - Option 4 – Creation of a new structure according to individual parameters and requirements of user – modelling new structure; modification of existing structure; modification of existing historical structure (under preparation)
- Part C – Simplified calculator of the building environmental profile based on the quantity of material used for construction (planned)
- Part D – Transport – calculation of environmental impact of material transport (planned)
- Downloads

Envimat should eventually serve as a guidepost for further information on environmental development in building industry. The following Figure 5 shows the Envimat tool interface.

Fig. 5. Envimat interface

3.2 Catalogue inputs

Envimat intern database with various material characteristics was created and is used to evaluate and compare environmental and physical profiles of structural elements or building structures. Some of the assessed characteristics are shown at the next Figure 6.

Název	GWP	PEI	AP	ρ	λ
	kg CO2 ekv./kg	MJ/kg	g SO2ekv./kg	kg/m3	W/mK
antireflexní sklo	1.4913	25.176	0.007702	2600	1.35
beton chudý	0.055726	0.366257	0.00011	2190	1.3
beton normální	0.109891	0.608789	0.000185	2380	1.4

Fig. 6. Envimat interface

As stated above, while working with the tool, user can either use pre-defined materials and structures, or he can create his own structure by filling in the material layers.

As stated in Methodology of Envimat chapter, the manufacturers will be allowed to fill in the data of their products. It is clear that the data entered into the database must be checked and approved before they are officially submitted into the database.

Envimat also provides a possibility of exporting data of a certain material to PDF and comparison of two materials and their environmental profiles.

4 Conclusion

Nowadays the developers, builders, and future users are not enough motivated to address the impact of used construction materials on the environment. They are usually not interested in other solutions that incorporate the same features and technical parameters, but a smaller environmental impact, partly because there is no existing tool that would allow them to do so.

Web-based catalog of materials and structures for new buildings and renovations - Envimat - helps them with environmental assessment and selection of suitable materials or structures. It will also allow producers of building materials to supply the necessary data to include their product into the internal database of the catalogue. In the Czech Republic the catalogue with localized data offers a detailed evaluation and comparison of building structures and components not only based on their physical parameters but also on the impact of their production on the environment.

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