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ENVIRONMENTAL LIFE-CYCLE COSTS OF BUILDING MATERIALS

The purpose of the article is to point to the necessary calculation of environmental costs in the construction budget. It is necessary for building materials to be in environmental databases. The databases contain the measured values of the different environmental loads, generated by the construction materials and products, during the life cycle phases of the building material. These databases are part of the calculator software. The article explains the principle and necessity to calculate the environmental costs for manufacturers of building materials and products in Slovakia, which will be required from 2020.

Keywords: environmental cost, life cycle assessment, databases, building materials, building products

1. Introduction

Currently, the environmental costs are calculated as costs for waste disposal, fines for environmental pollution and so on. But real environmental costs are rooted in every building product and materials. Environmental costs represent the amount of environmental burdens, which are created by the manufacture of building products and materials. These calculation problems will begin to resolve after 2020, according to the European Directive EPBD 2 – Energy Performance of Building Directive. The EPBD is an instrument for enhancing the building regulations on energy performance of the building stock in the EU member states. The directive sets binding targets that have to be transposed into national law and implemented via national regulations [1, 2, 10]. The environmental impact assessment is based on the life cycle assessment of building products. The article maps possible approaches to calculating environmental costs in the world. The purpose of this paper is to offer an explanation of the environmental costs calculation for Slovak producers of building materials.

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2. Environmental databases

For the purpose of calculating environmental costs, is necessary, that building materials must be written into databases. The databases contain the measured values of the different environmental loads, which are generated, when construction materials and products are produced. Those values are measured during the life cycle phases of the building materials and products. Calculation software draws these values from these databases.

There are several databases in the world that can be used to calculate environmental costs such as:

The Ecoinvent database [3] provides well documented process data for thousands of products, helping you make truly informed choices about their environmental impact. The database was developed by the Swiss Center for Life Cycle Inventories. The "Cradle-to-gate" model is applied in most LCA studies. The database is accessible free of charge and is also included in the SimaPro and GaBi software.

The GaBi Databases [4] are the largest internally consistent LCA databases on the market today and contain over 10,000 ready-to-use Life Cycle Inventory profiles. Over 20 years of life cycle expertise by thinkstep is captured in GaBi Databases, which always feature the most accurate Life Cycle Inventory profiles based on primary industry data.

The Athena's databases [5] are regionally sensitive, taking into consideration manufacturing technology, transportation and electricity grid differences as well as recycled content differences for products produced in various regions. Athena databases are built from the ground up using actual mill or engineered process models and are not reliant on trade or government data sources.

The U.S. Life Cycle Inventory (LCI) database [6] is created to help life cycle assessment (LCA) practitioners answer questions about environmental impact. This database provides individual gate-to-gate, cradle-to-gate and cradle-to-grave accounting of the energy and material flows into and out of the environment that are associated with producing a material, component, or assembly in the U.S.

These databases contain the values of monitored environmental loads during the individual phases of the life cycle of the construction product (material). On the basis of these values, we can find out product, which has less of a burden on the environment. Based on the emission values, we are able to classify building products from the most environmentally conscious. Based on this consideration, then it is possible to make an appropriate selection of products in the budget of the building object, for the investor. There is plenty of software, which uses these databases to draw data from them.

2.1. Building for environmental and economic sustainability

An example of the use of environmental values is the BEES software. BEES (Building for Environmental and Economic Sustainability) software brings a technique for selecting cost-effective, environmentally-preferable building products. Developed by the NIST (National Institute of Standards and Technology) Engineering Laboratory the tool is based on consensus standards and designed to be practical, flexible, and transparent. BEES measures the environmental performance of building products by using the life-cycle assessment approach specified in the ISO 14040 series of standards [7]. All stages in the life of a product are analyzed: raw material acquisition, manufacture, transportation, installation, use, and recycling and waste management. Figure 1 shows the structure of the observed environmental values (Fig.1).

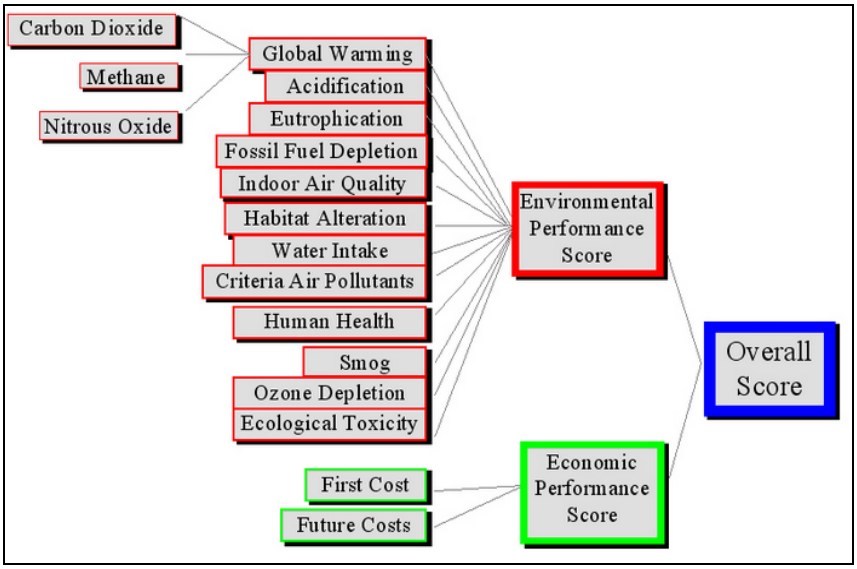
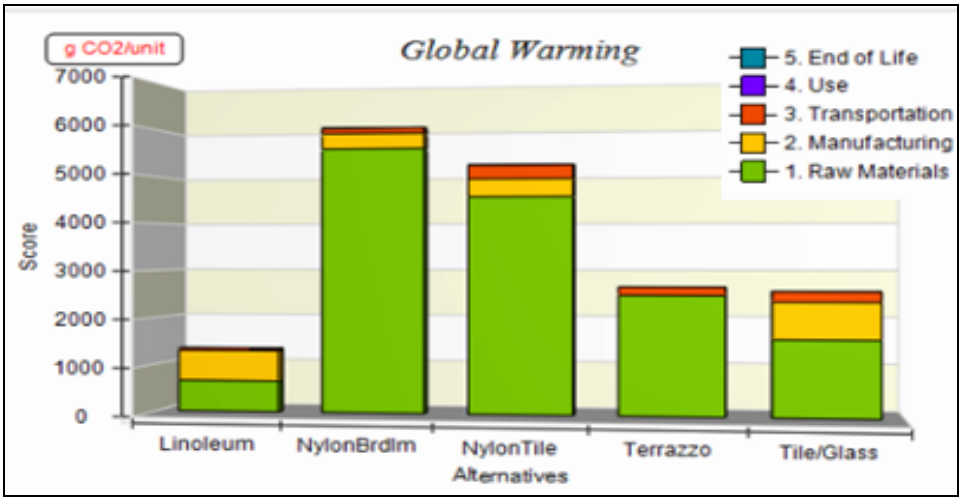


Fig. 1. The structure of the monitored environmental values (BEES), based on [7]

Rys. 1. Struktura monitorowanych wartości środowiskowych (BEES), na podstawie [7]

As an example: We also mention the environmental assessment of the building material of the top layers of flooring (Fig.2). It would be necessary to evaluate all construction materials in this way, for calculation environmental cost.



Note: Lower values are better

Category	Linoleum	NylonBrdlm	NylonTile	Terrazzo	Tile/Glass
1. Raw Materials	649.5848	5567.6270	4540.0944	2492.9625	1602.0258
2. Manufacturing	638.6637	321.4957	375.6831	0.0000	766.5896
3. Transportation	43.1574	113.5873	292.4296	172.4351	211.5102
4. Use	0.0000	0.0000	0.0000	0.4488	0.0000
5. End of Life	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	1331.4059	6002.7100	5208.2071	2665.8464	2580.1256

Fig. 2. Measured CO_2 values throughout the life cycle (top layers of floors), based on [7]

Rys. 2. Zmierzone wartości CO_2 w całym cyklu życia (górne warstwy podłóg), na podstawie [7]

2.2. Environmental declaration of building products EPD

One of the environmental databases is also the EPD - Environmental Product Department. Thanks to the international standardization organization and ISO 21930:2007 - Environmental declaration of building products, there are more and more manufacturers of construction products, which are preparing environmental statements about their products. The EPD has to provide information for planning, design and construction of the assessment, that information is verifiable, accurate and comprehensive estimate any impact on the environment. EPD is based on the LCA standards, but it may also include information about a product or material only in a certain phase of LCA (Fig.3) [8]. In this article, the issue of environmental costs was analyzed on a specific example under the following marginal conditions:

The cement used in the concrete constructions was chosen as the building material. Only the production phase was selected from the LCA due to the missing data in the other LCA phases. From Global warming was selected for the monitored environmetal parameter only CO_2 eq.

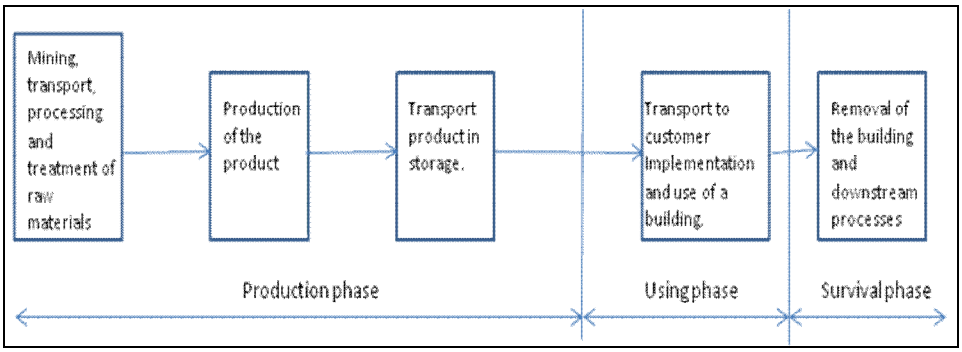


Fig. 3. The phases of LCA in EPD

Rys. 3. Etapy LCA w EPD

On the basis of the comparison, a cement is selected which has less of a burden on the environment in its production phase. With this methodology, it is possible to compare products and materials to each other. However, it is necessary to measure all the values of environmental damage in all phases of LCA products and materials. The investor can then choose an environmentally more suitable product. It is also cheaper because it is less damaging to the environment and smaller sanctions for its use are calculated [9].

The investor has to bear the costs of his project in advance, throughout the LCA of the project. This is a measure to protect the environment for future generations. This transfers responsibility from the environmental burden on the investor.

Next, the values of CO_2 in the production of cement are given from the EPD database [9].

The Romanian cement manufacturer Holcim has registered 3 EPD certificates. The certificate from which the data were used was registered 16.05.2014 and is valid until 16.05.2018. Upon expiration of the license, the manufacturer is required to repeat and declare the new EPD, or to demonstrate that the measured values have not changed and the certificate extended by 4 or 5 years. Manufacturer Holcim declares the following average values for its cements.

Another producer is Israeli manufacturer Nesher Israel Cement Enterprises Ltd. This manufacturer has also registered 3 certificates, all for cement. The certificate from which the information is drawn up is registered as of 16.01.2014 and is valid until 14.01.2019.

The third producer is the Brazilian manufacturer Votorantim Cimentos. Votorantim has also registered 3 EPD certificates for cement, plaster and concrete. The certificate I used for the calculations is registered as of 06.07.2016 and is valid until 20.06.2021.

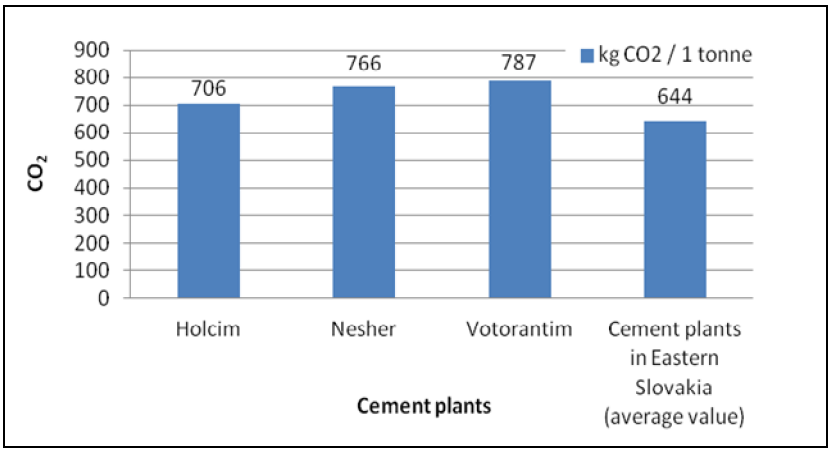


Fig. 4. The release of CO_2 eq. in the production of cement. Source: Author and based on [9]

Rys. 4. Uwolnienie równoważnika CO_2 w produkcji cementu. Źródło: Autor oraz na podstawie [9]

For example, in calculating the construction budget, it would be possible to choose the cement that is less burdensome for the concrete. The release of CO_2 eq. from production of cement is shown in the graph (Fig.4).

3. Joint calculation construction costs and environmental costs

In Slovakia, the most commonly used calculation tool for creating budgets is currently CENKROS. CENKROS is quality software of measurement and management of building production. This system covers all activities associated with the preparation and execution of the contract. The program allows you to quickly prepare a quality quote, simply calculate the cost-effective use of execution and billing of the work performed and price estimates compiled by financial indicators. The system is designed for budget designer, cost accountants, preparer, purchasers, designers and suppliers of construction work [11].

Technological and organizational variant for baseband concreting has added columns for CO_2 values for used Holcim cement. An identical table would include data for cement from Nesher and Votorantim. Consequently, the budgeter could choose an environmentally more advantageous product. Although there is no quantifiable financial cost to date, we can build a range of building materials and products that we more or less burden the environment. High environmental value will mean a high cost. The technical organizational version of the calculation of concrete foundation strips in Cenkros software.Cement manufacturers must apply for inclusion in the database. Then we will be able to calculate the environmental costs in Slovakia from 2020.

4. Conclusion

In order to calculate construction costs together with environmental costs is dependent on the existence of environmental data (EPD database). It is equally important to develop an tools and formats in which environmental information will be connecting to the calculated construction costs, and that this environmental information to assign their economic impacts. Similarly as in European countries and in Slovakia after 2020 will be need the calculations of the environmental costs still topical in the design phase of the project in order to choose the best possible solution with respect the principles of sustainable development. The investor will be responsible for the construction during its entire life cycle. Therefore, the investor chooses products that are more environment-friendly, which means they have less environmental costs.

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ŚRODOWISKOWY CYKL KOSZTÓW ŻYCIA MATERIAŁÓW BUDOWLANYCH

S t r e s z c z e n i e

Celem artykułu jest wskazanie na niezbędne obliczanie kosztów ochrony środowiska w budownictwie. Konieczne jest, aby materiały budowlane znajdowały się w środowiskowych bazach danych. Bazy danych zawierają zmierzone wartości różnych obciążeń środowiskowych, generowanych przez materiały budowlane i produkty, podczas faz cyklu życia materiału budowlanego. W artykule wyjaśniono zasadę i konieczność obliczania kosztów środowiskowych dla materiałów budowlanych i produktów przez producentów na Słowacji, które będą wymagane od 2020 roku.

Słowa kluczowe: koszty środowiskowe, ocena cyklu życia, bazy danych, materiały budowlane, produkty budowlane

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