LCA and EPD - Polish experiences

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ABSTRACT: Building Research Institute (ITB) contributes to reductions of the environmental impacts from construction in Poland by providing the essential information, advices and services on all aspects of the building product and building sustainability like: life cycle analysis (LCA), national environmental product declarations (EPD), carbon and water footprint labels and building assessment methods. ITB actively represents polish construction sector in CEN TC 350, LMI, Concerted Action EPBD III, ECO-Platform, SB Alliance, E2B Association, GPP criteria development and FP7 projects. This article offers a selected review of these activities highlighting subject of EPDs.

. INTRODUCTION

The consulting and technical services of ITB in the area of product and process sustainability are based on performing LCA in order to quantify the environmental effects of products and processes but including social and economic assessment. ITB holds the secretary of Polish Standardization Board (PKN) 307 Technical Committee the mirror group to CEN TC 350 (sustainable construction) and its experts actively participate to the standardization work on the building and building product assessment methods development (table 1).

ITB has continued to gradually extend the research services in product sustainability over the last 15 years and many scientific projects, expertizes, monographs and publications were performed. Institute can provide construction product producers with both consulting services and software solutions for product sustainability that enable the integration of environmental parameters based on CEN TC 350 approach into the technical and economic aspects of decision making process.

Table 1. Actual (2011/2012) polish experts participation to CEN TC 350 WGs

SC/WG	WG title	status
CEN/TC 350/WG 4	Economic performance assessment of buildings	active
CEN/TC 350/WG 5	Social performance assessment of building	active
CEN/TC 350/WG 1	Environmental performance of buildings	active

2. A NEW PACKAGE OF STANDARDS FOR SUSTAINABLE CONSTRUCTION

By the collective decision of KT 307 the mirror group members, Poland support CEN TC 350 standardization process and will implement this approach to practice. A long waited package of European Standards is being developed for assessing the sustainability of construction works, including construction products, by the CEN 350 covering all three dimensions of sus-

tainability (Ilomaki, 2011). It provides the horizontal methodology and standardized quantitative environmental indicators under mandate M/350, where the main standards are:

- EN 15643-2 Sustainability of construction works – Assessment of buildings - Part 2:
- Framework for the assessment of environmental performance;
- EN 15978 Sustainability of construction works – Assessment of environmental performance of
- buildings - Calculation method;
- EN 15804 Sustainability of construction works – Environmental product declarations Core rules for the product category of construction products.

This standard are being used for national benchmarks system development. EN 15643-2, EN 15978 and EN 15804 provide a consistent horizontal EN-standardised methodology and indicators for the assessment of environmental performance of buildings using a life cycle approach in a transparent way. This is the main principle in all CEN/TC 350 standards, because without a long-term perspective and life cycle approach it is not appropriate to refer to sustainability. EN 15643-2, EN 15978 and EN 15804 provide a consistent framework and approach to collection, calculation and presentation of the environmental data on a range of impacts and aspects for construction products and in the application this data as part of building level assessment. As such they are tools that are used within polish national scheme providing a more consistent basis for the 'judgements' on performance.

Furthermore, Europe is a part of global market area and any European Standards for declaring environmental information on construction products should be in line with the relevant framework of the existing performance based globally recognised ISO standards. Otherwise the EU would be in danger of creating technical barriers to trade for construction products manufactured outside EU (Hammans, 2011). Especially from the regulatory point of view the environmental indicators described in EN 15978 and EN 15804 should be regarded as a basket of indicators that have an agreed scientific basis for European standardization and therefore included in EN 15978 and EN 15804.

EN15804:2012 relates to the environmental assessment of construction products. The standard essentially provides a basis for creating a national PCR document and defines some of the key methodological decisions that have to be made. One of the purposes of defining these choices is to resolve the differences between European national EPD programmes and, by doing so, facilitate the mutual recognition of EPD both across borders and within the various building assessment schemes that exist in Europe. There is a clear advantage for construction product manufacturers in this approach as they will need to produce fewer EPD to cover International trade within the European Union.

The CEN TC350 expect that feedback received during the first twelve months of the standard will form the basis for subsequent revision. As expected, practical experience of implementing EN15804 has shown that there are many areas of the standard that are not yet fully resolved. The implication of this is that EPD produced to different EN15804 compliant PCR documents may not be directly comparable: EN15804 requires EPD to contain a statement to this effect (Crowhurst, 2012). Differences may be introduced by factors such as the choice and availability of the background data that EN15804 requires, the detail of modelling assumptions and the optional exclusion of certain lifecycle stages from EPD. This potential lack of comparability creates an obstacle to the use of EPD from different schemes within LCA design tools and building assessment schemes.

In response, ITB is collaborating with a group of European EPD programs providers to agree a process for developing and managing a core set of rules for implementing EN15804. This harmonization work will be informed by a broader group of industry stakeholders to ensure that the views of all parties are considered, and that the agreed rules are developed objectively and independently. The working title of this cooperation is the 'ECO Platform'. Mostly all GBCs support this initiative.

2. NATIONAL EPD SYSTEM

The most accepted internationally way to communicate construction product's environmental profile to clients (B2C) or business partners (B2B) is Environmental Product Declaration. EPDs(cradle to grave or cradle to factory gate) according to EN 15804:2012 may support com-

panies in proving their responsibility for providing relevant product related environmental information (Piasecki, 2010). EPD should be widely verified and be presented in a uniform and internationally recognized format. More and more demanded by architects, constructors and planners, it can directly be used in sustainable building design tools, e.g. to carry out a building LCA (EN 15978:2011).

ITB supports construction companies in providing EPDs projects (as national program operator) via performing the environmental analysis products which construction company may use for internal environmentally conscious product development, presenting actual environmental performance and use benefits, marketing promotion, development of ISO 14001 or as a communication format with end-user and clients. ITB offer support in creating Environmental Product Declarations for construction product manufacturers and with more than 50 already done projects is the leader on the eastern market. ITB guaranties highest quality due to an internal EPD quality management (ISO) and a standardized CEN approach. ITB also provides (based on LCA results) decision making aid for sustainable product development. ITB personnel is additionally skilled in the technology lines assessment because of ITBs notification for construction product CE marking.

EPD enables to analyse the entire life cycle of products with regard to their environmental impacts and to display these analyses in a transparent and standardized way (figure 1). In accordance to EN 15804 two options of LCA (cradle to gate or crade to grave) are offered by ITB. All life cycle stages are presented as modules; A1-A3 product stage, A4-A5 construction stage, B1-B7 use stage, C1-C4 End of Life stage.

EPD	Unit.	Concrete roof tile: Profil S i Extra [1 Mg] CRADLE TO GRAVE									
		Cradle to gate			Construction		Use	End of life			
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4
Environmental Impacts											
Greenhouse effect GWP	kg CO_2	190	8,4	75	8,1	16	0,00	5,28	1,17	0	5,8
Depletion of ozone layer ODP	kg CFC11	3E-05	0	2,2E-6	3E-05	1E-06	0,00	4,0E-07	0	0	0
Acidification effect AP	kg SO_2	0,73	0,06	0,52	0,019	0,068	0,00	0,022	0,007	0	0,008
Air contamination: potential for ozone creation POCP	kg C_2H_4	0,013	0,004	0,02	0,006	0,004	0,00	0,003	0,001	0	0,003
Water contamin. eutrophication EP	kg PO_4	0,09	0,009	0,11	0,003	0,016	0,00	0,005	0,001	0	0,006
Depletion of mineral resources ADP	kg Sb	0,7	0	0,04	0,007	0,001	0,00	0,0003	0	0	0
Depletion of fossil fuels ADP	MJ	1001	108	310	68	120	0,00	40	15	0	6
Environmental Aspects											
Water use	m^3	0,08	0	0,009	0,001	0,08	0,00	0,03	0	0	0
Renewable energy use	MJ	25	0	23,2	0,482	4,8	0,00	1,6	0	0	0
Primary energy use	MJ	1026	119	340	74	160	0,00	53	17	0	10
Solid wastes	kg	151	0	43	1,94	16	0,00	5,28	0	0	5,8
Solid wastes	kg	151	0	43	1,94	16	0,00	5,28	0	0	5,8

For cradle to grave the scenarios of construction product use are developed for each product group. In the system the impacts generated in the course of production of resources fuels and non-fuels presented is considered (A1 module). Manufacturer prepare a number of certain input date for the representative industry plant with a detailed allocation of all products (A3 module). Quality of manufacturer data is audited. Declared emissions and resource consumption form Manufacturer according to ISO 14025 is verified. The emissions generated in the production

phase in the process are compared with the data shown in the specialist literature regarding gas burning in the furnace in order to make eventual correction, i.e. the balance of emission by nature and calculated emissions. The process of preparing a product for sale, efficiency of the energy generation, transmission loss of energy and transport of raw materials to the plant and around a plant have are considered in the calculations. ITB approach is to use as much specific data as it is possible. For example, in table 2, the data resources for glass wool LCA calculation are presented. ITB doesn't suggest using a software generated generic data without scientific and deep verification of data quality. Selection of data has a great impact on the LCA results.

Table 2. Generic and Specific Data Sources (LCI) used for a glass wool LCA calculation

Raw Material	LCI data sources
Gas	PGEI 2007, DUKES, Górzyński(2004)
Transport	Chalmers University CPM, GUS, ITB
Czech ElectricityMix	IEA statistics(2010), DG TRN(2008)
LPG, ON	NETCEN, PGEI 2007, Górzyński(2004)
Sand	IGSMiE PAN-specific
Etibor/borax	Atatürk University-specific
Dolomite	Czatkowice dolomite mine-specific
Soda	ETH-ESU
Nepheline	Ecoinvent v.2.2
Cullet (50% recycled)	Ecoinvent v.2.2 & local specific
Ammonia water	EFMA and Frischknecht
Dextrose	Utrecht University
Dedusting oil	EMPA-DU
Ammonium sulfate	EFMA and Frischknecht
Silicon	Ecoinvent
Glue	IO USA
Product Labels	Producer specific by ITB
Wooden pallets (not recycled)	Producer specific by ITB
Foil	BBA
Pallets	EMPA-DU
Defoaming oil	EMPA-DU

Every LCA is grounded on the same basic principle with varying areas of application extending from carbon footprints, water balances, analyses of material flows and processes to examinations of economic factors (for impact allocation). By considering the whole life cycle (or selected parts) of a product incurred environmental impacts can, not only be partially avoided, but be exposed for analysis. This allows to determine in which stage of life (it can be in the production of raw materials or to disposal) cause the greatest impact to the environment. Therefore, specific organization activities can be both identified and adjusted to maximize environmental performance where it is most beneficial. To achieve this aim of environmental optimality, individual solutions are necessary due to the diversity of requirements for various products and branches of industry. One such of individual solution developed by ITB for large insulation producer is presented in tables 3-5. Potential environmental benefits were calculated for a specific scenario use – thermal modernization of non-insulated roof. The results presentation is unique, LCA impacts are recalculated to a car emission and the number of a pine tree sequestrating CO_2 (tables 4-5). The results are presented on $1m^2$ roof insulation systems (1-3). A representative national model of a building were used, local weather parameters and 3 different heat systems were analysed. Calculation was made for 50 years period including cradle to gate impacts. Three insulation systems were assessed: 15cm+5 cm, 15cm+10cm, 20cm+5 cm (Figure 2)..

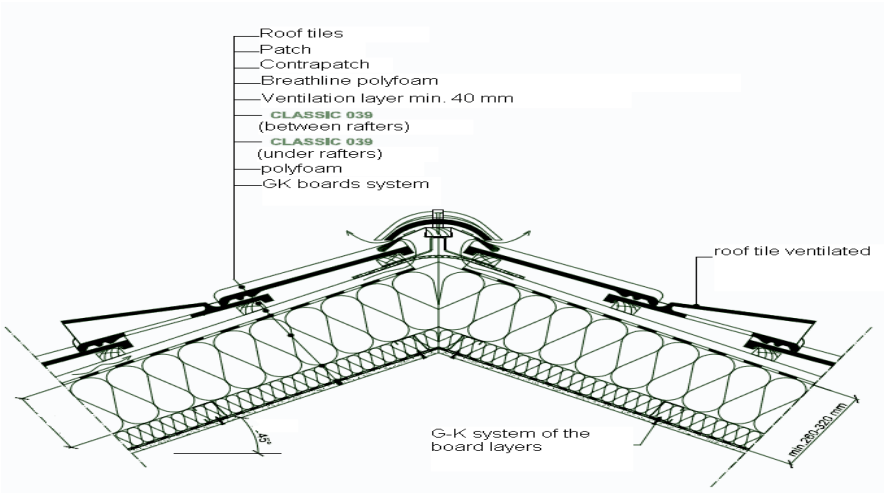

Figure 2. Pitched roof systems with Knauf Classic 039 layers

Maximum potential environmental benefits, in relation to the non-insulated pitched roof, obtained thanks to the use of 1m^2 of mineral glasswool Classic 39 used in 1-3 systems in the course of 50 years of using in the single-family house located in Warsaw heated with gas stove are presented in table 3.

Table 3. LCA based environmental benefits of 1m^2 roof systems calculated for 50 years

Environmental indicators	Units	System 1 „15”+”5”	System 2 „15”+”10”	System 3 „20”+”5”
Greenhouse effect GWP	kg CO_2	-2 316,3	-2 373,2	-2 357,8
Depletion of ozone layer ODP	kg CFC11	-0,00046	-0,00047	-0,00047
Acidification effect AP	kg SO_2	-2,75	-2,82	-2,79
Potential for ozone creation POCP	kg C_2H_4	-0,63	-0,64	-0,64
Use of primary energy PE	GJ	-40,7	-41,7	-41,5
Eutrophication EP	kg PO_4	-0,48	-0,49	-0,49

Potential environmental benefits (by 1m^2 Roof Insulation Systems) from non-insulated roof thermo-modernization, measured as the equivalent of the CO_2 absorption made during 50 years by one polish pine-tree (109,2 kg CO_2/50 years) are presented in table 4..

Table 4. Environmental benefits of 1m^2 roof systems calculated for 50 years

Technical solution	Units	Gas heating	Coal heating	Electric heating
System 1 „15”+”5”	Number of trees	21	53	109
System 2 „15”+”10”	Number of trees	21	54	112
System 3 „20”+”5”	Number of trees	21	54	111

Potential environmental benefit) – measured as the equivalent of the c-class car emission (160g CO_2/km) presented on the “km” basis are shown in table 5.

Table 5. Environmental benefits of 1m^2 roof systems calculated for 50 years

Technical solution	Units	Gas heating	Coal heating	Electric heating
System 1 „15”+”5”	km	-14676	-36441	-74880
System 2 „15”+”10”	km	-14832	-37337	-76720
System 3 „20”+”5”	km	-14736	-37095	-76223
System 4 „20”+”10”	km	-14991	-37736	-77541

3. EUROPEAN "ECO EPD" PLATFORM

25 organisations from 17 European countries including ITB agreed on establishing the European EPD Platform. The European construction products industry is going ahead with the standardization of EPD as agreed a meeting in Brussels on 23 September 2011.The EPD programs from Finland, France, Germany, Great Britain, Italy, the Netherlands, Norway, Poland, Portugal, Sweden and Spain signed a "Memorandum of Understanding" to establish an umbrella organization beyond national systems. The ECO Platform aims at initiating the development of a uniform and European core EPD. The basis for the ECO Platform is the work of CEN TC 350 on product sustainability. The national Green Building Councils were also supportive party to the Memorandum of Understanding. Objectives of the Eco Platform. The objective of ECO is to support the provision of unbiased, credible, consistent and scientifically sound information in a form of type III Environmental Product Declaration for construction products.

This objective will be achieved by following steps and actions:

- development of a common EPD core system for construction products based on ISO 14025 (ECO platform is not intended to be a European program operator)
- development of consistent implementation of EPD according to EN 15804
- elaboration of a common European format (interpretation) based standards
- description of a common quality management and verification procedure leading to mutual recognition across national borders

ECO is an organization based on EPD program operators (one vote per country in the board). Platfiorm includes supporting members such as Associations, GBCs, EU Commission representatives, CEN observers. ECO is aiming for being widely visible and recognized as the benchmark for EPD Program Operators in Europe. There are some positive voices form European Commission that ECO would harmonize EPD market as necessary thing for new CPR requirements. The regulation CPR (EU) No 305/2011 of the European Parliament and of the Council, as of March 9th 2011, laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC (known as CPD).

4. SB ALLIANCE

The SB Alliance is an international non-profit organization bringing together operators of building rating tools and certification, standard setting organizations, national building research centers and key property industry stakeholders. Since 2010 ITB has been active member. The purpose of SB Alliance is accelerating the adoption of sustainable building practices through the promotion of shared indicators for building performance assessment and rating.On the voluntary level the Sustainable Building Alliance (SBA) is conducting a pilot studies to assess the ability of an even larger number of partners, e.g. members of the World Green Building Council to apply the core indicators of SBA in their tools. These core environmental indicators are based also on CEN TC 350. Because the same indicator are used on product level and building that's why EPDs can be used for building assessment.

Undertaken studies have highlighted the link between sustainability features and an asset value, namely in terms of the impact of sustainable and green properties in the valuation of Buildings. ITB supports one of the SBA researches projects on sustainability building value assessment. Performed studies have shown, for instance, that green buildings, especially those awarded with a certification mark or an energy label are behaving with and increased economic added due to its environmental features. Current studies allow to approximately quantify the green value of certified or sustainable buildings value (in terms of accelerated sales period, market value, rental value), but it is still necessary to identify which are the sustainability performance indicators that do contribute for this increase of value and beyond which performance levels the referred green value starts expressing an impact. So, this research work is directed towards the analysis, understandings and presentation of key findings and conclusions regarding the impact of sustainability indicators (especially those already tested by SBA) into the calculation of the asset valuation. The aim of the research is to understand how the environmental and social performance of a building can be communicated with simple indicators and translated into economic performance that is triggered beyond certain thresholds. This research will concern not only corporate real estate but also residential buildings.

5. UEATC AND LCA.EXE PROJECT

LCA.EXE initiative (2006-2008) was supported and founded by the UEAtc members, platform of the national technical approvals providers. The work was carried out by the two Active Members: BBA (UK), and ITB (PL) and it was assisted by twelve members (DIBt, EMI, ETA, NSAI, SCIC, ITC, LNEC, NIISK, SINTEF, TZUS, BBRI). Industry partner in the project was URSA. LCA.EXE project was built of nine main tasks, as follows:

- Task 1. Identify manufacturer
- Task 2. Define methodology
- Task 3. Prepare LCI questionnaire
- Task 4. Complete LCI questionnaire with client
- Task 5. Prepare Audit Template Checklist and Audit
- Task 6. Decide use of secondary (generic) data
- Task 7.Conduct profile calculations (LCA)
- Task 8. Report findings
- Task 9. Draft UEAtc LCA methodology and Guidance Document

The UEAtc guidance document provided a rules for LCA for construction products and was based on prEN 15804 (2008 version) and experiences from product examination. It provided a structured information to ensure that all LCA of construction products can be done, controlled and presented in a harmonised way accepted by UEAtc members. LCA results information was expressed in the information modules, which allows easy organisation and expression of data packages throughout the life cycle of the product. The results that was product EPD was expressed in a form that allows aggregation to provide complete information for buildings. UEAtc guidance doesn't deal with aggregation for the building level nor does describe the rules for applying EPD in building assessment and doesn't define requirements for developing and operating EPD programs. The UEAtc guidance document includes a summary of experiences based on prEN 15804 used for the LCA of products URSA DF40 and URSA DF37. UEAtc guidance highlights practical aspects and difficulties. UEAtc document deals only with a cradle to gate approach and limited number of parameters which are quantifiable with sufficient experience and which have been agreed on a European consensus with the stakeholders involved in this standardisation.

This project also has compared EPDs from different certification bodies (BBA, ITB, CSTB, EMPA, Chalmers and BRE- Appendix C in Report II) for glass wool insulation materials and significant differences were identified. BRE Environmental profile methodology uses "Per installed element over 60 years study period in the building (cradle to grave)", in particular 1m² of insulation with sufficient thickness to provide a thermal resistance value of 3 m²K/W, equivalent to approximately 100mm of insulation with a conductivity (k value) of 0.033 W/mK. ITB calculated EPDs of glass wool insulation cradle to gate per declared unit (1 tonne of insulation material) or cradle to gate + options per thermal resistance unit (1 m²K/W). INIES uses $1m^2$ of wall and EMPA and Chalmers present the results as 1 kg (gate to gate) of the product. EPDs for URSA products have been identified in France, Switzerland, UK and in Poland. It can therefore be concluded that it was not possible to compare EPDs as different functional requirements were used. ITB will continue transfering EPD "know how" to European Organization of Technical Approvals (EOTA).

D. CARBON FOOTPRINT

During a product's life cycle, energy is required to extract, transport and refine raw materials, to manufacture and distribute the final product, and treat the waste at the end of its useful life. As fossil energy carriers currently play the main role in supplying energy, all of the above listed steps are associated with the generation and release of greenhouse gases (GHG) such as carbon dioxide, methane, nitrous oxide, etc. These gas emissions in turn contribute to the global warming effect (GWP), which is measured as the Product Carbon Footprint (PCF). A carbon footprint is "the total set of greenhouse gas (GHG) emissions caused by an organization Greenhouse gases can be emitted through production process and transport. For simplicity of report-

ing, it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted. LCA according to EN 15804 (as well as in the British BSI PAS2050) is the premier methodology for determining a Product Carbon Footprint. Facilitating such a 'cradle-to-grave' carbon footprint analysis of construction product will disclose a real Product Carbon Footprint (PCF), reveal reduction potentials and highlight negative trade-offs, e.g. the shifting of environmental burdens from one stage of the life cycle to another. It is impossible to rely only on company specific data to properly conduct a Life Cycle Assessment and still comply with the high requirements of the international standards. ITB software allows all the GHG emissions of construction product to be captured in a systematic and standardized way. Primary data specific to selected product can then be incorporated into analyses and combined with secondary data on GHG emissions available from the ITB knowhow and databases. Calculation procedures can help manufacturer to determine and analyse his carbon footprint and the next step may provide to reduce it and make his products carbon neutral. Reduction methodologies may include alternative fuels, process energy efficiency, material substitution, fuel switching, eco-innovations etc. In order to achieve carbon neutrality, unavoidable carbon emissions can be offset by investing in emission reduction projects.

There are in Poland environmentally leading companies that decided to provide certified carbon labels for its products demonstrating the company's commitment to reduce the environmental impact . The carbon label shows the amount of CO_2 generated by construction company which is determined, among other factors, by product composition. The carbon footprint is measured by the amount of carbon dioxide and other greenhouse gases (CO_2 eq.) generated from cradle to gate (or grave), including the extraction of the raw materials, to manufacturing, distribution, use by customers and disposal at the end of life. The carbon footprint label by ITB is based on EN 15804 and the PAS2050 requirements which is the first international standard for companies to measure their carbon footprint of products and services. For example CEMEX is the company thta meet the high standard of 30% CO_2 reduction for main cement products (table 6).

Table 6. List of the cement products with the significant factor of the CO_2 emission reduction

Cement products	Manufacturing plant	Total CO_2 reduction
CEM II/B-V 32,5 R	Chełm	31,1%
CEM II/B-M (V-LL) 32,5 R	Chełm	34,3%
CEM II/B-S 42,5 N	Rudniki	38,3%
CEM III/A 32,5 N	Rudniki	65,7%

The carbon labelling demonstrates the progress and commitment that construction company made in reducing the carbon associated with manufacturing process (figure 3). Particularly for Cemex it was the replacement of fossil fuels with alternative waste fuels and the blending of cements with by-products from other industries to minimize raw materials use and clinker factor. The carbon labelled cements and XtraBet concretes were introduced to customers during international Construction Budma Fairs 2011..

Figure 3. Carbon footprint label - EKO-ITB

7. SUMMARY

Article presents how ITB supports a formal process of EPD implementation on the market and support construction industry in developing a strategy and accompany on the way to a verified and sustainable building products and provide a variety of services to help companies understand how their product and processes will perform and how they might improve the environmental performance. Selected experiences and remarks collected during active representation of Poland in CEN TC 350 and other European initiatives (like ECO Platform and SB Allaince) were discussed in article.

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