



## **Life Cycle Assessment within BNB<sup>1</sup> – Online-Tool eLCA and materials database ÖKOBAU.DAT**

**Abstract:** *Life Cycle Assessment (LCA) is an instrument for the evaluation of environmental quality of buildings. Based on specific data from environmental product declarations (EPD) or from the ÖKOBAU.DAT under consideration of the life-cycle phases, a quantified assessment of buildings is possible.*

*To unify and simplify this process of creating LCAs, the online tool eLCA was developed. eLCA is a flexible and modular online tool which enables the creation of LCAs for buildings based on templates of construction elements and materials.*

*Both, ÖKOBAU.DAT and eLCA are initiated and maintained by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), a research Institution under the portfolio of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).*

### ***Sustainability, Building Materials, Life Cycle Assessment, Tools, ÖKOBAU.DAT***

#### **Introduction**

There are numerous political initiatives - at global, European and national levels - that formulate political objectives in connection with sustainability, such as energy efficiency, resource efficiency and reduction of greenhouse gases. Frequently, the topics relevant to construction are linked to requirements with respect to building materials and building products.

In applying the BNB, many of the sustainability aspects mentioned in the various political initiatives are taken into account by means of the comprehensive sustainability criteria, such as the deconstruction of buildings, recyclability of building products, global environmental effects with the global warming potential at their core, environmental and health-relevant effects on soil, water and air, indoor air quality and other aspects [1].

BNB is part of the National Sustainability Strategy. With the binding implementation of BNB to new constructions, Germany is pioneering the implementation of certifications schemes for Sustainable Buildings in Europe. It is one of the few countries where the State requires a binding sustainability assessment for its federal construction projects. Most European Countries use such certification systems only on a voluntary basis, if at all.

As the sustainability of a building under the BNB principles is ensured by taking into account all sustainability criteria in relation to Ecological, Economic, Socio-Cultural, Technical and Process Quality, building products are not assessed as individual products, but looked at within the context of the entire building (*Fig. 1*).

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<sup>1</sup> BNB – German assessment system for sustainable construction for federal buildings



Figure 1: Considered dimensions of sustainability within BNB [2]

Particularly with respect to Ecological Quality, that is, when considering the impact on the global and local environment, building materials form an essential part of the overall assessment. The effects on the global and local environment play a vital role (global warming, ozone depletion, photochemical ozone creation, acidification and eutrophication potential), which are determined by a life cycle analysis, taking into account the life cycle over the chosen time period of 50 years.

As part of the Sustainable Building programme, the federal government provides important aids for choosing suitable building products. ÖKOBAU.DAT supplies basic data for life cycle analyses at building level with the online-tool eLCA.

### Lify Cycle Assessment in BNB

BNB altogether comprises 45 different sustainability criteria profiles. There, 7 out of 11 are related to Ecological Quality and 7 of them are covered by LCA on building level (i.e. 1.1.1 "Global Warming Potential", 1.1.2 "Ozone Depletion Potential", 1.1.3 "Photochemical Ozone Creation Potential", 1.1.4 "Acidification Potential", 1.1.5 "Eutrophication Potential", and 1.2.1 "Primary Energy Demand, non renewable", 1.2.2 "Primary Energy Demand, renewable").

The LCA within BNB takes into account the phases of building construction, use and disposal. For all of these phases the database ÖKOBAU.DAT supplies necessary data on the building materials and products used in the building.

For the phase of **construction**, all materials used in the building are listed by cost groups 300 and 400 according to DIN 276 [3]. They must then be quantified and included in the life cycle analysis.

The **use** phase includes consideration of building services and systems engineering, such as energy and water supply. In addition, planned repairs must be considered in the use phase. A listing of service lives of materials/products which is provided by the federal government via the information portal indicates the construction elements that will have to be replaced within

the considered period of 50 years. These must be recognised in the life cycle assessment, including the materials to be used.

As for the **disposal** phase, generally one must differentiate between the disposal and/or recycling possibilities of recycling, thermal recycling and landfilling.

All these data are factored into the life cycle assessment at building level. Life cycle assessments are generally carried out by experts by means of appropriate software tools, such as e.g. eLCA. Frequently, these tools generate additional data for relevant life cycle costs (relevant to criteria profile 2.1.1 "Building-related Life Cycle Costs"). At the end, the building-specific values of the environmental factors are supplied that result, depending on the extent of requirements, in the assessment of the corresponding criteria profile. The objective is to select the materials for a positive assessment in such a way that the negative contributions to environmental impact remain as low as possible.

### **ÖKOBAU.DAT**

ÖKOBAU.DAT is a database of life cycle assessment (LCA) data sets for generic and specific construction materials and components. ÖKOBAU.DAT is offered as online database on the newly developed webpage [www.oekobaudat.de](http://www.oekobaudat.de).

ÖKOBAU.DAT contains generic basic data sets that provide suitable averages of the environmental indicators for the building materials, as well as product-specific data sets that are determined for environmental product declarations (EPD). Using the generic data sets allows sustainability studies of buildings already in early planning stages when architects or planners do not yet work with product specific but with generic building product information. In a later stage, the generic data in the model is then substituted by specific data representing actual construction products.

When the first version of the ÖKOBAU.DAT was provided (by PE International AG within a research project of BMUB), there was neither a commonly accepted standard defining the specific calculation rules for EPDs nor a technical data format available to store the LCA results.

Only since EN 15804 [4] was written to introduce more rigorous rules for the building sector in how to set up the environmental models of the life cycle products and calculate comparable environmental life cycle indicators, more EPD program holders implemented EN 15804 into their specific programs. The German IBU scheme from the Institute for Construction and Environment e.V. (IBU), which significantly contributes product specific data sets for the ÖKOBAU.DAT, was the first to introduce the new standard in their EPD program rules.

Hence, a BMUB research project was initiated to develop a data format which meets current European standardization processes and carried out by KIT (Karlsruhe Institute of Technology, Institute for Applied Computer Science). As a result, ÖKOBAU.DAT follows the European Standard EN 15804 since September 2013. In new versions of ÖKOBAU.DAT only data are accepted that follow this standard. For example, the modular approach with life

cycle modules (A1-A3, B1 to B6, C1 to C4, and D) as well as required environmental indicators (24 parameters) according to EN 15804 has to be regarded. The ÖKOBAU.DAT therefore is the first database which comprehensively offers life cycle data meeting European Standard EN 15804.

### Webpage

ÖKOBAU.DAT is presented in a newly developed webpage which offers a userfriendly access to the database. For example, basis information as well as interesting links is given, different versions of the ÖKOBAU.DAT are archived (*Fig. 2*).

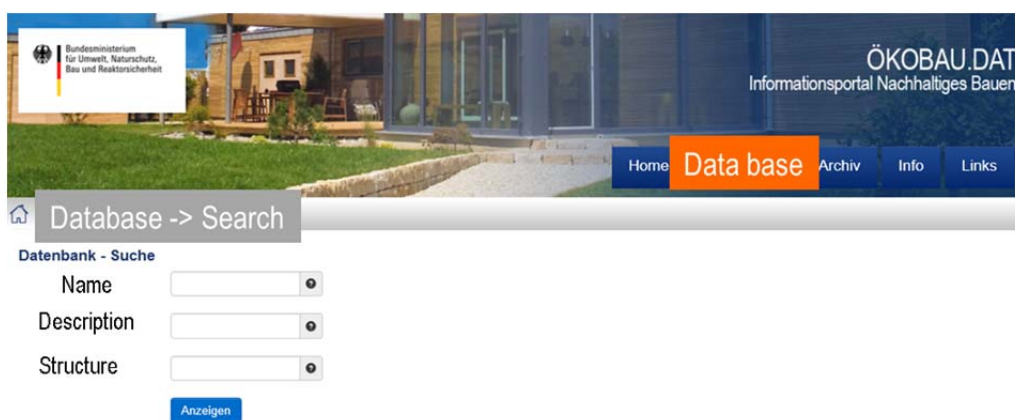


Figure 2: Screenshot of [www.oekobaudat.de](http://www.oekobaudat.de) – search functionality in German online data base ÖKOBAU.DAT

In the past, the data had to be downloaded as a single comprehensive zip.file. Hence, it is an important innovation that now, there is given direct access to the online-database. Search- and filter- functionalities allow finding relevant datasheets for chosen materials or products directly in the online database. *Fig. 3* shows a detail of a datasheet of the ÖKOBAU.DAT: here modules A1-A3, A5, C3, C4, D conforming to EN 15804 for different environmental indicators. The datasheets furthermore include information on the raw materials production and production processes used in the manufacture of the product, e. g. cradle-to-gate.

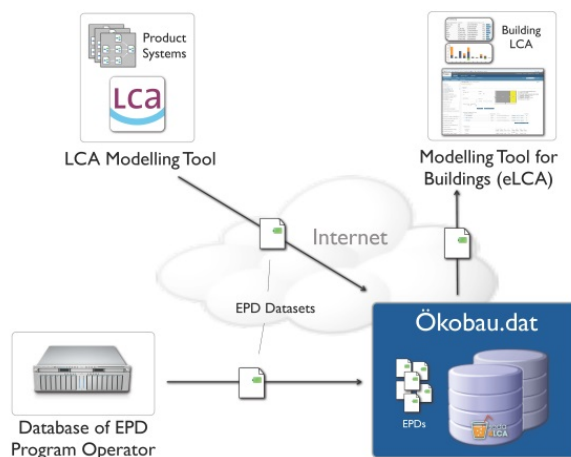
Indikator ↕	Einheit ↕	A1-A3	A5	C3	C4	D
ADP,E	kg Sb-Äqv.	0.0009389	4.667E-9	5.211E-10	2.133E-7	-1.372E-7
ODP	kg R11-Äqv.	2.839E-8	3.694E-11	2.1E-12	5.4E-10	6.833E-12
AP	kg SO <sub>2</sub> -Äqv.	0.03972	0.00005444	0.000005356	0.003667	-0.01228
EP	kg Phosphat-Äqv.	0.005367	0.00001067	0.000001133	0.0006611	-0.001
GWP	kg CO <sub>2</sub> -Äqv.	21.26	0.5056	0.1	2.994	-3.5
ADP,F	MJ	313	0.1444	0.01111	7.978	-42.21
POCP	kg Ethen-Äqv.	0.004867	0.000003406	6.333E-7	0.001044	-0.001839

Figure 3: Data sheet (details) in online database ÖKOBAU.DAT according to modules of EN 15804

### Online database

Due to the new organization as an online database, ÖKOBAU.DAT does not only show helpful applications on the user surface, it furthermore allows the online import and export of data for all interested stakeholders.

In consequence of the EN 15804 standard, the EPD data format employed by the ÖKOBAU.DAT was revised, as described above [5]. Furthermore, the online data base follows an extended ILCD data format, which originally has been specified by the European Commission and implemented by KIT as an XML data exchange format to exchange LCA data (EU COM 2011). As an Internet aware data format, it has been designed to explicitly allow publishing and linking of data as resources over the Internet. Within the project, an extended data format based on ILCD for modelling EPD data was developed. The advantage of this new approach is that existing software tools with built-in support for the ILCD format can be easily enabled to support the new EPD dataset as well, with only minor changes to their internal information structures. It is to emphasize that ÖKOBAU.DAT is running on an open source programme software platform (soda4LCA), which allows the development of further modules which use or can add new features to the ÖKOBAU.DAT. The integrated tool chain for online data exchange is organized as shown in *Fig. 4*.



*Figure 4: Tool chain for online data exchange with ÖKOBAU.DAT (figure by Oliver Kusche, KIT)*

Data from EPD program holders can easily be imported in the online data base. For example, in Germany, IBU as an important EPD program holder is working to equip its own database application with facilities to directly import its data online into ÖKOBAU.DAT. As not all institutions which may offer suitable building materials related data will be able to generate data with an tool of their own, a further research project has been set up to modify the widely-adopted open source LCA modelling tool “openLCA” accordingly to allow creating suitable EPD data which subsequently can be imported into ÖKOBAU.DAT, even online directly from openLCA (*Fig. 4*).

## eLCA

However, ÖKOBAU.DAT delivers life cycle assessment data of building products that are factored into the life cycle assessment at the building level. Consequently, a further BMUB



research project was initiated with main purpose to develop a BNB compliant LCA tool for buildings. eLCA was developed within a BMUB research project by BEIBOB Medienfreunde, Germany. eLCA is an open source online tool, which is available free of charge via [www.bauteileditor.de](http://www.bauteileditor.de). The underlying data is based on the building materials database ÖKOBAU.DAT. The structure of the online eLCA tool is organized in three levels.

In "building materials" all information and environmental parameters from the ÖKOBAU.DAT are stored. The online data base ÖKOBAU.DAT allows an export of its data to eLCA. All versions of ÖKOBAU.DAT can be chosen within eLCA.

In "templates of construction elements" public templates of typical building components and construction elements are given, e. g. a sandwich panel as a component and an external wall as a construction element. These templates are helpful, as in general within a project, components or construction elements will be used frequently when data input for specific building models has to be carried out.

In “projects”, in addition to the public templates of construction elements, the user can create private, project-specific components and construction elements. Within the project level, the data input is based on the project specific building models. The building structure is created by the components and construction elements with the associated materials. The underlying data of materials is given in the ÖKOBAU.DAT – in eLCA the contribution of all materials to the environment (indicators 1.1.1 to 1.2.1, global warming potential etc., see above) has to be calculated in the amount of the materials as used in the real construction, following the structure of German Standard DIN 276. A specific feature of eLCA is that the creation of elements is associated with dynamic graphs which show the thickness of different material layers – this helps to prove the created building components and elements (Fig. 5).

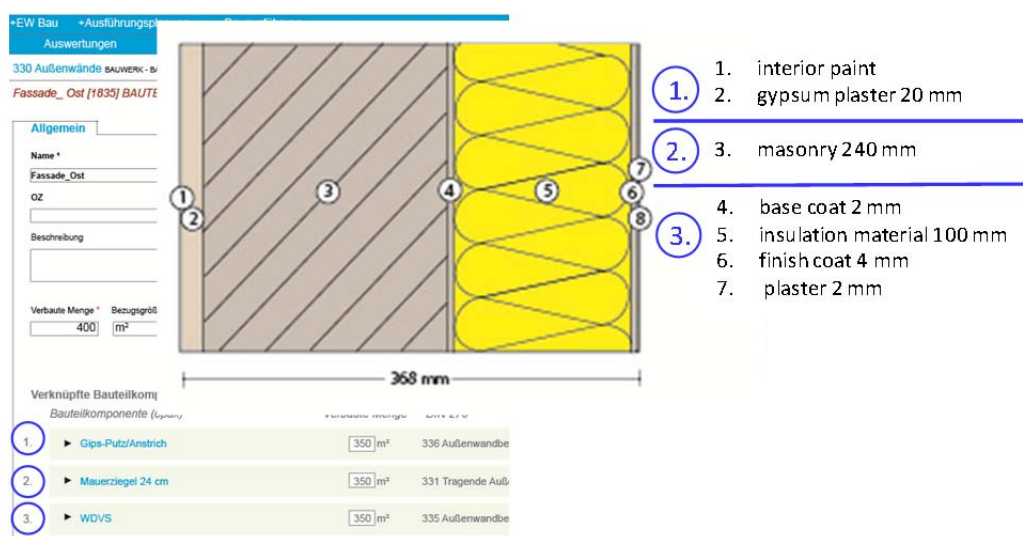


Figure 5: eLCA - Dynamic graph of building component

The product and construction stage, use stage, and end of life stage are considered within eLCA. The evaluation of the project's life cycle assessment can be presented as a total score result, which is relevant for the evaluation of the addressed sustainability criteria within BNB, but also separated into construction elements (cost groups according to EN 276) or relative to the life cycle stages (Fig. 6).

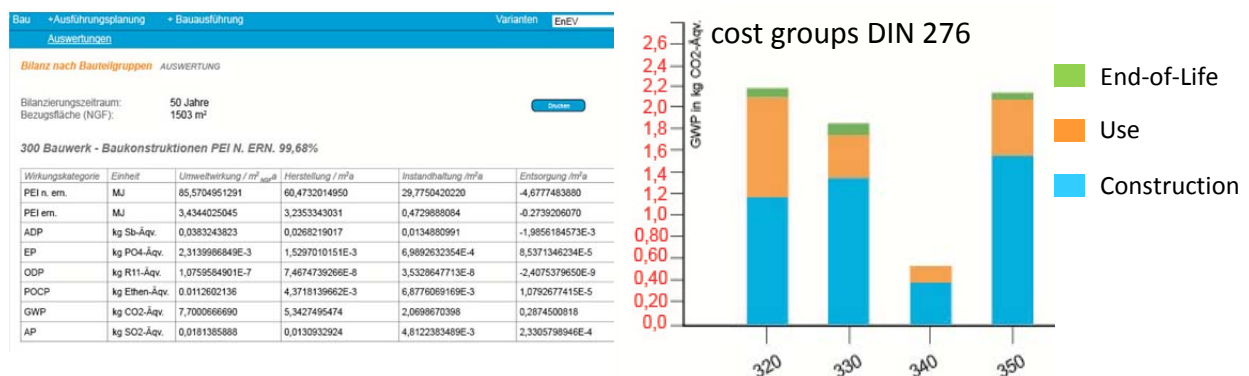


Figure 6: eLCA - Total score result and separation of results to cost groups and life cycle stages (left: table of results for environmental indicators; right: results of GWP in cost groups and life cycle stages)

First users all emphasized the userfriendliness of the tool and were highly satisfied with this tool. Ideas of an English version of eLCA are currently being discussed.

## Summary

The possibility to directly import of data into the online ÖKOBAU.DAT database with a given harmonised data format which follows the generally accepted European standards is a great chance for the idea of a consistent and comparable establishment of life cycle assessment within the context of sustainability considerations in the construction field. Some European countries are already highly interested in using the developed data format and finding a way of integration of their data to the ÖKOBAU.DAT. These developments of the new ÖKOBAU.DAT data format and organisation in an online data system are in the phase of first applications. There is a high potential for a harmonised and consistent way of using material and product relevant LCA data, or EPD data respectively, for life cycle assessment on building level.

## References

- [1] Brockmann, T. (2013) *Ecological Aspects of Building Materials/BNB*, SB 13 Helsinki.
- [2] BMUB (2014-05-20) Guideline for Sustainable Building.  
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- [3] DIN 276 Kosten im Bauwesen (*costs in civil engineering*).
- [4] EN 15804 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products.
- [5] Kusche, O. et al. (2013) *Extending the ILCD Format to support Environmental Product Declarations of Construction Products*; EnvironInfo Hamburg.