SMART MODELS AS INTELLIGENT ASSISTANTS IN BUILDING LCA

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Summary

Life Cycle Assessment (LCA) is one of today's key issues if we look at the environmental performance of building materials, construction components or especially if we discuss about the sustainability of entire buildings. LCA assists in answering questions concerning these topics by using specific software, such as the GaBi 4 software, and by setting up tailored models. The difficulties in designing such tailored models for building LCA are high expenditures of time for modeling, the need for flexibility in assessing conditions and the representation of various building circumstances.

In the context of a sustainable certification according to the German Certification for Sustainable Construction (DGNB), a generic built and hierarchical drawn up model for an office building is assembled within the GaBi 4 software [1]. Its structural design complies with the ISO 14040/44 standard [2], [3] and with the requirements for a sustainable evaluation according to the German Certification for Sustainable Buildings and Construction [5]. As fully parameterized model it was applied in practical certification process for assessing the environmental impacts of the accredited office building and furthermore its applicability was validated.

Therefore, the structural assembly of the described model and the flexibility of application for other building types will be demonstrated and discussed, to work out, how a smart model for building LCA may look like.

Keywords: Life Cycle Assessment, Building models, German Sustainable Building Council (DGNB)

1 Challenges of building models for LCA

Today, the implementation of life cycle assessment for various building types in Germany is mainly driven by the wish of achieving the 'German Sustainable Building Certificate' [5] accredited by the German Sustainable Building Council (DGNB). The certificate addresses seven criteria (e.g. global warming potential [4]) which necessarily require results of a building LCA as input and life cycle assessment is asked increasingly as a service. Therefore, the demand for smart building models is obvious.
Challenges in this context are e.g.:

- A tailored design of the building model itself,
- The applicability in the certification process,

- High expenditures of time for setting up the model
- And the flexibility of representing various building circumstances or assessing conditions, as the buildings differ e.g. in size, layout, construction materials and building type.

2 An intelligent building model structure in detail

For systematically conducting life cycle assessments for buildings in general, the model set-up integrates the following building life cycle phases: construction, use phase (operation and maintenance) and end of life. Its hierarchical layout is displayed in Fig. 1. On the left side, the breakdown for the construction phase into cost groups according to DIN 276 [6] (Building construction costs) is apparent. Furthermore the considered building life cycle phases are shown on the highest level of modeling.

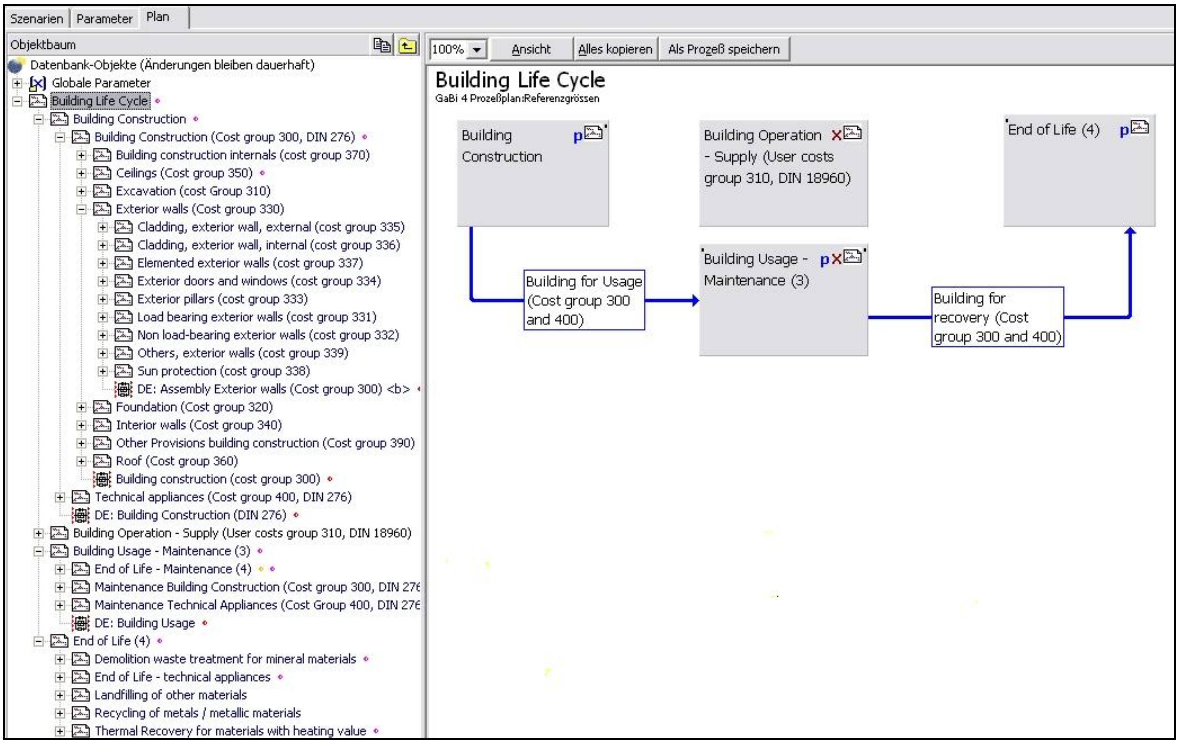

Fig. 1 Overview of the building model structure and the building life cycle within the GaBi 4 software [1].

As fully parameterized and generic model, it offers the possibility to assess buildings which may differ with regard to e.g. construction types (e.g. massive or lightweight construction) and building materials.

It includes therefore all important parameters such as e.g. quantities and types of different building materials and service lives of construction elements [8]. The application of parameters supports an easy transfer of information from construction to maintenance and end of life. For the construction phase, the model divides into the cost groups ‘Building Construction’ and ‘Technical Appliances’. The use phase ‘operation’ counts for the demand of electricity and heat, while the use phase ‘maintenance’ represents the exchange of building elements and building materials throughout a period of consideration of 50 years for the life cycle assessment. The end of life phase distinguishes between mineral materials, metallic materials, materials with heat value and other materials for land filling.

3 LCA building models in practice

One specific example of using the described general building model is conducting a LCA according to the German Sustainable Building Certificate for the office building "Zentrum für Umweltbewußtes Bauen" in Kassel, Germany. Tab 1 describes exemplary key input data, which are fed into the lowest-level plans of the parameterized building model.

Tab 1 Exemplary key data for the LCA of the „Zentrum für Umweltbewußtes Bauen", ZUB, Kassel, Germany

General data	Key data: construction	Key data: use phase
Net surface area: approx. 1,700m²	Mineral materials (e.g. concrete, gravel, lime sand brick, screed): 5,957,984 kg	Service life of construction components according to 'Leit-faden Nachhaltiges Bauen' [8]
Building service life: 50 years	Steel: 100,670 kg	Energy demand for heating: 170,780 MJ/a
Data source: Ökobau.dat [7]	Polystyrene, Polypropylene: 19,700 kg	Energy demand for electricity: 68,032 MJ/a

The LCA is conducted within the GaBi 4 software. The assessed impact categories are: 'global warming potential' (GWP), 'acidification potential' (AP), 'eutrophication potential' (EP), 'photochemical oxidant formation potential' (POCP), 'ozone layer depletion potential' (ODP) and the indicator 'primary energy demand' (PE_total).

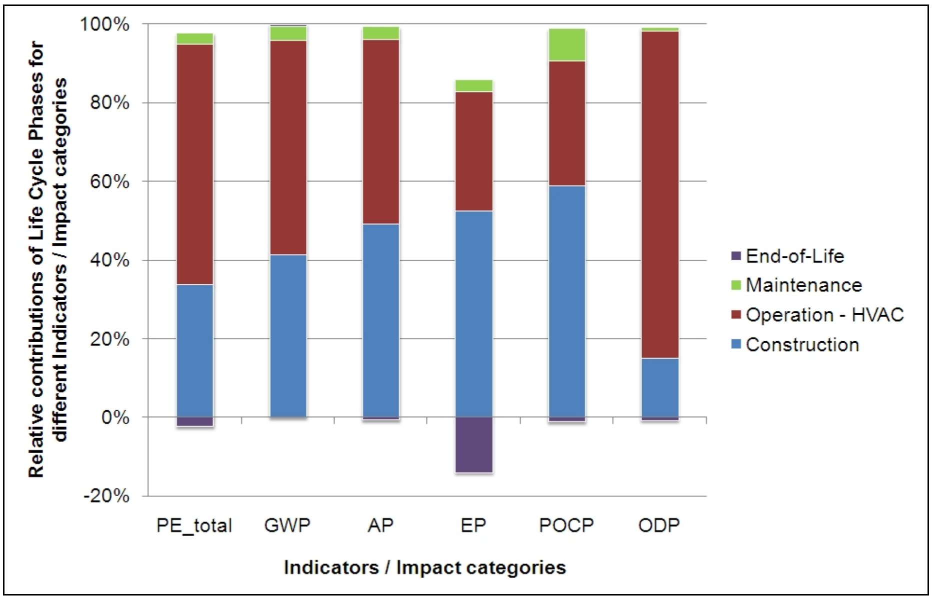

Fig. 2 Relative contributions (CML 2001) of the life cycle phases for different indicators/impact categories for the „Zentrum für Umweltbewußtes Bauen" in Kassel, Germany.

They are displayed in Fig. 2 by showing the relative contributions of all building life cycle phases into the different impact categories/indicators. In comparison, the operation phase has the highest impact on ‘primary energy demand’ and ‘global warming potential’ due to usage of electricity and fossil fuels in district heating.

4 Discussion and outlook

The building model presented, complies with the ISO 10040/14044 standards [2], [3] by giving defined system boundaries and fixing a functional unit. It is therefore applicable for conducting a comparative LCA study for different buildings by its ability of displaying several construction types, building materials and transport processes. Furthermore it simplifies the assessment process by offering a full parameterization and by representing the whole building life cycle.

Its structural layout practically proofed to be usable for supporting the LCA in the context of the German certificate for sustainable buildings. The building model design helps illustrating the results in the required format, e.g. the differentiation in building construction and technical appliances. Necessary steps or preconditions for taking advantage of such a model, is the appropriate preparation of input data for modeling (e.g. the structuring of construction materials and elements according to DIN 276 [6]). Its validity was further tested by the application for the “Zentrum für Umweltbewußtes Bauen” (ZUB) in Kassel, Germany.

Further features to be implemented in the model may be connecting processes (e.g. bolting of construction elements) or applied building site processes. If typical representative building materials may be included, the time need for modeling may be further reduced and the flexibility of the model for future application further increased.

References

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