WHAT IS GREEN? BENCHMARKING THE ENVIRONMENTAL PERFORMANCE OF SUSTAINABLE BUILDINGS

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Summary

In Germany, the ‘Certification for Sustainable Construction’ currently receives tremendous attention throughout the building industry and from the general public. Launched with the claim to demand for meeting performance indicator benchmarks, it uses Life Cycle Assessment (LCA, as defined in ISO 14040/14044) to quantify the environmental performance of a building’s life cycle.

Along with Life Cycle Costing, LCA is one of the two single most relevant assessment methods within the system, which currently has around 50 criteria in the version for new construction of office buildings. Due to its nature of being applicable to any product, process or service, LCA is standardized to allow for extensive adaptations to the scope of the assessment. The German Sustainable Building Council (DGNB) specified the application of LCA for the certification procedure in detail. This includes the life cycle stages and system boundaries to be considered, the environmental impact categories to be assessed (such as Global Warming Potential) or the background data to be utilized.

Moreover, LCA indicator benchmarks are set by the DGNB for buildings to be met over the entire life cycle. These benchmarks use a fixed value for the building’s constructional stages including building materials, maintenance and end-of-life, and a variable value for the energy demand, based on the German implementation of the Energy Performance of Buildings Directive (EPBD).

Keywords: German Sustainable Building Council, DGNB, Green Buildings, Life Cycle Assessment, LCA, Benchmark

1 The German Certification for Sustainable Construction

The quest for green buildings had slowly taken up speed in the last years and throughout the world. More and more national Green Building Councils appear on the stage and quite different approaches to green buildings are pursued. In Germany, the German Sustainable Building Council (“Deutsche Gesellschaft für Nachhaltiges Bauen”, DGNB) was founded in summer 2007 and by spring 2010, it lists more than 820 member organizations [1]. The DGNB has claimed for their German Certification for Sustainable Construction

(“Deutsches Gütesiegel Nachhaltiges Bauen”) to having built the “first system of the second generation” [2], asking for performance oriented indicators – in contrary to prescription based and measure oriented indicators – wherever possible and considering the entire life cycle of a building.

On the basis of a catalogue of approx. 50 criteria, an overall sustainability performance of the building is evaluated and a metal color (gold / silver / bronze), as well as a grade is awarded to the building. Each criterion reflects one aspect that is understood to be relevant to sustainability. One criterion thereby has one or several indicators, each quantitative or qualitative and defines the method for the assessment, resp. the calculation method for quantification and benchmarks.

Two prominent methods to perform a life cycle based quantitative assessment are Life Cycle Costing (LCC), accounting for economic aspects and Life Cycle Assessment (LCA) as defined in ISO 14040 [3] and 14044 [4], quantitatively investigating environmental impacts. Both of these methods, which are mandatory parts of a DGNB sustainability assessment, yield a share of 13,5 % (each) on the overall contribution to the sustainability performance of the building [5].

2 Life Cycle Assessment within the German Certification for Sustainable Construction

Life Cycle Assessment is a method to quantify environmental consequences of human activities in relation to the life cycle of a product, process or service. Hereby, the term ‘product’ has to be interpreted according to the needs of the individual situation. A product can be anything from e.g. a distinct quantity of one chemical or intermediate material to complex technical systems such as automobiles, aircrafts or buildings. The ISO standards that define LCA as a method thus have to provide a framework that allows any technical system to be assessed. The consequence of the definition of such a framework is that numerous detailed specifications have to be made in the course of conducting an LCA of a building.

Such detailed specifications include the definition of a functional unit, which reflects the function that the system provides (e.g. shelter and comfortable living in a building). These specifications also include definitions of the system boundaries and considered or omitted processes (e.g. inclusion of servicing of the building), but also environmental impact categories to be used and the data basis to be employed. Especially if statements on environmental impacts of a product are produced for direct comparisons, but also when it is likely that results will be compared, such specifications have a potentially high influence on the results. See e.g. [6] for further information on LCA.

The outcome of an LCA in general is a quantification of environmental impacts, e.g. using several environmental impact categories (‘midpoint indicators’). Five of such impact categories plus two energy demand indicators are considered within the DGNB system as individual criteria. These are Global Warming Potential (GWP_{100}), Ozone Layer Depletion Potential (ODP), Photochemical Ozone Creation Potential (POCP), Acidification Potential (AP), Eutrophication Potential (EP), Primary Energy (PE) Demand (non-renewable) and Primary Energy Demand (non-ren. + renewable) with the share of renewable energy (second indicator to PE non-ren. + ren.). The impact categories used are based on the CML 2001 characterization model [7].

For the purpose of being used within a certification scheme for sustainable buildings, the method of Life Cycle Assessment has to be brought to a distinct level. Here, the results have to be directly comparable. In addition, all possible choices that the LCA expert has to make in full LCA studies are specified within the application rules. Moreover, experts and practitioners without extensive LCA expertise both have to be able to perform the LCA as required.

If all variables and possible choices are set, results can be compared to each other. This comparability also allows for setting benchmarks for the buildings. Within the DGNB system, the buildings are awarded a number of evaluation credits by relating the LCA results to this benchmark. Below, the application rules (i.e. the necessary LCA specifications and definitions) and, based on that, the benchmarking within the DGNB system[1] is explained.

3 Application Rules for LCA within the DGNB System

The first prerequisite to conduct an LCA is the specification of the considered life cycle and of the processes to be included. For the building, the entire life cycle, consisting of four major elements has to be taken into account. These elements are the construction phase, necessary refurbishment during the reference service life of 50 years, the building's end-of-life and the building's operation during the use phase.

Within the construction phase, simplifying rules on which building components have to be considered are in place, reducing the building's structure to eight elements such as exterior walls, roof or foundation. Hereby it has to be noted that the building's technical equipment that has to be considered is limited to the heat generator itself, without any energy distribution or cooling devices.

The refurbishment of the building during its use of 50 years considers any necessary material exchange measures. For that purpose, default reference service life values for individual building elements are used to define an exchange frequency for each material used, where technical constraints (e.g. material A is glued to material B, hence, if material B needs to be replaced, material A needs to be replaced, as well) are taken into account.

The prediction of the necessary measures to be taken, and of possible improvements of the building's performance is difficult to make – if at all. To assure comparability of the different buildings, for the use phase scenario, no retrofit-measures that improve the building's e.g. energy efficiency are considered. Neither are maintenance measures such as cleaning or inspection considered.

The end-of-life is accounted for by means of a 'standardized' scenario. A number of different material groups are identified and each group has an individual end-of-life scenario. Examples of such scenarios are incineration with recovery of thermal and electric energy for plastics, wood and other materials that have a calorific value or recycling of stones and bricks to yield recycled aggregates (etc.).

The combination of these three life cycle phases yield the results for the "construction". The operation of the building uses the results of the "Energieausweis", i.e.

[1] The DGNB originally released a set of criteria for the certification of new constructions of office / administrative buildings. Subsequently, catalogues of sustainability criteria are tested and released for other building categories, such as retail buildings, manufacturing plants and others. Within this article, all specifications refer to the version "NBV09" [5], i.e. for the new construction of office and administrative buildings in the release of 2009.

the calculation results from the German implementation of the European Energy Performance of Buildings Directive (EPBD) [8]. Here, final energy values for heat and electric energy are calculated for the building and of a reference building. The energy demand values are multiplied with the LCA datasets of the energy used to assess the environmental impacts of the operation phase. The environmental impacts of the building's life cycle are then normalized to one year and one m² net floor area ("Nettogrundfläche" NGF_a = share of the net floor area that has wall on all sides, as opposed to terraces, etc.)

4 Benchmarking of the Environmental Performance

The LCA benchmarks for buildings within the DGNB system are set on the level of the entire life cycle of the building. I.e. one overall value has to be met by the building. This procedure (instead of e.g. setting separate benchmarks for the construction of the building and it's operation) leave the greatest possible flexibility to the planner about how to meet the set requirements. Both, a highly energy efficient building (i.e. small energy demand for operation) that yields more environmental impacts in the construction of the building and a less efficient building with less impacts from the construction are possible to meet the requirements.

The benchmarks are compiled from two elements. The first element is a fixed value that refers to the construction of the building. It is derived from a German national research project [9] that evaluated a number of "typical" buildings in order to derive benchmarks on the basis of mean values and an understanding of the relation between a building and its environmental impacts. For this element of the benchmark, values are given in the characteristics documents of each criterion, e.g. 9,4 kg CO_2-Eq./m^2_{NGFa}*a for GWP. The second element is a variable part that is derived from the "Energieausweis". In accordance with the EPBD, each building has a benchmark set for primary energy demand. For the purpose of LCA-benchmarking, the corresponding final energy demand is multiplied with conversion factors (separately for electric and thermal energy) for each indicator. Therefore, the energy demand is separated into electric energy and thermal energy. These factors are also given in the characteristics documents, e.g. for GWP: power demand to be multiplied with 0,71 kg CO_2-Eq./kWh and thermal energy demand to be multiplied with 0,31 kg CO_2-Eq./kWh. These factors stem from the national building products database and reflect the electric energy grid mix, resp. heat generation with a mix of 50 % oil and 50 % natural gas.

The resulting benchmark (called "reference value" = "Referenzwert") for the building's life cycle represents 5 valuation credits out of a range of 1 credit (minimum) to 10 credits (maximum). The reference value is then multiplied with specific factors to yield the benchmarks for 1 credit and for 10 credits. These specific factors are defined individually to reflect the idea of relation between "state of the art", "still acceptable" and "best practice".

5 Conclusions

While the absolute values of benchmarks can be discussed extensively, the framework in which a benchmark is defined is the really crucial element of benchmarking. Within the DGNB system, such a framework with detailed specifications and characteristics for conducting a building LCA has been established. On this basis, benchmarks with two elements (construction and operation) have been derived and can be used to define the life cycle based environmental performance of buildings. It is expected that with more buildings that are certified, an experience-based discussion on these benchmarks, both concerning the procedure and the actual values, will take place in the future.

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