DGNB
Deutsche Gesellschaft für Nachhaltiges Bauen
German Sustainable Building Council

DGNB GUIDE APRIL 2018

Life Cycle Assessments - a guide on using the LCA

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Overview

» The present guidelines, which the DGNB has developed together with its members, convey a basic understanding of the great benefits that is offered by the **use of life cycle assessments in the planning process**.

» The **potential of life cycle assessments** to reduce environmental impacts in the construction industry is emphasised **with reference to the individual work phases**.

» Example possibilities for **visualising life cycle assessment results** are shown with the aid of a toolbox.

CONTENTS

What can we achieve through life cycle assessments?

The DGNB has made it its primary goal to plan, operate and use the built environment of the present day for the benefit of all, and in such a way that the generations that follow us can fully utilise their own potential and not be constrained in their opportunities by the decisions that we make today. This goal is inevitably linked to planning districts, buildings and interior spaces in a way that is logically oriented to their entire life cycle, reducing both the consumption of finite resources and environmentally critical air, water and soil pollution to a minimum across all phases of a building's life.

The appropriate tool for this purpose is the method of life cycle assessment (LCA).

Aim of these guidelines

1. **To encourage designers and building contractors to employ life cycle assessments as a planning and optimisation tool for environmentally oriented buildings**
2. **To provide arguments as to why it is worth employing life cycle assessments in the early stages of building planning**
3. **To provide examples of how to successfully communicate the results of life cycle assessments**

These guidelines aim to promote the increased use of life cycle assessments in the planning process, by demonstrating the relevance and potential of this tool. Designers and building contractors are additionally provided with arguments for employing these methods as an optimisation tool as early as possible in the planning and implementation process, and the sustainability effects that can be achieved as a result of this are emphasised. Furthermore, the reader is presented with examples of how the results of life cycle assessments are communicated and can serve as supporting arguments for making more environmentally sensible decisions in the course of the planning process.

LCA Life Cycle Assessment (see page four)

> In a market with a multitude of "green" products and solutions – how should I make substantiated decisions for truly environmentally friendly construction?

Who are these guidelines aimed at?

BUILDING CONTRACTORS

The complexity of the methodology and the presentation of LCA results frequently presents an obstacle to its use in the early planning phases. As a result of this, the life cycle assessment is in many cases only carried out at the end of a construction project as part of the requirements for building certification, meaning that valuable potential for optimisation is left unexploited.

These guidelines aim to clarify the relevance of LCA methodology as a basis for decision-making for building contractors and convey an understanding of LCAs with the aid of visualisation examples.

DESIGNERS AND AUDITORS

Through the continued use of life cycle assessments in the planning process, designers are provided with a tool for the substantiated evaluation of alternative solutions even in the early stages of planning, which takes into account all long-term environmental impacts that are linked to these.

The valuable knowledge concerning early optimisation potential allows designers to retain the ability to make arguments and decisions as part of the planning process.
The understanding of the factors which influence the results of life cycle assessments is frequently lacking at present.
The suggestions contained in these guidelines for visualising LCA results should help designers to reduce the complexity of the methodology to the core messages, thus providing the building clients with an essential basis for decision-making.

BENEFITS OF LIFE CYCLE ASSESSMENTS

The method of life cycle assessment is one of the most effective ways to find out the impact on the environment resulting from construction methods, energy concepts, components, and products – essentially, all aspects of planning that take place in the construction of a new building, a renovation or a modernisation project.

The two substantial advantages of a life cycle assessment are:

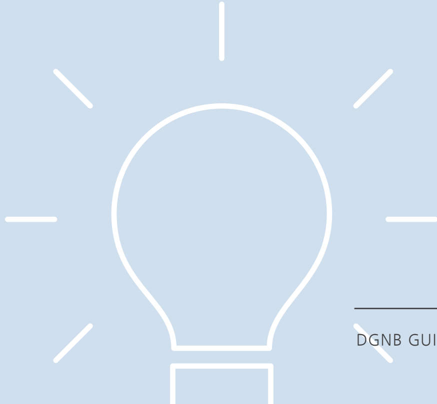
1. It helps those in charge of a project to make better informed decisions in the planning and implementation process.
2. It stimulates innovation by highlighting opportunities to create products and buildings with higher environmental quality and better efficiency.

Life cycle assessments help building contractors:

Good LCA results can be employed in communication with their clients and official bodies as well as for the purposes of sustainability certification, and can be put forward as a argument when seeking approval for grants.

Life cycle assessments help architects and specialist designers:

The knowledge of the environmental impacts that have resulted from the manufacturing of components, the environmental impacts that result from ongoing operation and the environmental impacts and potential that can result from possible recycling at the end of the useful life facilitates the planning of buildings that are more environmentally friendly.



Life cycle assessments as a means of classification

Looking at the bigger picture from a life cycle perspective

Against a background of a rapid rise in environmental pollution, the focus in the construction industry of today concerning the planning, design and implementation of buildings no longer has to exclusively relate to aesthetic, technical and economic aspects. In order to ensure the environmental sustainability of our buildings, additional aspects have to be taken into consideration – such as energy consumption, pollution of air, water and soil, waste production and the conservation of raw materials. In order to be able to make reliable statements in this regard and optimise buildings accordingly, it is critical that the entire life cycle of a building and the materials used in its construction are analysed and that the results of this are incorporated into the planning process.

Extraction and processing of raw materials, use and maintenance as well as recycling or disposal have to be taken into account accordingly. The result of these considerations is an integrated assessment that analyses all the materials required for the creation, operation, maintenance and removal of a building, from "cradle to grave" – i.e. over its entire life cycle. This method is known as life cycle assessment (LCA). Life cycle assessments can be compiled for a product, a service, a building or any other contained system and consequently quantified via meaningful and communicable environmental indicators.

Establishing standardised and comparable environmental information

The EN ISO 14040 and EN ISO 14044 standards constitute the normative basis of such analyses. Fundamental definitions of terms and approaches to life cycle assessment are defined in these standards. The EN 15978 (relating to buildings) and EN 15804 (relating to construction products and services) standards, which have been available since 2012, are of relevance to the construction sector. The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU) has produced a database for construction products and services that is free to access (www.ökobaudat.de). Manufacturers are increasingly providing product-specific LCA data in the form of independently verified Type III environmental product declarations (EPDs). In Germany, these are most frequently awarded by the Institut für Bauen und Umwelt e.V. (IBU).

Life cycle assessments exclusively constitute a neutral method of calculation (and consequently optimisation) concerning the life cycle of a building with regard to its environmental impacts, along with that of the construction products that are used. These environmental impacts are determined via a bill of quantities – i.e. the construction products with the largest proportions of mass tend to have the greatest influence on the result. This means that it is important to determine the quantities over the anticipated period of use. Components that are replaced multiple times are therefore included in the results the respective number of times. As one of the first organisations in the world to do so, the DGNB defined detailed guidelines for determining the life cycle assessment of buildings in 2008 and provided benchmarks in their certification system for this purpose.

WHAT IS A LIFE CYCLE ASSESSMENT?

- The term "life cycle assessment" can be used to summarise the following: All resources consumed for and emissions that result from a product, a service, a building or any other contained system from "cradle to grave", i.e. for the entire life cycle or parts of this, which are expressed in the form of meaningful environmental indicators.
- The "cradle to grave" approach usually encompasses every relevant element of the value chain – from the raw material extraction and every step involved in production and transportation, through to the period of use, and ultimately concluding with recycling or final disposal. It allows us to look at our human activities beyond traditional boundaries in a scientifically substantiated manner, taking the ecological perspective into consideration.
- With the aid of life cycle assessments, ecologically optimised and meaningful environmental communication can take place.

EPD Environmental Product Declaration

Environmental topics in life cycle assessments

A wide variety of environmental and health-related topics can be evaluated by LCA in the form of LCA indicators. The DGNB monitors scientific developments and currently recommends the use of seven indicators. The chosen indicators address relevant environmental topics such as climate change, summer smog, nutrient pollution, forest dieback and the consumption of fossil and renewable fuels. Health considerations such as toxicity of pollutants are currently not addressed by the recommended indicators.

This means that life cycle assessments are therefore not suitable, as per the DGNB and EN 15978, for making statements with regard to the constituent parts or absence of pollutants in the construction materials that are used. For this purpose, there are a number of certifications relating to construction products such as the Blue Angel (Blauer Engel), natureplus or the Cradle-to-Cradle certificate. These certifications aim to give a reliable indication with regard to the absence of pollutants in construction products, in order to allow designers and contracting companies to select products that are unobjectionable. These certifications also partially integrate topics relating to the socially responsible extraction of materials ("responsible sourcing") or other aspects of the manufacturing process. Indeed, the Cradle-to-Cradle approach aims to optimise products to the extent that they can be used almost infinitely in the form of different products or applications, or instead generate waste materials that are purely biodegradable and consequently take the form of "nutrients". The use of such optimised (and if applicable, certified) products will lead to accordingly improved results as part of life cycle assessments. The interaction of different construction products in their application scenario can be determined exclusively at the building level through the neutral and performance-oriented approach of the life cycle assessment.

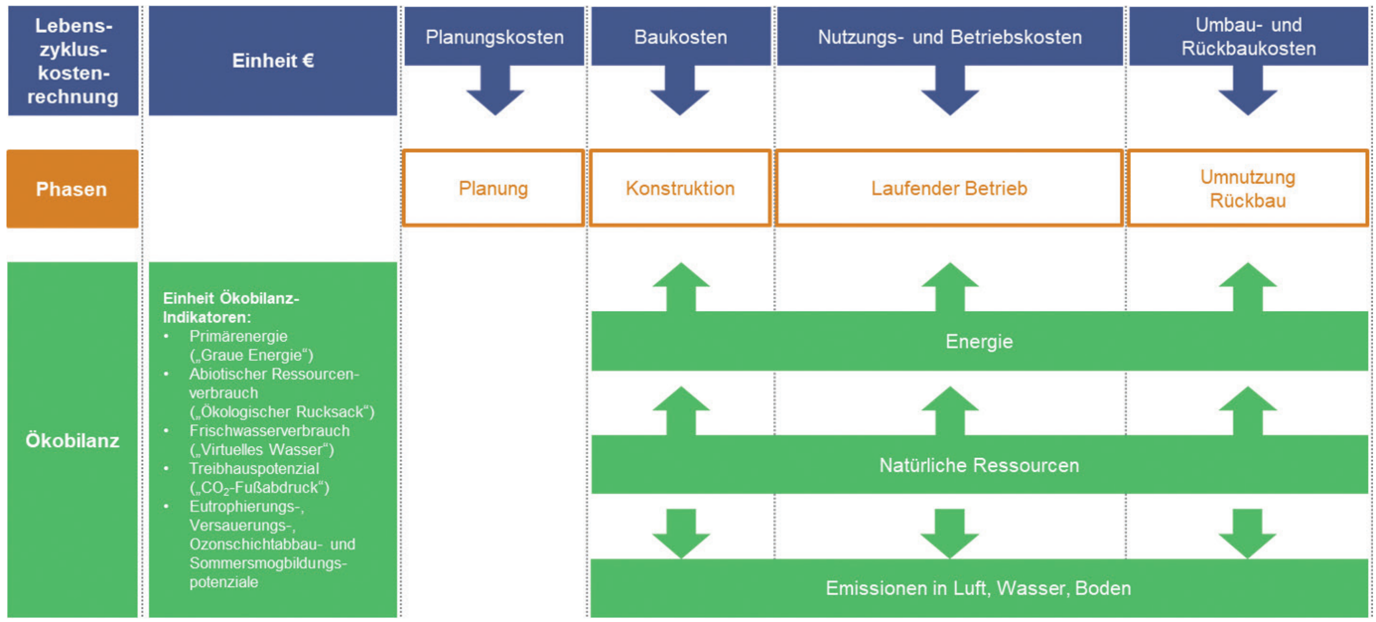


Fig. 1 – How the life cycle assessment works
Source: DGNB (own diagram)

Potential of life cycle assessments to reduce environmental impacts in the construction industry

These guidelines aim to demonstrate how the life cycle assessment can be integrated into early planning phases, as well as the potential that lies in the different phases for optimising planning decisions and consequently reducing environmental impacts.

The comparison of options with the aid of life cycle assessments in early planning phases can represent a significant basis for decision-making for central components (at the building/construction level) and materials (at the material/product level) and decisively influence the long-term environmental impacts that originate from the building.

The life cycle assessment consequently offers considerable potential for optimisation over the course of the planning and implementation process.

Since a conventionally applied life cycle assessment is often carried out exclusively for the purpose of certification, and consequently only towards the end of a construction project (see Fig. 2), this potential is generally not utilised or only partly utilised at present. The reason for this frequently comes down to the time-consuming process of data collection or the lack of suitable average values for the different planning phases.

In Fig. 3, by contrast, a repeated application of the life cycle assessment is depicted in the different planning phases, consequently showing how it can be used as a planning and optimisation tool. In this case, the LCA results from different construction options in the planning process can be compared with one another and factored into central planning decisions.

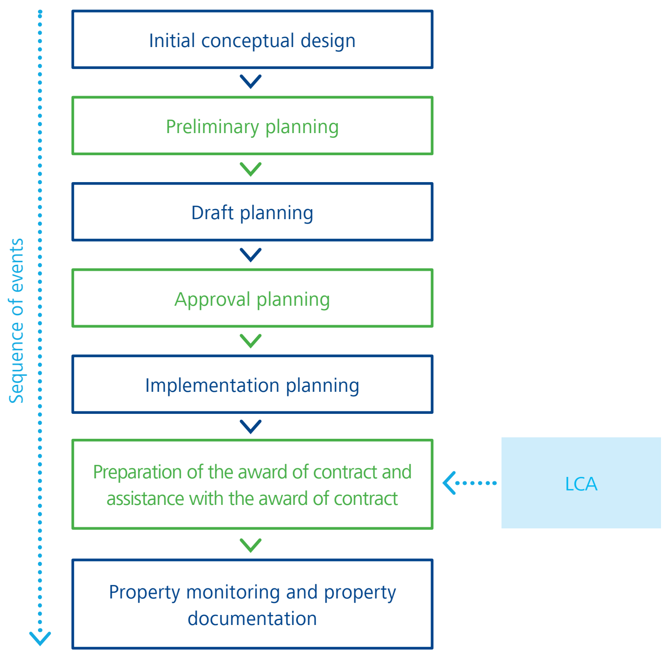


Fig. 2 – Conventional application: Single implementation of the life cycle assessment at the end of the construction process as a prerequisite for certification.
Source: Fraunhofer Institute for Building Physics (IBP)

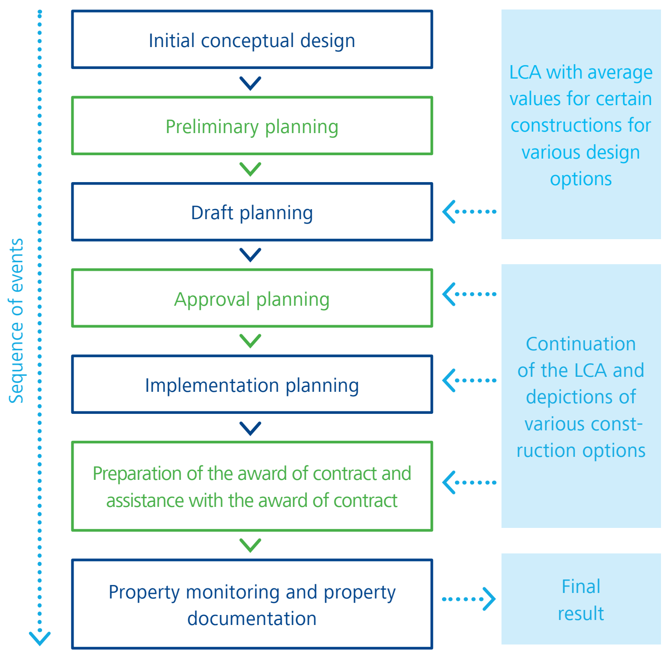


Fig. 3 – Optimised application: Repeated implementation of the life cycle assessment at various points throughout the planning process.
Source: Fraunhofer Institute for Building Physics (IBP)

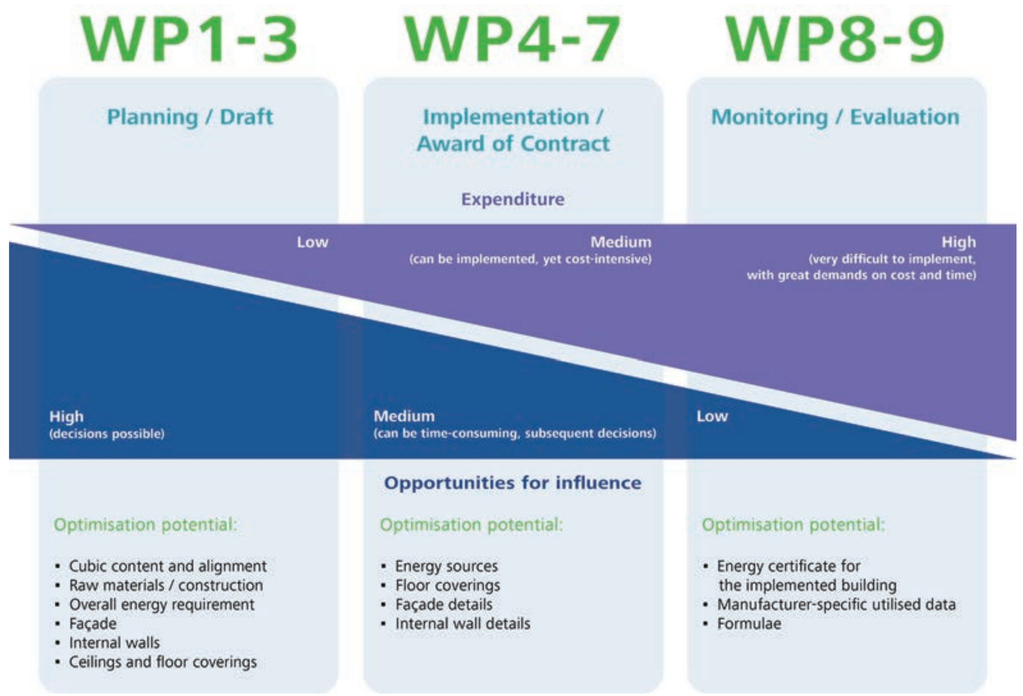


Fig. 4 – Optimisation potential, opportunities for influence and expenditure incurred by changes in the planning and manufacturing process (WP=Leistungsphasen according to HOAI)
Source: DGNB (own diagram)

Exploiting potential

Particularly in the early planning phases, in which changes can be implemented and fundamental decisions made at little extra cost, the life cycle assessment can deliver great additional value as a supporting factor in decision-making. It is therefore recommended to carry out the life cycle assessment alongside the construction project – from the early planning phases, through to the tendering process and possible green procurement processes, and concluding with the completed building itself.

The key components that are particularly crucial for the construction of better buildings should be thoroughly considered at the beginning. Over the course of the planning and optimisation process, an increasing level of detail should be taken into account, from the building/construction level to the material/product level.

In this regard, it is not just the manufacturing process and the disposal costs and risks ("end of life") that should be the focus of the assessment, but also the period of usage and maintenance – particularly with regard to optimising the energy requirements and the energy sources for electricity, heating and cooling.

Initially, it should be checked whether the new construction of a building can be substituted by a renovation if appropriate, thus avoiding an additional deployment of resources (Work Phase 0 – assessment of needs).

If a new construction is implemented, work phases 1 to 3 offer the greatest potential in the planning process for the implementation of changes and optimisation decisions in accordance with the HOAI (German fee structure for architects and engineers). When these occur at an early stage of the process, they are also connected with significantly lower costs and reduced time expenditure (see Fig. 4).

The optimisation potential of the early WP is consequently listed below.

HOAI Honorarordnung für Architekten und Ingenieure (German fee structure for architects and engineers)

Potential of life cycle assessments in the early work phases (WP1–3)

WP1 INITIAL CONCEPTUAL DESIGN

- Possible advantage:
  Here, the life cycle assessment serves as a declaration of intent.

- It is used for the purposes of defining aims and processes:
  For a life cycle assessment that accompanies the project, it should be considered and determined how the people involved in the planning and construction process (e.g. structural engineers, architects, facility managers, etc.) influence the results of the life cycle assessment in their own separate ways, as well as who requires information from whom for calculating the life cycle assessment and at what point in the process (data transfer).

- Status quo:
  There is often no adequate basis in place for a substantiated life cycle assessment calculation at this stage.

WP2 PRELIMINARY PLANNING

- Possible advantage:
  A life cycle assessment in this work phase offers the greatest potential for influencing the raw materials and the construction of the façade.

- Use at the building/construction level:
  Comparing options in terms of different construction methods offers a significant advantage with regard to the improvement of buildings.
  The benchmarks for the life cycle consist of a fixed percentage for the construction and a dynamic percentage for the use. Due to efficiency measures with regard to the use of buildings that have already been implemented and those that are anticipated in future, e.g. through constant intensification of EnEV regulations, the relevance of the environmental impacts caused by construction will continue to increase (see Fig. 5).

  Numerous material decisions are already determined by the chosen method of construction. In connection with this, the use of certain construction products and connection materials is also predetermined in part.

EnEV Energieeinsparverordnung (German Energy Saving Ordinance)

Fig. 5 – Increasing relevance of the construction proportion in comparison with the usage proportion.
Source: DGNB (own diagram)

As early as this point in time, a good separability of construction and materials at the end of life should be taken into consideration to ensure a higher quality and better degree of recyclability.

- Status quo:
  The life cycle assessment calculation occurs only rarely in this work phase at present. However, a means of support is frequently required at this early point in time: Comparisons of raw materials and components that take into account the interaction with the German Energy Saving Ordinance (EnEV) can provide important insights here.

WP3 DRAFT PLANNING

- Possible advantage:
  A life cycle assessment in this work phase offers the greatest potential for influencing the individual components. Use at the material/product level:
  Through a comparison of options in terms of materials or components that have a great influence on the complete building, it should always be checked for each individual project whether the choice of materials will also result in direct or indirect negative or positive implications for the use phase, for example with regard to heat storage capacity, cooling requirements, sound insulation, humidity, etc.

  This means avoiding the following: Although environmental impacts caused in the manufacturing phase can be minimised, the environmental impacts incurred in the use phase will however be significantly increased and the assessment of the entire life cycle will be worse as a result.

  - Principal strategies for reducing the environmental impacts at the material level include reducing the overall quantity of material used, replacing non-renewable raw materials with renewable raw materials where it makes sense to do so and replacing non-recyclable materials with recyclable ones. Blanket recommendations that apply to every project regarding the use or avoidance of certain materials from a life cycle assessment perspective cannot be made, however.

  - It is worth considering the possibility of linking to the EnEV assessment (calculation as per DIN (V) 18599) and expanding this to include the life cycle assessment

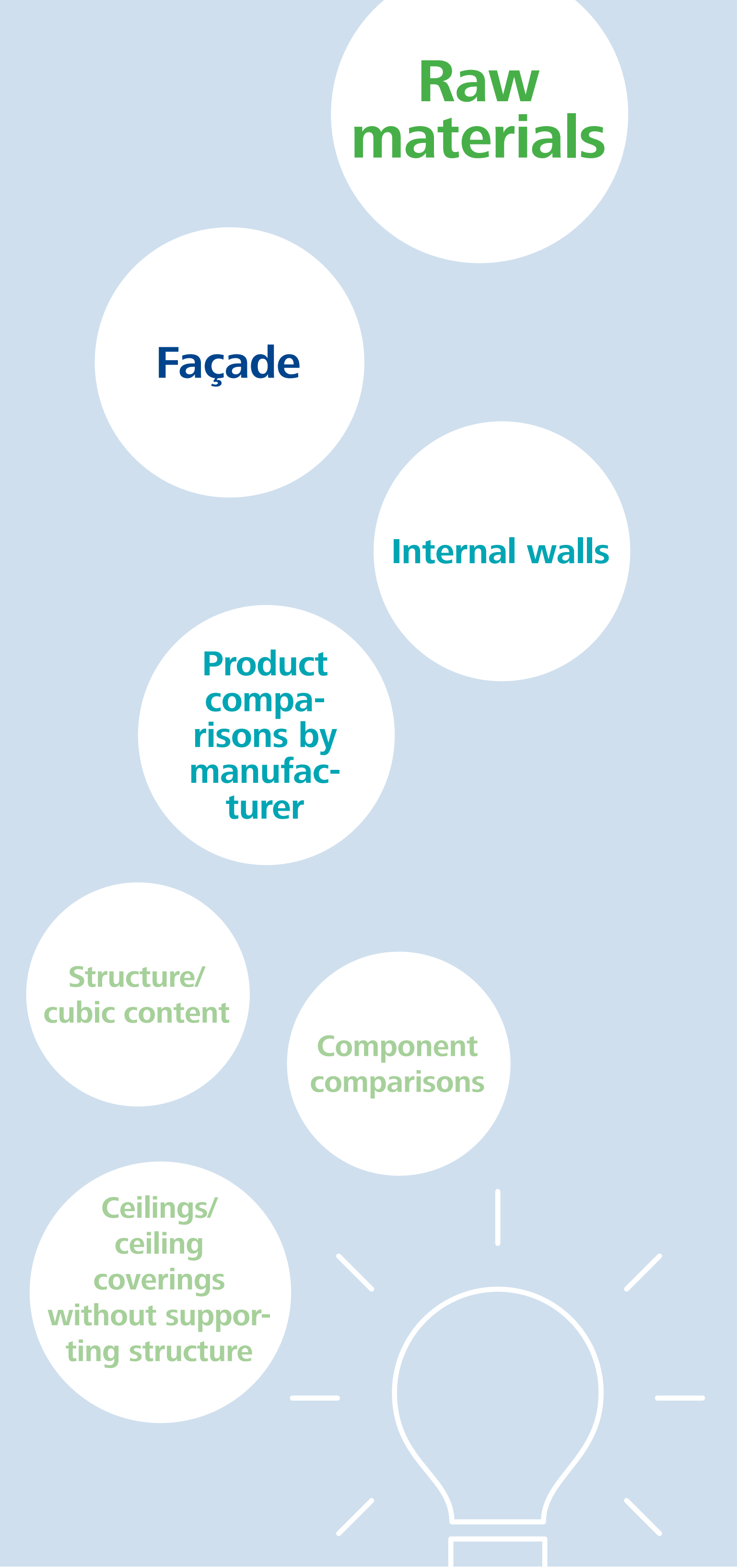
  - Extending the lifespan of materials does not necessarily result in a positive impact on the life cycle assessment. Instead, this should be tailored to the planned useful life of the building and potential structural changes.

  - For materials that have a low impact on the LCA result of the complete building, other ways to reduce negative environmental impacts should be found. In this way, for example, the motivation of construction product manufacturers to continually improve their own products could lead to the increased implementation of product life cycle assessments, thereby providing assistance in selecting the most reasonable materials for the project.

- Status quo:
  The fact that available LCA data and tools for the simple calculation of a life cycle assessment (see next page) are used very little at present is preventing the repeated application of LCA methodology in this work phase, which could offer key foundations for decision-making when evaluating different options. The inclusion of the calculations for these options and the decisions connected with them represents a significant advantage for a real reduction in the negative ecological impact of the building throughout its entire life cycle.

A great advantage for the improvement of buildings lies in the early work phases
Through the choice of construction method, many environmentally relevant subsequent decisions, for example concerning the use of material, are already taken care of in the early work phases.

KEY COMPONENTS OF BETTER BUILDINGS – THE POTENTIAL OF LIFE CYCLE ASSESSMENTS ACCORDING TO PLANNING TASKS



How do I find out the life cycle assessment of my building?

1. Identify all masses of the components used or planned for use in the building (in the case of renovations, only the components used in the renovation project are required).
2. Allocate typical replacement cycles for the components used or planned for use in the building from reference lists.
3. List energy consumption and energy sources for the (planned) ongoing operation using the energy certificate or calculations of energy requirements.
4. Combine the masses and energy flows with LCA data from the ÖKOBAUDAT database or EPDs.
5. Generate totals for all selected LCA indicators.
6. Prepare and evaluate the results of the calculations for target groups.

How do I find out if the life cycle assessment of my building is good?

1. Use the DGNB benchmarks for the building design that correspond to the type of building under examination.
2. Combine the energy requirements of the respective reference building taken from the energy certificate with DGNB emissions factors and DGNB resource factors.
3. Generate totals for construction and operation and compare these results with the LCA results for the actual building.

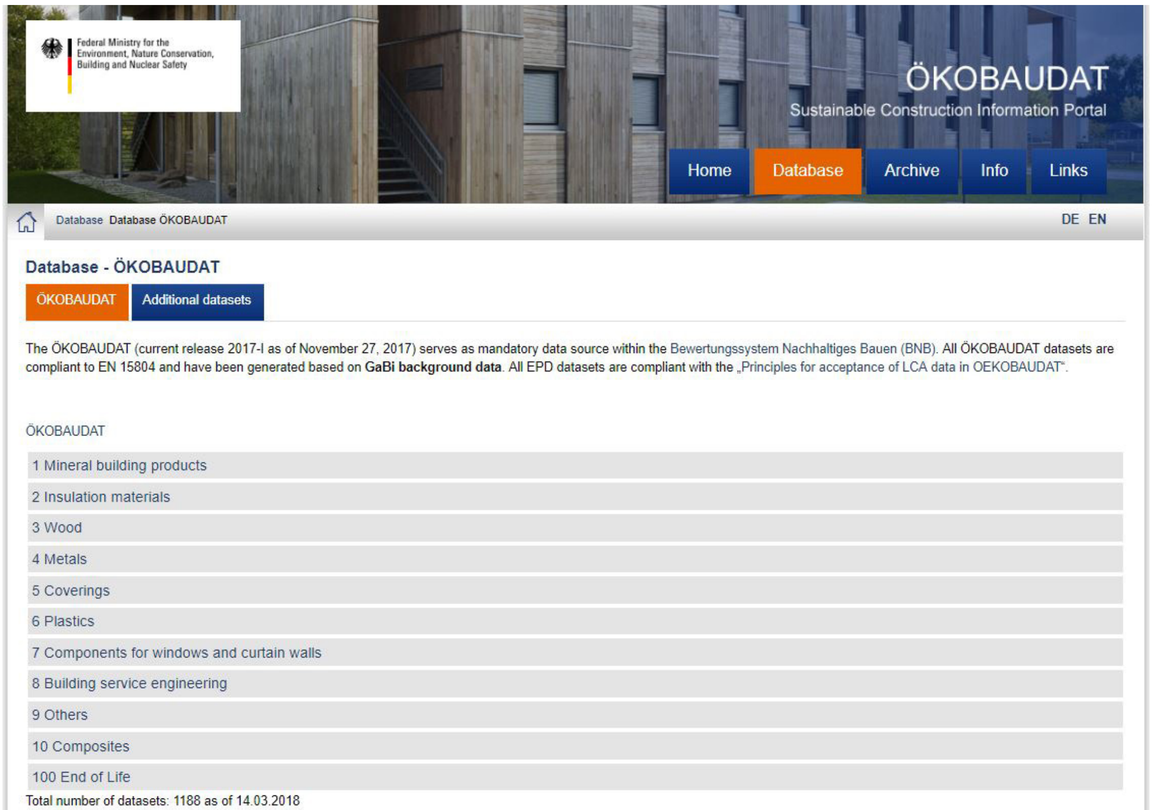


Fig. 6 – The ÖKOBAUDAT database with life cycle assessment data for the construction sector
Source: http://oekobaudat.de/datenbank/browser-oekobaudat.html [dated 29th January 2018]

Tools and data for calculating life cycle assessments

The publication of the first database for life cycle assessments of typical construction products in 2008 has meant that a good, comprehensive basis has been available free of charge since then to interested designers for the purposes of calculating life cycle assessments of whole buildings or optimising the life cycle assessment of components. This database contains (as at 2018) almost 1200 data sets that have been calculated and documented in accordance with the regulations of DIN EN 15804. As well as the ÖKOBAUDAT database, which contains many typical data sets that are not specific to individual manufacturers, a multitude of additional data from companies and associations can be found on the online platform of the IBU (www.epd-online.com). The IBU is an initiative by manufacturers of construction products and components who are committed to the guiding principle of sustainability in the construction industry, and provides ecolabel Type III environmental product declarations in accordance with ISO and CEN standardisation in its capacity as an association of manufacturers. This verified information offers a very good basis for determining the life cycle assessments of buildings.

At present, however, there are only a few practicable tools that enable a simple and quick calculation of life cycle assessments in accordance with the available level of information in the individual work phases. Designers should be given the opportunity to carry out a quick calculation and preliminary assessment of the results depending on the relevant planning stage, without incurring additional expenditure through the use of complex tools. For example, this can relate to the input of surface areas or the selection of standard components. Using tools, it should be possible to create a clear and transparent representation of the results, with which designers can contrast the specific features and advantages of the individual options for the client. The development of such independent tools that offer great benefit in conjunction with reduced expenditure is pivotal for integrating the life cycle assessment as a fixed component in the planning and optimisation process, and consequently effectively increasing the influence of life cycle assessments on decisions relating to construction and materials.

Due to the lack of available manufacturer-specific data sets, generic data sets are generally relied upon at present for compiling life cycle assessments. New, innovative solutions in the project often cannot be modelled via existing data sets or EPDs and are therefore not accordingly taken into account in the life cycle assessment.

THE LIFE CYCLE ASSESSMENT IN THE DGNB SYSTEM – CRITERION ENV1.1 "BUILDING LIFE CYCLE ASSESSMENT"

Indicators for evaluation:

1. Life cycle assessments in planning
2. Life cycle assessment optimisation
3. Life cycle assessment comparative analysis
4. Agenda 2030 bonus – climate protection goals
5. Circular economy
6. Halogenated hydrocarbons in refrigerants

DATA FOR CALCULATING LIFE CYCLE ASSESSMENTS

- ÖKOBAUDAT: DIN EN 15804-compliant database from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (www.ökobaudat.de)
- EPD online tool from the Institut Bauen und Umwelt e.V. (IBU): Verified environmental product declarations (EPDs)
  - EPD-Online Tool: EPDs in PDF-Format (www.epd-online.com)
  - Digital EPD datasets in XML-Format (www.ibu-epd.com/ibu-data-start)
- ECO platform: European initiative from EPD programme operators (www.eco-platform.org)

TOOLS FOR CALCULATING LIFE CYCLE ASSESSMENTS:

- CAALA: Software for integrated energy optimisation and life cycle analysis (www.caala.de)
- eLCA: Online LCA tool from the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) (www.bauteileditor.de)
- LEGEP construction software: Software for the integrated planning of sustainable buildings (www.legep.de)
- oekobilanz-bau.de (www.tool.oekobilanz-bau.de)
- SBS online tool: (www.sbs-onlinetool.com)

Communication and visualisation of LCA results

In order to achieve increased use of the life cycle assessment as a planning and optimisation tool, it is crucial that the LCA results are not passed on to the building contractor in their full complexity, but are instead reduced to the aspects that are relevant for understanding the central message.

For ease of comprehension, it is important to dedicate time to how the results will be communicated and presented. In contrast to direct monetary assets such as the life cycle costs, the benefit of a good life cycle assessment of a building lies primarily in the interests of society. Frequently, this involves a troublesome effort to convince the building contractors that investment, time and ideas are important and necessary in order to decide on solutions that are ecologically better. Practical experience shows that an easily understandable translation of the seemingly complex figures that also appeals to emotion can have an impact on the decision-making process.

The following figure offers pragmatic and functional solutions to the typical challenges encountered in communicating life cycle assessment results.

CURRENT OBSTACLES		POSSIBLE SOLUTIONS
Misleading use of the **positively connoted term "potential"** (e.g. global warming potential)	>	**Visualisation:** Converting the environmental impacts into universally recognisable variables that convey the negative impact Number of trees for CO_2 balance, kilometres travelled by car, number of oil barrels
Large amount of information and communication that is frequently **very scientific in nature** when presenting all calculated environmental impacts	>	**Focus:** Concentrating on topics that are already supported by a high level of awareness CO_2, embodied energy/primary energy, proportion of renewable energies
No adjustments made for **different target groups**	>	**Level of detail:** Only presenting the percentage deviation from the average/benchmark figure for lesser known environmental impacts (ancillary indicators) Target group-oriented preparation: Presenting or contrasting individual elements of the life cycle/process chain (e.g. manufacturing vs. ongoing operation)
Classifying the **abstract results of the equivalents** can be difficult for the reader, since no reference values are known **Urgency** of the individual environmental impacts is not immediately apparent from the results	>	**Inevitability and relevance:** Using benchmarks such as those of the DGNB for assessing the environmental impacts and possible improvements and grading these according to the weighting of the DGNB Presenting the results as an "Emissions budget" per person, grading according to the weighting of the DGNB indicators

Communication of life cycle assessments – parameter formation

Depending on the progress of the project, different perspectives can be chosen in order to communicate different options to the building contractor – for example, by comparing a reference variant with corresponding alternatives. In doing so, it is always helpful to point out a monetary connection to the building contractors and to carry out and communicate the life cycle cost calculation in parallel with the life cycle assessment.

Two possible perspectives for use in communication are listed below:

CHRONOLOGICAL PERSPECTIVE

- Question:
  "When does the investment relating to CO_2 become worthwhile?"
- Possible portrayal in communication:
  Via ROIs in terms of energy or CO_2-related amortisation periods
- Calculate and present options with energy price increases/ CO_2 levy
- Present emissions/energy requirements on a timeline

CO_2 / COST-SAVING PERSPECTIVE

- Question:
  "Which option is worthwhile?"
- Application:
  Can be applied in the work phase in which there is adequate information available (masses and costs) for comparison of options.
- Possible portrayal in communication:
  Via "eco-efficiency" parameters that result from the saved CO_2 emissions per EUR spent.
- Scale:
  a) In relation to other options
  b) In relation to external sources

Concrete recommendations for presenting LCA results

The life cycle assessment of a building encompasses the entire production chain, the "history" of the materials used and the ongoing consumption of resources, as well as emissions resulting from this consumption. Differentiating between these two key elements of "construction" and "operation" is very important for most projects and discussion partners. Since the benchmarks of both elements also differ in the evaluation according to the DGNB (construction is fixed and operation is variable – depending on the reference value of the energy certificate), it is useful to explain this to the recipient/client.

Even if the calculation of all seven indicators in the context of the life cycle assessment takes place at the same level of detail, it is recommended to differentiate between leading and ancillary indicators in communication (see next page). Leading indicators are more highly weighted in comparison to ancillary indicators.

The weighting of the indicators of the 2018 version make provisions for the following weighting keys:

INDICATOR	GWP	PE^{nr}	POCP	AP	EP	PE^{tot}	PE^{re}/ PE^{tot}
WEIGHTING	40%	15%	10%	10%	10%	10%	5%

ROI Return on Investment
GWP Global Warming Potential
PE^{nr} Primary energy, non-renewable
POCP Photochemical Ozone Creation Potential
AP Acidification Potential
EP Eutrophication Potential
PE^{tot} Primary energy, total
PE^{re} Primary energy, renewable

LEADING INDICATORS

- Detailed representation of the results with absolute values, if necessary supplemented by graphic representation for classification of the results (absolute values for construction and operation):
  - GWP [kg CO_2e]
  - Embodied energy/primary energy [kWh or MJ]:
    Graphic representation and explanation:
    - Total primary energy PE^{tot}:
      Total of non-renewable and renewable energy flows throughout the entire production chain
    - Primary energy requirement PE^{nr}:
      Total of fossil and nuclear energy flows "from borehole to building"
    - Renewable primary energy requirement PE^{re}:
      Total of wind, solar, hydropower and biomass energy
  - Proportion of renewable energy [%]

ANCILLARY INDICATORS

- Representation of the percentage deviation from the current value to the set reference value (e.g. via a traffic light function or in words: "Fulfilled" or "not fulfilled")
  - POCP [kg C_2H_4e]
  - AP [kg SO_2e]
  - EP [kg PO_4^{3-}e]

KPI Key Performance Indicators, see DGNB version 2018

VISUALISATION TOOLBOX

This toolbox presents a collection of suggestions for presenting life cycle assessment results. The example presentation methods mentioned in the guidelines are denoted by this symbol and expanded upon here.

Potential options for presenting the results

- ☐ Recognised variables: Planted trees, kilometres driven (for GWP indicator), test tubes of sulphuric acid (AP), oil barrels (PE^{nr}), number of wind turbines (PE^{re})
- ☐ Recognised topics: CO_2, embodied energy, proportion of renewable energies;
- ☐ Target group-oriented preparation
- ☐ Proportion of "emissions budget" per person
- ☐ Graphic representation: Defining the scope of assessment, using symbols (speedometer, horizontal bar, ring diagram)
- ☐ Use of monetary comparative figures

Further suggestions for visualisation

- ☐ Clear colour scheme
- ☐ Clear language
- ☐ Visualisation of the tables from the DGNB certification for discussions with building contractors and the planning team (e.g. ring diagram/pie chart)
- ☐ Clarify scales (e.g. concerning the size of the symbols used, see page 6)
- ☐ Use of presentation formats from corporate communications of product manufacturers

Support through the DGNB system

- ☐ Presentation of the central key data and KPIs from the DGNB certification
- ☐ Emphasising the relevance of individual indicators with the aid of achievable DGNB evaluation points/weighting

Best practice examples of visualisation

A few examples for the visualisation of life cycle assessment results are shown below. These should help the reader to classify the results in their context and consequently be able to make a significant contribution towards ecologically reasonable decisions in the planning and construction process. The following examples explain the relevance of the use of life cycle assessments and consequently provide an argument in support of the use of this methodology in the planning process.

Fig. 7 – From the German Thermal Insulation Ordinance to the German Climate Protection Ordinance – CO_2 emissions in non-residential buildings (offices) balanced over 50 years of operation; Source: Drees & Sommer, Dr. Peter Mösle

A good transfer of complex figures into a graphic representation can be seen in the figure from Dr. Peter Mösle (Drees & Sommer) (Fig. 7). The demands for a reduction in energy requirements of buildings, which have been increasing over the years, are represented in this graphic through the size of the human figures equivalent to the typical CO_2 emissions. The change in the distribution of the CO_2 emissions with regard to heat and electricity is very clearly identified by means of colours inside the person. The fact that the rucksack representing the "embodied emissions", i.e. the CO_2 emissions involved in construction, does not get smaller over the timescale up to 2020 and consequently becomes a proportional "burden" for the person is a good way to communicate that these emissions must now be at the forefront of the designer's mind. The desire to make the rucksack smaller and consequently "bearable" again in future is made clear.

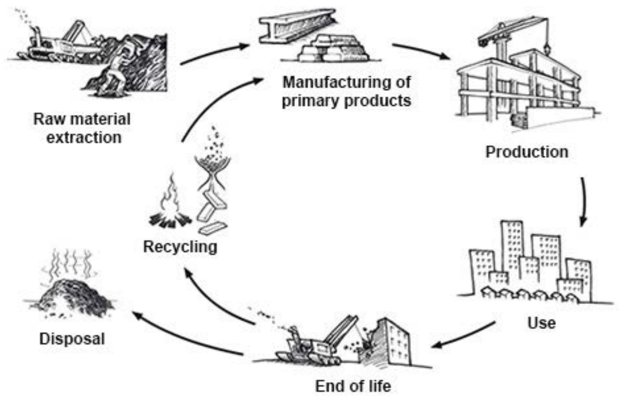


Fig. 8 – Representation of the life cycle as a process chain
Source: Fraunhofer Institute for Building Physics (IBP), Life Cycle Engineering department, Jan Paul Lindner

A graphical representation of the entire process chain – from the extraction of raw materials, through to production, use and dismantling, and concluding with potential recycling and disposal – helps to make the life cycle concept easier to understand. This representation should be prepared for the life cycle of buildings or construction products and use common terminology associated with these. This depiction from the Fraunhofer IBP (Fig. 8) is captivating and stands out through its sketch-like portrayal in comparison to conventional technical graphics. If the focus is on closing the loop, this graphic helps to highlight the potential of recycling.

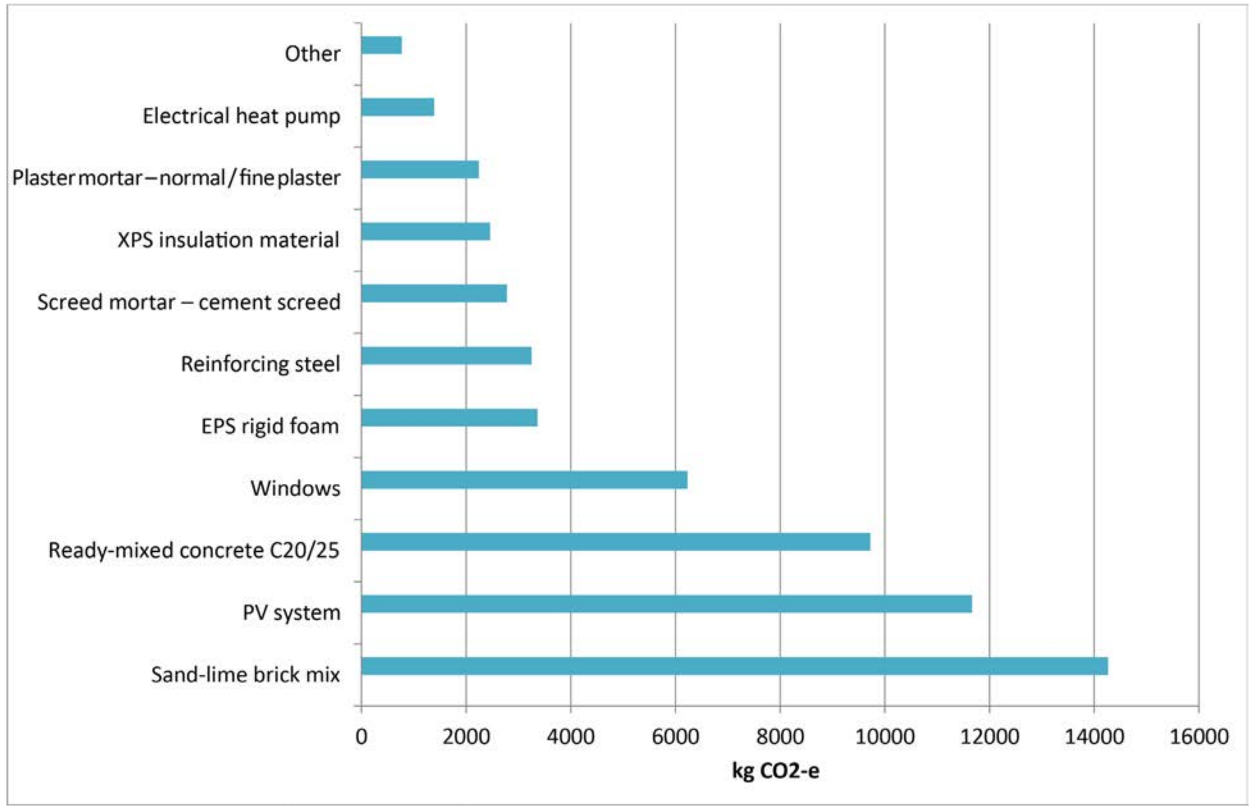
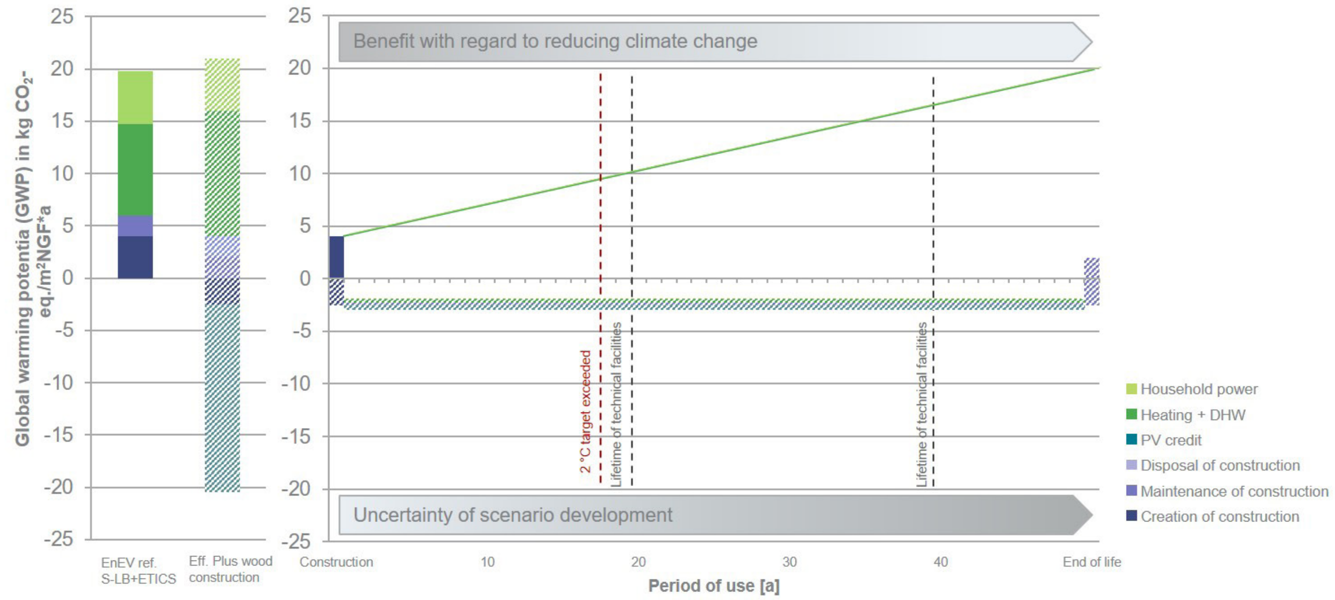


Fig. 9 – Identifying "hotspots" for the optimisation of the life cycle assessment
Source: Fraunhofer Institute for Building Physics (IBP), Johannes Gantner

If the life cycle assessment is employed for optimisation purposes, it is important to identify the "hotspots" first. A classification of the components according to GWP intensity as a leading indicator, for example, can help with this. In the example from the Fraunhofer IBP (Fig. 9), it is shown by way of example that the focus of the optimisation on brickwork, the PV system, the load-bearing structure (concrete and reinforcing steel) and windows is a reasonable approach.



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Energy requirements in accordance with DIN V 18599. Household power for Efficiency House Plus. Data source for construction: Ökobaudat 2011 (maintenance divided among all years, PV production not taken into consideration); data source for operation: Ökobaudat 2016.

Fig. 10 – Appearance of the effects over time
Source: ina Planungsgesellschaft mbH, Joost Hartwig

The figure from Joost Hartwig (ina Planungsgesellschaft GmbH) transfers a large amount of information onto a combined, easily readable graphic (Fig. 10). On the left, a comparison of two construction methods is contrasted for the GWP leading indicator, with the use of colour to identify the contribution to construction (blue) and the contribution to ongoing operation. The right half of the graphic additionally represents when the CO_2 emissions occur for the individual bars of the timber construction variant and the degree of uncertainty with which the information on the "predicted values" of the operation, the maintenance measures and the end of life should be understood.

Outlook

These guidelines provide building contractors, designers and any other interested persons with an introduction to the topic of life cycle assessments. They emphasise the benefits and advantages of using this method when planning new buildings or in renovation projects, preferably in the early planning phases. They are the result of a series of workshops in which the basic content was developed with members of the DGNB Expert pool.

Since its founding, the DGNB has been confident that the use of life cycle assessments can contribute to achieving its primary goal – better buildings in a sustainable built environment. For this reason, the life cycle assessment has been enshrined in the DGNB system with a very high weighting since its first version, and has already been able to show in many planning processes that "perceptibly more sustainable" construction methods also exhibit factually better environmental parameters. In the current version of the DGNB system, significant steps have already been taken with regard to the continued development of the LCA criterion, which support the early and repeated application of the LCA methodology in the planning process. This means that new incentives have been developed that also acknowledge the implementation of smaller optimisation measures with a positive environmental impact or promote the development of project-specific innovations. Important new incentives have been established in the form of bonus points in order to achieve buildings that are climate-neutral during use and construction.

In order to incorporate insights from life cycle assessments of buildings into the decision-making process even quicker and simpler, we must first acknowledge the current lack of prepared studies and analyses. Analyses on the component level could effectively help to decide on the better solution without a person needing to have calculated a complete life cycle assessment by themselves. Just as cost parameters are available in all possible levels of detail, it would be desirable to be able to use environmental parameters in this way. Case studies at all levels – buildings, construction methods, components, details – on a comparable calculation basis could significantly contribute to the optimisation of the planning process and could help with making environment-oriented decisions. The DGNB is working on developing a database of this kind.
In times of the ever increasingly important topic of climate change, there is great potential for the life cycle assessment to strongly attract attention and gain political relevance, both among customers and on the level of society as a whole. It is therefore crucial that clarity concerning industry targets, boundaries and pricing relating to the impact of CO_2 emissions is created through political commitments, by introducing a future CO_2 levy or future recycling quotas for buildings. Broad-based financial eligibility of life cycle assessments and certifications in general as well as increasing transparency concerning the sustainability indicators to be considered, as created by the indicator set of the "Level(s)" EU reporting framework for sustainability in the building sector, for example, act as a supporting factor in this.

Furthermore, a legal anchoring of LCA calculation in approval tools such as the EnEV or successor instruments can be very conducive to identifying and implementing balanced solutions for the operation of buildings. An acknowledgement in approval procedures as alternative or supplementary documentation for the DIN (V) 18599 calculation is desirable and helps to find the best and most conducive solution for the individual project in a manner that is open to all types of technology. A glimpse into the past – i.e. the developments that have occurred since the first German Thermal Insulation Ordinance – show that legal requirements are the most effective instrument for reducing impact on the environment. An extension of the energy certificate to include LCA indicators would additionally help to create acceptance of the topic.

Through these guidelines, the DGNB wishes to make a constructive contribution to disseminating knowledge concerning the relevance and feasibility of life cycle assessments as well as giving specific instructions on how to communicate this information. We would like to thank everybody involved in the compilation of these guidelines for their time and commitment.

TABLE OF FIGURES

GLOSSARY

LCA	Life Cycle Assessment
EPD	Environmental Product Declaration
HOAI	Honorarordnung für Architekten und Ingenieure (German fee structure for architects and engineers)
EnEV	Energieeinsparverordnung (German Energy Saving Ordinance)
ROI	Return on Investment
GWP	Global Warming Potential
PE^{nr}	Primary energy, non-renewable
POCP	Photochemical Ozone Creation Potential
AP	Acidification Potential
EP	Eutrophication Potential
PE^{tot}	Primary energy, total
PE^{re}	Primary energy, renewable
KPI	Key Performance Indicators


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German Sustainable Building Council – DGNB e.V.

Founded in 2007, the DGNB today constitutes Europe's largest network for sustainable construction with around 1200 member organisations. The association aims to promote sustainability in the construction and real estate industry as well as anchoring this in the consciousness of the general public. Through the DGNB certification system, the independent non-profit organisation has developed a planning and optimisation tool for assessing the sustainability of buildings and districts, which helps to increase real sustainability in construction projects. This means that the DGNB system is based on an integrated understanding of sustainability that incorporates the environment, people and the economy in equal measure. Additionally, through the DGNB Academy education and training platform, more than 3000 people in over 30 countries have already been qualified as experts in sustainable construction.

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