ENV1.1

Building life cycle assessment

Objective

Our objective is to ensure a consistent life cycle approach to the planning of buildings in order to reduce emissions-related impacts on the environment and consumption of non-renewable resources to a minimum across all stages in the life of a building.

Benefits

A life cycle approach to the building planning, using life cycle assessment, helps building commissioners and designers to make environmentally friendly decisions on the basis of comprehensive information. This enables the identification of solutions that are optimised, both in terms of various relevant environmental issues and in terms of various locations and times of environmental impacts. The application of a consistent method is useful for reporting relevant environmental indicators for a building, such as CO_2 emissions or energy demand throughout the entire life cycle.

Contribution to sustainability

	CONTRIBUTION TO SUSTAINABLE DEVELOPMENT GOALS (SDGS) OF UNITED NATIONS (UN)		CONTRIBUTION TO THE GERMAN SUSTAINABILITY STRATEGY	
Significant	3.9	Effects of chemicals, air, water and soil contamination	7.1.a/b	Resource conservation
			7.2.a	Renewable energy
	7.2	Proportion of renewable energy	12.1.b	Sustainable consumption
	7.3	Energy efficiency	13.1.a	Climate protection
	8.4	Global resource efficiency and decoupling of economic development		
	12.2	Use of natural resources		
	13.2	Climate protection measures in guidelines, strategies and planning		
Moderate	6.3	Improvement of water quality	3.2.a	Air pollution
	14.1	Avoiding marine pollution	14.1.aa/ab	Protect the seas
	14.3	Avoiding acidification of the seas		

Low	6.4	Efficient use and sustainable extraction of water	6.1.a	Water quality
			7.2.b	Renewable energy
	12.4	Environmentally friendly handling of chemicals and waste	8.1	Resource conservation
	15.1	Conservation of land and freshwater ecosystems	15.2	Ecosystems

Outlook

The reference values for construction and operation will be tightened further in future in accordance with increasing requirements regarding national climate protection, emission and resource consumption targets for industry and the building sector. In order to promote positive measures with regard to energy demand (which is not regulated by building energy laws), an appropriate expansion of the system limits will be developed. This will enable escalators and lifts to be taken into consideration in future. The increasing level of technology and engineering in buildings will place more emphasis on building services installations. This will also require regular comprehensive data regarding the components used in the technical building equipment as a basis.

The scope of analysis of the life cycle assessment (LCA), as a method for evaluating ecological impacts based on the life cycle, should model additional environmental impacts in future. If qualification and characterisation methods are available which have been accepted with a broad consensus among experts and for which suitable data is available in life cycle assessment data sets, additional environmental impacts should be calculated using the life cycle assessment. Examples of such impacts include ecotoxicity, use of natural resources and biodiversity.

In future, it will be possible to create life cycle assessments more easily thanks to improved, networked tools and to provide decision-makers with a greater range of reliable evaluations in order to enable better buildings to be planned more quickly. As a result, life cycle assessments will also increase in importance for life cycle optimisation across all phases of building planning.

Indicators 1 and 2 are inserted as incentives to promote earlier and more consistent integration of the life cycle assessment method into building planning processes. In the long term, these indicators can be omitted again once life cycle assessment calculations are established as a normal element of building planning processes.

Share of total score

	SHARE[1]	WEIGHTING FACTOR
Office **Education** **Residential** **Hotel** **Consumer market** **Department stores** **Logistics** **Production**	**9.5%**	**8**
Assembly buildings	**7.5%**	**6**
Shopping centre	**9.0%**	**8**

[1] Variable, building location related factors from the criterion ENV2.2 may influence the share of total score.

EVALUATION

Points are awarded for incorporation of the life cycle assessment results in the early planning process and use of an energy consumption analysis with a scope that goes beyond the statutory requirements (indicator 1). In addition, implementation and comparison of variants with life cycle assessment calculations is evaluated positively (indicator 2). The results of a complete building life cycle assessment, calculated in accordance with predefined conventions, are evaluated on basis of the comparison values (indicator 3). If the target values for the life cycle assessment have been exceeded, up to 20 additional points can be awarded. In addition, an "*Agenda 2030 bonus*" is awarded if the building operation is climate-neutral or partly climate-neutral and /or if the final lifecycle values are equal to or below the half of the GWP construction benchmark. The use of reused components or elements is included in the life cycle assessment calculation. Contribution to the circular economy is thereby fully implemented in the "Life cycle assessment comparison calculation" indicator. In this criterion a maximum of 130 points including bonuses can be achieved.

NO.	INDICATOR	POINTS
1	**Life cycle assessments in planning**	
1.1	**Integration of life cycle assessments into the planning process**	**Max. 10**
1.1.1	A life cycle assessment model is created for the project in an early planning phase. The building variants included in the planning phase are compared with regard to their potential environmental impacts resulting from construction and relevant potential environmental impacts resulting from use. As part of this, information from at least three different specialist planners or subject areas (e.g. support structure planning, heating, ventilation and air conditioning planning (HVAC), building physics planning or energy planning) is included in the assessment. As a minimum, the typically expected life cycle assessment parameters for the construction (e.g. derived from studies or benchmarks) and specific values for energy-related impacts are determined and communicated within the planning team, differentiated by operation and construction.	+8
1.1.2	Life cycle assessment results are determined for the building at regular intervals during the planning process (adjusted to match the relevant planning status) and are discussed in accordance with the specific planning issues and communicated (differentiated by operation and construction) within the planning team. The construction and all relevant building-related usage effects are integrated into the calculations at least in accordance with the simplified process in service phase 4 of the project at the latest. The service phases described under the chapter “terms and definitions” ([T&D_01]) of the document “Evaluation and structure of the DGNB system”.	+3
1.1.3	Life cycle assessment results are determined for the operating phase of the building, going beyond the statutory scope of the energy calculation. This includes, for example a differentiated analysis of the energy demand related to the building use in or at the building or at the site (AI, power supply, production, (effect) lighting, etc.), the complete energy demand of the technical building equipment (lifts, escalators, etc.) or similar. The results are communicated within the planning team.	+2
	INNOVATION AREA	**Same as 1.1**
Re 1.1	Explanation: Alternative approaches that accomplish integration of life cycle assessments for the building into the planning process can be selected and credited.	

2 Life cycle assessment optimisation

2.1 Life cycle assessment optimisation during the planning process **Max. 18**

2.1.1 The effects of significant alternative decisions on the expected life cycle assessment results are determined for the building. This process is carried out as a full consideration of the entire building. A plausible range of alternatives are available, which provide opportunities for improvement. The planning team select a suitable solution and explain the reasons for their choice.

- Per alternative as part of a full consideration within the scope of service phase 2, 3 or 4 (according to the [T&D_01]) +8
- Per alternative as part of a full consideration within the scope of service phase 5, 6 or 7 (according to the [T&D_01]) +4

2.1.2 The effects of significant decisions on the expected life cycle assessment results are determined for the building. This process is carried out as a partial analysis (section) for the relevant scope of analysis. A plausible range of alternatives are available, which provide opportunities for improvement. The planning team select a suitable solution and explain the reasons for their choice.

- Per alternative as part of a partial analysis within the scope of service phase 2, 3 or 4 (according to the [T&D_01]) +6
- Per alternative as part of a partial analysis within the scope of service phase 5, 6 or 7 (according to the [T&D_01]) +2

INNOVATION AREA **Same as 2.1**

Re 2.1 Explanation: Alternative approaches that accomplish optimisation of the life cycle assessment for the building can be selected and credited.

3 Life cycle assessment comparison calculation

3.1 Weighted environmental impacts **Max. 90**

Weighted environmental impacts according to the partial calculation method (PCM) **Max. 70**

3.1.1 Building life cycle assessment results provided At least

3.1.2 Evaluation of the building life cycle assessment results 0–90

Evaluation of the building life cycle assessment results according to the PCM 0-70

- Weighted environmental impacts exceed the weighted limit value 0
- Weighted environmental impacts comply with the weighted reference value (PCM) 30
- Weighted environmental impacts comply with the weighted reference value 40
- Weighted environmental impacts reach the weighted target value (PCM) 60
- Weighted environmental impacts reach the weighted target value 80
- Weighted environmental impacts fall below the weighted target value (PCM) 70
- Weighted environmental impacts fall below the weighted target value 90

4 AGENDA 2030 BONUS – CLIMATE PROTECTION GOALS[2]

4.1 Potential to achieve climate neutrality **+ max. 30**

[2] Note: no bonus points can be awarded for indicators 4.1.4 and 4.1.6 (construction) with the partial calculation method (PCM)

4.1.1	Partial consideration of the building operation – building energy demand: The building-related energy demand is determined in accordance with the rules of the "Framework for carbon neutral buildings and sites" of the DGNB. The boundary conditions of the use phase must reflect the reality as precise as possible. On site generated renewable energy can at least compensate the building energy demand related CO_2 equiv. emissions.	+10
4.1.2	Partial consideration of the building operation – user energy demand: The user-related energy demand (usually exceeds the standard EPC calculation boundaries) is determined in accordance with the rules of the "Framework for carbon neutral buildings and sites" of the DGNB. The boundary conditions of the use phase must reflect the reality as precise as possible. On site generated renewable energy can at least compensate the user energy related CO_2 equiv. emissions.	+10
4.1.3	Climate-neutral building operation: Alternatively, to 4.1.1 and 4.1.2 the following can be assigned: The total energy demand (operation = building energy plus user energy) is determined in accordance with the rules of the "Framework for carbon neutral buildings and sites" of the DGNB. The boundary conditions of the use phase must reflect the reality as precise as possible. On site generated renewable energy can at least compensate the building operation (building + user energy demand) related CO_2 equiv. emissions.	+20
4.1.4	Climate neutral construction: The total greenhouse gas emissions from manufacture, maintenance and end-of-life of the construction ($GWP_{C.Proj.}$), determined via a life cycle assessment according to DGNB, fall below the reference value $GWP_{C.ref}$ for the construction by at least 50%.	+5
4.1.5	Climate action roadmap for "the climate neutral building operation achieved by 2040": for the operation of the building there is a plausible climate action roadmap in accordance with the "Framework for carbon neutral buildings and sites", which will result in a CO_2 neutral operation by 2040.	+5
4.1.6	Climate action roadmap for "the climate neutral building" (calculation boundary: operation plus construction): for the whole building lifecycle (construction + operation) there is a plausible climate action roadmap in accordance with the "Framework for carbon neutral buildings and sites", which will result in a CO_2 neutrality by 2050.	+5

5 CIRCULAR ECONOMY

5.1 Use of reused components or structural elements

The environmental pollution prevented by the reuse of components or structural elements can be recorded in the life cycle assessment calculation and incorporated into the life cycle assessment evaluation. The contribution of the reuse of a component or element to the circular economy is thereby depicted in indicator 3, "Life cycle assessment comparison calculation".

5.2 Building generates energy "for other users"

The excess energy is recorded in the life cycle assessment and incorporated into the life cycle assessment evaluation. The contribution to the circular economy is thereby fully implemented in indicator 3, "Life cycle assessment comparison calculation".

6 Halogenated hydrocarbons in refrigerants

6.1	**GWP factor of refrigerants in refrigeration systems**	**2**
	No use of refrigerants with a CO_2 equiv. ≥ 150 kg.	+2

SUSTAINABILITY REPORTING AND SYNERGIES

Sustainability reporting

The CO_2 emission values for building operation determined on the basis of the life cycle assessment represent part of the "Scope 1" and "Scope 2" emissions in accordance with the "Greenhouse Gas Protocol" (www.ghgprotocol.org). This parameter can also be used in CSR reports or as part of environmental management measures. The life cycle assessment results and calculation basis can be used for reporting in accordance with the "Level(s) – Common EU framework of core environmental indicators".

NO.	KEY PERFORMANCE INDICATORS (KPIS)	UNIT
KPI 1	Final energy demand (building operation), differentiated by heating, cooling, ventilation, hot water and lighting – corresponds to elements of Level(s) indicator 1.1.1	[kWh/m²a]
KPI 2	Primary energy demand (building operation), divided into total primary energy demand, non-renewable primary energy demand and renewable primary energy demand, differentiated by heating, cooling, ventilation, hot water and lighting – corresponds to elements of Level(s) indicator 1.1.1	[kWh/m²a]
KPI 3	Exported energy – corresponds to Level(s) indicator 1.1.2	[kWh/m²a]
KPI 4	CO_2 emissions (building operation) with reference values for net floor area (NFA) and year (= life cycle assessment results for GWP, "Use" section)	[kg CO_2-e/m²a]
KPI 5	$CO_{2\text{-}e}$ emissions (building operation) with reference values for building users (in accordance with assumptions across all criteria) and year (= life cycle assessment results for GWP, "Use" section)	[kg CO_2-e/person*a]
KPI 6	$CO_{2\text{-}e}$ emissions (construction/$CO_{2\text{-}e}$ involved) with reference values for net floor area (NFA) and year (= life cycle assessment results for GWP, "Construction" section)	[kg CO_2-e/m²*a]
KPI 7	$CO_{2\text{-}e}$ emissions (life cycle) with reference values for net floor area (NFA) and year (= life cycle assessment results for GWP, "Use" and "Construction"); corresponds to Level(s) indicator 1.2, Simplified Reporting Option Please note: Can be used as a Simplified Reporting Option when using the complete process. When using the simplified process, "Incomplete Life Cycle" must be specified. For complete reporting, in accordance with Level(s), all modules must be determined and specified in accordance with EN 15978.	[kg CO_2-e/m²*a]
KPI 8	Life cycle assessment results, complete in accordance with the DGNB method; corresponds to Level(s) indicator 2.4 Note 1: Unlike the DGNB, in accordance with Level(s), all modules must be specified in accordance with EN 15978. Note 2: In accordance with Level(s), the indicators "ADP fossil fuels", "Biotic resources, renewable" and "Biotic resources, non-renewable" must also be	[Life cycle assessment units]

	specified.	
KPI 9	Detailed component list; corresponds to Level(s) indicator 2.1, "Building Bill of Materials" Note 1: The "Bill of Materials" corresponds to a detailed component list (99% complete) specifying all dimensions and including allocation to four material groups	[kg]
KPI 10	Component list with durations of use; corresponds to Level(s) indicator 2.2, "Scenarios for lifespan" Note: All assumptions regarding durations of use for products, materials, elements, etc. should be specified in accordance with Level(s) for all modules in accordance with EN 15978	[years]
KPI 11	Construction and demolition waste; corresponds to Level(s) indicator 2.3 "Construction and Demolition Waste" Please note: All construction waste and future demolition waste for all modules in accordance with EN 15978 in kg of waste and material assignment – not included in the DGNB method.	[kg waste/m²]
KPI 12	GRI Disclosure 302-01 "Energy Consumption within the Organization" Note 1: Divided into heating, cooling and other energy demands.	[kWh/a]
KPI 13	GRI Disclosure 305-01 "Direct Greenhouse Gas Emissions" Note 1: In accordance with GHG protocol "Scope 1" definition. Note 2: Also communicate biogenic CO_2 emissions separately. Note 3: The CO_{2-e} emissions produced directly at the building can be incorporated here	[kg CO_2-e/a]
KPI 14	GRI Disclosure 305-02 "Energy Indirect Greenhouse Gas Emissions" Note 1: In accordance with GHG protocol "Scope 2" definition. Note 2: This includes CO_{2-e} emissions from electricity, long-distance district heating, etc. from external energy-related sources.	[kg CO_2-e/a]
KPI 15	GRI Disclosure 305-03 "Other Indirect Greenhouse Gas Emissions" Note 1: In accordance with GHG protocol "Scope 3" definition. Note 2: CO_{2-e} emissions from module B1–B5 can be referenced here	[kg CO_2-e/a]
KPI 16	GRI Disclosure 305-05 "Reduction of Greenhouse Gas Emissions" Note 1: Relates to operation of the building and the resulting CO_{2-e} emissions.	[kg CO_2-e/a]

Synergies with DGNB system applications

- **DGNB BUILDINGS IN USE:** High synergies with criterion ENV9.1 from the scheme for buildings in use: For operation, the energy requirement values from the DIN V 18599 (detailed description of the norm under the chapter [T&D_03]) calculation or simulations can be used. This enables consumption values to be checked and helps users to optimise operation. The CO_2 values from the use phase can likewise be used for operation.

- **DGNB RENOVATED BUILDINGS:** High synergies with criteria ENV1.1 and ENV2.1 from the scheme for renovated buildings.

- **DGNB DISTRICT:** The calculated life cycle assessment results for the buildings can be transferred directly as achieved values into the criteria ENV1.1 and ENV2.1 from the schemes for urban districts and business districts.

- **DGNB INTERIORS:** Elements of the calculations can be transferred directly into criterion ENV1.1. In addition, results for CO_2 emissions and energy efficiency can be transferred into criterion ENV2.1.

APPENDIX A – DETAILED DESCRIPTION

I. Relevance

Buildings cause emissions and consume resources in all phases of their life cycle, from construction (e.g. due to use of construction materials and construction products) to use (e.g. due to building operation and maintenance) through to end-of-life (e.g. due to demolition). Emissions pass into the air, water and soil and cause a wide variety of environmental problems. These include global warming, destruction of the stratospheric ozone layer, summer smog, forest dieback, fish mortality and eutrophication of water and soil. A life cycle approach to the planning of buildings helps building owners and designers to make decisions that favour solutions optimised in terms of various environmental issues, in terms of various locations and times of environmental impacts.

II. Additional explanation

Using life cycle assessment data, these emissions and resource consumptions are calculated throughout the entire life cycle – for construction, operation and end-of-life – and can be evaluated using benchmarks. Environmental problems are found in the following environmental indicators:

(1) Climate change: Global warming potential (GWP)
(2) Destruction of the stratospheric ozone layer: Ozone depletion potential (ODP)
(3) Summer smog, ground-level ozone: Photochemical ozone creation potential (POCP)
(4) Acidification of soil, forest dieback and fish mortality: Acidification potential (AP)
(5) Eutrophication of surface water: Eutrophication potential (EP)
(6) Non-renewable primary energy demand (PEnr)
(7) Total primary energy demand (PEtot)
(8) Proportion of renewable primary energy
(9) Abiotic, non-energy resource consumption: Abiotic basic resource depletion potential (ADPelements)
(10) Water consumption: Net use of fresh water (FW)

The building LCA should be conducted as early as the planning phase if possible. It can also serve as an important instrument for improving the ecological quality of the building.

III. Method

Indicator 1: Life cycle assessments in planning

The objective of indicator 1.1 is to clearly present life cycle assessment results from an early planning phase, tailored to the specific context or to the point in time and scope of planning.

To this end, a life cycle assessment model (indicator 1.1.1) should be drawn up in an early planning phase (service phase 2–3). The most likely/preferred building variants are compared with regard to their potential environmental impacts resulting from construction and use phase. As part of this, information from at least three different specialist designers (e.g. support structure designers, heating, ventilation and sanitation designers, building physics designers or energy designers) is included in the assessment. As a minimum, typical life cycle assessment parameters for the construction and specific values for energy-related impacts are determined, differentiated by operation and construction and communicated within the planning team.

In addition, points can be included in the evaluation if a life cycle assessment model is created and used for evaluation at least in the service phase 4 of the project (indicator 1.1.2). Construction and all relevant building-related usage effects must be included into the calculations at least in accordance with the simplified method described in indicator 3.

Construction-related or use-related expenditure that goes beyond this assessment framework or expected "environmental yields" can also be included in the assessment in accordance with indicator 1.1.1 or 1.1.2 – these can include transport expenditure, construction site expenditure, demolition or recycling expenditure, etc. Life cycle assessments in the planning phase can also take into account, all aspects that are not part of the DGNB calculation scope in accordance with indicator 3, such as the inclusion of exterior space or other construction components. It is likewise possible to factor conventions into the assessments, such as reference periods or reference values.

For assessment during the planning process and communication of the life cycle assessment results to the planning team, target values (tailored to the planning status) should be defined that are compared to the achieved values in various planning phases.

In principle, the calculation method can be freely chosen, but it should fulfil the objectives of the sub-indicators. At the very beginning of the planning process, simple tools can be selected, such as the use of statistical construction parameters as a starting point for calculation with a combination of the energy-related impacts on a few selected environmental indicators.

If life cycle assessment results are determined for the operating phase of the building across the entire scope of analysis as defined by the law, additional points can be included in the assessment (indicator 1.1.3). This includes, for example, a differentiated analysis of the energy demand related to the building use in or at the building or at the site (AI, power supply, production, (effect) lighting, etc.), the complete energy demand of the technical building equipment (lifts, escalators, etc.) or similar. The results should likewise be communicated within the planning team.

Indicator 2: Life cycle assessment optimisation

The objective of life cycle assessment optimisation during the planning process is to address the environmental impact of all stages in the life of a building as early as possible and to reduce or optimise them via variant calculations. Life cycle assessment optimisations should be carried out at various suitable points in time.

Alternatively, full considerations (life cycle assessment results for the entire building in accordance with the scope of analysis of indicator 3 and the minimum scope of analysis specified in indicator 1) or partial analyses (life cycle assessment results for a section of the scope of analysis) can be incorporated into the evaluation.

Optimisations should investigate the life cycle assessment results of significant alternatives for decisions that are not irrelevant. Depending on the planning phase, these can vary greatly and affect aspects such as variants of the A/V ratio, duration of use of planned components or the use of alternative manufacturers.
Aspects that are not part of the scope of analysis of the "life cycle assessment comparison calculation" can also be taken into account for calculating life cycle assessment variants (see indicator 3). This includes for example, consideration of additional components (external installations or equipment). An expanded scope of analysis can also include the assessment of possible environmental yields. Conventions that differ from the life cycle assessment comparison calculation defined below (see indicator 3), such as reference periods, reference values, etc., can also be factored into the alternatives. All environmental indicators, included in the evaluation of indicator 3, should be taken into account in order to make optimisation. When using only one or two core indicators such as GWP and PEnr as part of an optimisation, a suitable method must be used to ensure that the potential environmental impacts are not

shifted to other environmental indicators to any great extent.

The findings of the life cycle assessment optimisation should be incorporated into the decision-making process. A plausible range of alternatives are available, which provide opportunities for improvement. The planning team select a suitable solution and explain the reasons for their choice. The number of alternatives for which comprehensive or partial life cycle assessment calculations were carried out in early or later planning phases is evaluated.

Indicator 3: Life cycle assessment comparison calculation

The methodology can be found in the section "DGNB life cycle assessment method" (below).

Indicator 4: Agenda 2030 bonus – climate protection goals

The objective is to encourage solutions that implement long-term climate protection targets today. This indicator evaluates whether it can be demonstrated via scenario calculations that at least climate neutrality has been achieved for the following aspects:

- CO_2 equiv. compensation for the building energy demand (indicator 4.1.1);
- CO_2 equiv. compensation for the user energy demand (indicator 4.1.2);
- Climate neutral building operation (building energy plus user energy demand) (indicator 4.1.3);
- Climate neutral construction (CO_2 equiv. construction materials) (indicator 4.1.4);
- Climate action plans for building operation (indicator 4.1.5) or for the whole lifecycle (construction and operation) (indicator 4.1.6);

For the indicators 4.1.1, 4.1.2 and 4.1.3:
calculation method for CO_2 equiv. emissions of a building operation or construction must be carried out in accordance with the rules defined in the "Framework for carbon neutral buildings and sites" of the DGNB. In addition, the following aspects have to be considered:

- If no thermal dynamic simulation is used to determine the energy demand, it is recommended to adapt the statutory calculation methodology to realistic parameters. The data quality index, described in the DGNB "Framework for carbon neutral buildings and sites" evaluates a performance of the calculation tool. It evaluates technical, spatial and temporal aspects for a realistic energy / CO_2 calculation.
- For indicators 4.1.1 and 4.1.2 the following simplified calculation method, which deviates from the DGNB "framework for carbon neutral buildings and sites", for the CO_2 emission calculation is accepted: If the CO_2 emissions from the building operation (building or user energy demand) are lower than the annual total CO_2-emissions from the renewable energy produced onsite, requirements are fulfilled. For onsite generated energy the same CO_2 factors to be applied as for the off-site final energy carriers (e.g. electricity mix data-set for photovoltaics, local district heating / gas / pellets / etc. for solar thermal energy, etc.).
- The following applies to the indicator 4.1.3: According to the DGNB framework, use of the specific CO_2 emission factors for the "green" electricity or other renewable energy sources is permitted. Nonetheless, purchase of the renewable energy from external sources must be considered as the last available measure and all requirements for energy suppliers must comply with the rules described in the DGNB "Framework for carbon neutral buildings and sites".

- The acquisition of the CO_2 compensation certificates cannot be taken into the account either for the “Operation” or “Operation and Construction” assessment.
- For indicator 4.1.3, the points can only be accepted if climate action pass (a climate protection certificate) with all mandatory information for the building operation according to the "Framework for carbon neutral buildings and sites" of the DGNB has be submitted.
- For the indicators 4.1.1 and 4.1.2 it is also recommended to draw up a climate action roadmap according to the indicator 4.1.5.

Indicator 4.1.4: five bonus points can be claimed, if the calculated value of the CO_2-e emissions for the projected building ($GWP_{C.Proj}$ results from the indicator 3) falls below the reference value for the construction ($GWP_{C.ref}$) by at least 50%. This target can be achieved by selecting the proper construction materials e.g. products made from renewable raw materials, climate-neutral concrete, etc. and precise consideration of the EoL (end of life) scenarios e.g. the possibility of reusing components, etc.

Indicator 4.1.5: “climate action roadmap” for climate-neutral operation achieved by 2040 (calculation boundary “operation”), a plausible climate action roadmap must be available for the building operation in accordance with the “framework for carbon neutral buildings and sites”. This action plan for building operation must contain the building-specific decarbonization path which brings the building operation related CO_2 emissions to zero-balance by 2040 at the latest. The action plan addresses all five focus areas: local context, building energy, use energy, supply systems and renewable energy. Purchase of the renewable energy can be included in the calculation as the last measure. The climate action roadmap for the “Operation” have to be presented to the client before the construction work began. In addition, climate action certificate for the building have to be available with all the mandatory information for the "operation" according to the "framework for carbon neutral buildings and sites" of the DGNB.

Indicator 4.1.6: "Climate protection roadmap” for climate-neutral building (calculation boundary “operation and construction"), a plausible climate action roadmap, including the construction (building materials), according to the DGNB "framework for carbon-neutral buildings and sites" is available. This action plan for building (operation plus construction) must contain the building-specific decarbonization path which brings the building related CO_2 emissions to zero-balance by 2050 at the latest. The action plan addresses all five focus areas from ind. 4.1.5 and construction related focus areas: high area sufficiency, circular construction, flexible use, low material consumption and low CO_2 intense material use, more detailed description is available under the DGNB "framework for carbon-neutral buildings and sites". Purchase of renewable energy can flow into the calculation as the last measure. The climate action roadmap for the “Operation and Construction” have to be presented to the client before the construction work began. In addition, climate action certificate for the building have to be available with all the mandatory information for the "operation" according to the "framework for carbon neutral buildings and sites" of the DGNB.

Indicator 5: Circular economy

Both the use of reused components and the provision of quantities of thermal or electrical energy for other users in excess of the internal energy demand of the building itself, can be fully included in the assessment in indicator 3 "Life cycle assessment comparison calculation". Reused components must be excluded from the recording of environmental impacts. Energy production can be incorporated into the calculation as described in the section "Module B6: Scenario for energy use in operation" (below). No bonus points are awarded here in order to prevent double awards.

Indicator 6: Halogenated hydrocarbons in refrigerants

Refrigeration systems that use refrigerants with a GWP factor ≥ 150 kg CO_2 equivalent in accordance with the schedule published by the German Federal Environment Agency (*Umweltbundesamt (UBA)*) should not be used. Such refrigerants also include substances that are still often used in building air conditioning systems such as R-134a, R-407c or R-410a. Buildings that are operated without active cooling also meet the requirements of this indicator.

More information regarding refrigerants is available here:
www.umweltbundesamt.de/en Topics› Economics | Consumption› Products› Fluorinated Greenhouse Gases and Fully Halogenated CFCs› Documents or
https://www.umweltbundesamt.de/sites/default/files/medien/2503/dokumente/global_warming_potential_gwp_of_certain_substances_and_mixtures_2017_05.pdf

Description of the DGNB life cycle assessment method (indicator 3)

Criterion ENV1.1 "Building life cycle assessment" is assessed in the same way as the results of a building life cycle assessment. The results of this life cycle assessment are designated as an "Environmental profile" or "Environmental quality" of a building. A building life cycle assessment determines and evaluates the environmental quality of a building, taking into account its scheme (office building, department store, school, etc.) and compares the results with reference values. The basis used for obtaining the data must be documented and provided in order to prevent any doubt when checking the results. The building life cycle assessment should be used during the planning phase itself, where possible. It can provide an important instrument for optimising the environmental quality of the building. The basis used for calculating the building life cycle assessment is DIN EN 15978.

1. Methodological basis for the building life cycle assessment

1.1 Area of application of the building life cycle assessment

The results of a building life cycle assessment can be applied to the subject of the evaluation. Calculation rules, data requirements, the selection of environmental indicators and other aspects described below must be taken into account here. In principle, the complete life cycle of buildings must be evaluated.

1.2 Description of the evaluated building

1.2.1 Functional equivalent (subject of the evaluation)

The subject of the evaluation is the entire building, but does not include the external installations. For evaluations that only consider specific parts of a structure, the system limits of the life cycle assessment must be clearly defined.

Evaluated building must be described in terms of its material and time-dependent properties. In addition, a clear description of the technical and functional properties of the building, the building type and the scheme (e.g. the number of users) must be recorded in a documentation data sheet. Details regarding documentation are described in more detail under the point "Required documentation". Description of the evaluated building represents the functional equivalent for the evaluation.

1.2.2 Reference period t_d

The reference period t_d (also known as "Reference study period") is specified for each scheme. If the intended duration of use of the evaluated building is shorter or longer than this period, the calculation of the results can be adjusted accordingly. However, it should be noted that the way in which certain processes are viewed always stays the same, even with a duration of use that deviates from the standard; this applies, for example, for construction, demolition, etc. However, as a part of DGNB certification, the specified reference period must always be applied as an estimate in order to enable comparison with the reference values.

1.2.3 System limits of the life cycle assessment

The evaluation only applies to the building, not including any external installations. The table 1 shows which processes and phases are included in the system limit and therefore incorporated in the evaluation and which processes and phases are excluded. The designations and descriptive information from modules A to D refer to DIN EN 15978.

Table 1: DIN EN 15978 modules for lifecycle assessment

LIFE PHASES	A 1–3			A 4–5		B 1–7							C 1–4				D
	PRODUCTION PHASE			ERECTION PHASE		USE PHASE							END OF THE LIFE CYCLE				BENEFITS AND LIABILITIES OUTSIDE OF THE SYSTEM LIMITS
	RAW MATERIALS PROCUREMENT	TRANSPORT	PRODUCTION	TRANSPORT	ERECTION/INSTALLATION	USE 1	MAINTENANCE 2	REPAIR	REPLACEMENT 2	MODERNISATION	ENERGY CONSUMPTION DURING OPERATION	WATER CONSUMPTION DURING OPERATION	DISMANTLING/DEMOLITION	TRANSPORT	WASTE RECYCLING	DISPOSAL	POTENTIAL FOR REUSE, RECOVERY AND RECYCLING
Modules in accordance with DIN EN 15978	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Declared modules	x	x	x						(x) 4		x				x	x	x

1) Impacts due to emissions that can impact health in the interior and the environment are assigned to criteria ENV1.2 and SOC1.2
2) A scenario for the energy demand of the building in use, whereby only the energy demand recorded in the building energy performance certificate (EPC), alternatively energy performance simulation, is taken into account (module B6).
4) Only includes the manufacturing (modules A1-A3) and disposal (modules C3, C4) incl. recycling potential (module D) of the replaced product, not the replacement process itself (same as for construction process).

1.3 Calculation rules for the building model

The physical building model enables mass and energy flows to be quantified. Its link to corresponding life cycle assessment data enables the life cycle assessment indicators to be determined. In order to enable the determined mass and energy flows and the resulting indicators to be checked efficiently, the results have to be organised and documented in a structured way. The documentation of the building must be divided as follows:

- Its constituent parts (all building elements, structural parts, construction products and construction materials);
- The associated processes such as maintenance, replacement and end-of-life processes as well as reuse, recycling and energy recovery;
- Usage (of energy) during operation.

For the building model, the corresponding life cycle assessment indicators must be determined and presented separately.

In principle, there are 3 methods to create a building model, partial calculation method to create the building model, which enables very simple recording of the constituent parts of the building. Simplified calculation method, which enables main components from the building component catalogue to be recorded and the complete calculation method, which includes recording all constituent parts and their associated processes.

In each case, the use of energy during operation (module 6) in accordance with the building energy performance certificate (EPC) or alternatively building energy performance simulation must be determined and included equally in the calculation. A whole building analysis is conducted using local climate data. A reference building method is used to evaluate the building's environmental performance.
Requirements and details for EPC and energy performance simulation are listed in Appendices 2, 4 and 5.

1.3.0 Production phase (modules A1–A3), Partial calculation method (PCM)
Calculation of the production phase includes only structural components listed below:

(1) External and basement walls – perimeter insolation and only mineral / metal-based core materials e.g. concrete incl. reinforcement, concrete blocks, bricks etc. No other layers e.g. cladding, painting, plastering, adhesives etc.
(2) Roofs – perimeter insulation and only mineral / metal-based materials e.g. concrete incl. reinforcement
(3) Internal floors and ceilings – only mineral / metal-based core structures and elements e.g. concrete incl. reinforcement without floor coverings, coatings, adhesives etc.
(4) Ground-level floor – perimeter insulation and only mineral / metal-based core construction materials e.g. concrete incl. reinforcement and.
(5) Foundations[3] - only mineral / metal-based materials e.g. concrete incl. reinforcement
(6) Internal walls – only mineral / metal-based materials e.g. concrete incl. reinforcement, concrete blocks, bricks, No other layers e.g. painting, plastering, adhesives etc.
(7) Load bearing structure – all mineral / metal-based materials e.g. concrete incl. reinforcement, metal columns, beams etc.

Appendix 1 shows the building elements that must be included in detail in the form of a table.

The constituent parts of the building and associated quantities must be listed systematically and organised in accordance with Appendix 1 if possible. Created building model must be sufficiently transparent that a unit of reference can be determined for the life cycle assessment datasets (e.g. ESUCO or other verified LCA dataset), Each unit of reference for the calculated quantity of the building model must be checked to ensure that it matches the unit of the assigned life cycle assessment dataset and adjusted to match if necessary (e.g. via density or weight per unit area).

Determination of quantities for the production phase should be carried out and documented as follows:
For the elements in (1), (2), (3), (4), (5) (6) and (7), total masses of concrete, (incl. reinforcement) concrete blocks and/or structural metal components, must be determined and documented accordingly. No layer structures must be calculated, except the perimeter insulation (building envelope) e.g. mineral wool boards, plastic foam insulating materials etc.

Transportation to the construction site is not to be included and products, processes and expenditure that do not relate to construction site work are likewise not to be taken into account. This also applies to preparatory work and soil excavation. In addition, losses when installing elements can be ignored; it is not necessary to calculate the gross total of the elements.

The building model for construction must be linked to life cycle assessment datasets. If there is no life cycle

[3] Retaining walls or other shoring methods must be included as estimates in the life cycle assessment if they remain as permanent parts of the structure. However, if they remain in the construction ground but are separate from the structure, they are not taken into account.

assessment data that precisely matches a component, a technically similar life cycle assessment dataset must be used. If there are multiple similar datasets available, a conservative approach must be selected (worst-case scenario principle).

Please note: If determination of quantities is carried out using the partial calculation method, the indicator results for the production phase, maintenance and replacement as well as for end-of-life must be multiplied by a **factor of 1.4**. If comprehensive passive measures are taken into account and recognised in criterion TEC1.4, indicator 1, the factor of 1.4 for the partial method can be reduced to a factor of 1.35 for passive buildings.

1.3.1 Production phase (modules A1–A3), simplified calculation method

Calculation of the production phase includes the calculation of the following structural and technical components listed below:

(1) External walls (including doors and windows) and basement walls
(2) Roofs
(3) Internal floors and ceilings (including floor structures and floor coverings and coatings)
(4) Ground-level floor (including floor construction and floor coverings and coatings, as well as floors above open space)
(5) Foundations[4]
(6) Internal walls and doors (including coatings and internal columns)
(7) Heating and cooling systems and air conditioning systems
(8) Other building installations (e.g. photovoltaic systems or the use of solar collectors)
(9) In individual cases: User equipment with considerable energy consumption in the use phase (if suitable life cycle assessment data is available for them, such as refrigerated counters and cold storage rooms), these can be described in more detail depending on their usage here.

Appendix 1 shows the building elements that must be included in detail in the form of a table.

The constituent parts of the building and associated quantities must be listed systematically and organised in accordance with Appendix 1 if possible. Created building model must be sufficiently transparent that a unit of reference can be determined for the life cycle assessment datasets (e.g. ESUCO or other LCA dataset), Each unit of reference for the calculated quantity of the building model must be checked to ensure that it matches the unit of the assigned life cycle assessment dataset and adjusted to match if necessary (e.g. via density or weight per unit area).

Determination of quantities for the production phase should be carried out and documented as follows:

- For the elements in (1), (2), (3), (4), (5) and (6), the results of the layer structures must be calculated with the corresponding area as a whole, and listed separately. Alternatively, total masses (e.g. concrete in the external walls) can be determined and documented accordingly.
- For elements (1), (2) and (5), the results of the layer structures must be calculated with the corresponding total surface area of the building as a whole, and listed separately. For windows/doors/gates/floor and ceiling structures or other structural installations, the calculations must be listed with an appropriate level of detail. Simplifications must be documented, and at least 90% of the masses or all significant layers of each structural element must be recorded.

[4] Retaining walls or other shoring methods must be included as estimates in the life cycle assessment if they remain as permanent parts of the structure. However, if they remain in the construction ground but are separate from the structure, they are not taken into account.

- For (7), the following applies: The creation of heating and cooling systems and the central units of air conditioning systems must be included in the building model. Pipes, lines, ducts and other systems that are part of the technical building equipment (BE) must not be included in the building model for simplified analysis.
- For (8), the following applies: The production of other building installations (PV, solar collectors, etc.) must be included in the overall calculation. If there are no life cycle assessment data sets available for this purpose, this must be indicated and explained in the project report. Small components such as switches, etc. are an exception to this.
- For (9), the use-specific specifications in Appendix 1 apply (currently, only refrigerated counters in the retail sector are to be recorded).

In order to simplify the creation of the building model, average values for similar building components or layer structures can be used in a corresponding ratio. These must reflect the actual use in the building. The use of simplifications must be disclosed and documented. Any constituent parts of the building that are required here but not recorded in the building model must be documented. Transportation to the construction site is not to be included and products, processes and expenditure that do not relate to construction site work are likewise not to be taken into account. This also applies to preparatory work and soil excavation. In addition, losses when installing elements can be ignored; it is not necessary to calculate the gross total of the elements.

The building model for construction must be linked to life cycle assessment data sets. If there is no life cycle assessment data that precisely matches a component, a technically similar life cycle assessment data set must be used. If there are multiple similar data sets available, a conservative approach must be selected (worst-case scenario principle).

Please note: If determination of quantities is carried out using the simplified calculation method, the indicator results for the production phase, maintenance and replacement as well as for end-of-life must be multiplied by a **factor of 1.2**. If comprehensive passive measures are taken into account and recognised in criterion TEC1.4, indicator 1, the factor of 1.2 for the simplified method can be reduced to a factor of 1.1 for passive buildings.

1.3.2 Production phase (modules A1–A3), complete calculation method

Structural work and fit-out must be incorporated into the calculation for the life cycle assessment values for construction of the building as though constructed. Structural and technical components must be ordered in accordance with the Appendix 1.

All materials that fulfil at least one of the following conditions (cut-off criteria) have to be taken into account:

- Materials that make up more than 1% of the total mass of the building. In total, the ignored materials/material groups must not make up more than 5% of the mass of the entire building.
- The following applies to plastics and products made from renewable raw materials: The total primary energy demand (PEtot) of the material is more than 2% of the total primary energy demand of the building (only construction, incl. production, maintenance and end-of-life). In total, the ignored materials/material groups must not make up more than 5% of the total primary energy demand of the building.
- The following applies to coatings: The summer smog potential (POCP) is greater than 2% of the summer smog potential of the building. In total, the ignored materials/material groups must not make up more than 5% of the summer smog potential of the building.

The completeness of the determination of quantities must be verifiably demonstrated and proven (see above). To do so, rough relevance estimations must be made for ignored materials.

Construction site work, waste and waste disposal on the construction site can be ignored in the same way as in the simplified process. The same applies for transportation, preparatory work and soil excavation.

The construction model must be linked to life cycle assessment data sets. If there is no life cycle assessment data that precisely matches a component, a technically similar life cycle assessment data set must be used. If there are multiple similar data sets available, a conservative approach must be selected (worst-case scenario principle).

1.3.3 Use scenario calculation method (modules B6, B4)
Supply and disposal systems and repair must be included in the calculation of the life cycle assessment values for use of the building. The appropriate value for the scheme must be considered as the reference period t_d. Calculations and results should be organised in compliance with criterion ECO1.1.

The calculation comprises the following modules:

- Module B6: Energy demand of the building in use, whereby only the final energy demands recorded in EPC alternatively, results from energy demand simulation are taken into account;
- Module B4: replacement, including construction and end-of-life phase;

Module B6: Scenario for energy use in operation
The values for the final energy demand of the various/individual energy sources for operation of the building can be found in the EPC calculation, details described in Appendix 2 (the country specific statutory requirements regarding the energy performance of buildings will be taken in to the consideration if there is a sufficient compliance with the calculation/simulation standards described in Appendix 2)[5]. Here, it must be ensured that the final and non-primary energy values are incorporated into the calculation. The calculated energy demand must refer to the NFA (net floor area) in accordance with the T&D_04, i.e. not to the conditioned/heated area based on EPC. Alternatively, results from a building energy performance simulation can be used for the actual building. When doing so, a calculation in accordance with specified standard parameters is required. These are described in Appendices 2, 4 and 5.

From the relevant LCA datasets (e.g. ESUCO, CHISUCO or country specific datasets[6]) **electricity mix** should be used as a basis for the life cycle assessment values of the estimated **electricity demand**. Purchase of the green electricity cannot be assessed in the schemes for the new building. Proportions of green electricity in the average electricity mix have already been taken into account.
The following applies to cases where energy is fed into the grid or generated for internal demand from building systems (photovoltaic systems, cogeneration units): The energy generated can be deducted from the building energy demand. The following should be noted here:

- The proven electricity demand may already be calculated in the EPC calculation by taking into account the internal use of electricity from installations that generate electricity. In this case – in the case of electricity generation from a PV system – for instance, the renewable primary energy demand and the total energy demand of the building would be incorrectly reduced. This must be corrected. Where the electricity production for internal use from a cogeneration unit is taken into account, all life cycle assessment indicators must be corrected accordingly.
- In all cases, it is necessary to state whether or not the energy production in building systems has been taken into account in the calculation of the energy demand and to include this accordingly in the calculation of the life cycle assessment results.
- In the case of extensive electricity production to reduce internal electricity demand from the grid and

[5] Country specific energy performance certificate (statutory regulation) must be fulfilled and consulted with DGNB.
[6] Use of the country specific LCA datasets for energy, to be agreed with DGNB.

to feed excess electricity into the grid, the net value of the electricity balance and similarly the total values of the life cycle assessment indicators can become negative. This corresponds to an energy-positive building (relating to the building operation). These results are valid only for the considered building. Extrapolation of these results across the market is not covered by the methodological framework of the life cycle assessment (particularly attributional life cycle assessment).

A clear list of the estimated gains must be attached to the calculations as an appendix.
The life cycle assessment values for additional energy sources, e.g. for covering the **heating demand**, are to be determined as follows: The method of heat generation must be specified and the corresponding LCA dataset must be used. Use datasets e.g. ESUCO already partially include losses from combustion efficiency rates (Q_G). These efficiency rates/losses are documented accordingly in the dataset.

The following approach applies to the use of **long-distance district heating** if no situation-specific long-distance district heating life cycle assessment dataset is available:

- If the energy supplier can demonstrate a proportion of renewable in the long-distance district heating. (but not the primary energy factor), this is estimated by the dataset for the secondary fuel combustion (if not available, by means of a dataset for industrial-scale wood combustion). The non-renewable proportion of long-distance district heating is linked to the corresponding LCA dataset e.g. ESUCO, long-distance district heating datasets represent the mix of non-renewable long-distance district heating. The size of the renewable proportion of the long-distance district heating provided by the supplier must be proven with a corresponding certificate or statement from the supplier. Regenerative sources of long-distance district heating include biomass, biogas, sewage gas, landfill gas and solar thermal energy.

When using **geothermal energy, PV systems, solar collectors or cogeneration units**, the following applies:

- The auxiliary energy shown in the energy certificate normally contains the electricity demand for the operation of a heat pump. In this case, the renewable energy in the form of geothermal energy must also be considered as renewable primary energy. If the energy certificate does not show the electricity demand of the heat pump, it is necessary to use a suitable heat pump data set (which must contain both the electricity demand and the renewable energy in the form of geothermal energy).
- Process for assessing an electrical heat pump: The electricity demand of the heat pump (final energy) specified in the EPC and the electricity mix life cycle assessment dataset can be used to determine the environmental impact potentials from operation of the heat pump as a first step. As a second step, the generated renewable energy (PEr) is determined by then multiplying the electricity demand of the heat pump (final energy) specified in the energy certificate by the Seasonal Performance Factor (SPF) of the heat pump.
- It is permissible to use life cycle assessment datasets for electrical brine water heat pumps for calculating deep geothermal energy.
- Only the generated renewable energy can be additionally taken into account for assessing photovoltaic systems and solar collectors in operation.
- It is permissible to use life cycle assessment datasets for gas condensing boilers for calculating the heat production of cogeneration units. In order to adequately take a small cogeneration unit, including electricity supply, into account, specific calculation of the cogeneration unit is recommended, and in any case the impact of the electricity production in the cogeneration unit must be taken into account. The allocation of the impacts must be carried out in accordance with the energy content of the products (to ensure consistency with LCA datasets).

If the energy production cannot be represented directly using LCA datasets, a project-specific calculation must be carried out, or, if this is not possible, a suitable conservative estimation with a comparable available dataset must be made. Selected method must be argued and documented. Alternatively, as a preferred variant, an Environmental Product Declaration (EPD) in accordance with DIN EN ISO 14025 and DIN EN 15804 for the specific method of energy production can be used.

The use of **waste heat from industrial processes** can be incorporated into the calculation separately, i.e. without including emissions and resource expenditure, if it can be proven that this waste heat is not used for any other purpose. The use of waste heat from industrial-scale waste incineration plants is an exception to this rule, and must be considered in accordance with the rules for long-distance district heating (see above).

Module B4: Scenario for replacement
Expected durations of use for components can be found in the following data sources:

- Construction materials/construction products and technical installations: "Guideline for sustainable buildings" on behalf of Ministry of Transport, Building and Housing, Germany 2001, or from corresponding information for the reference durations of use from Environmental Product Declarations (EPD) in accordance with DIN EN 15804.

Calculations for replacement must be carried out for all materials and components or surfaces with duration of use smaller than the reference period t_d. The frequency of replacement of components/products after their expected duration of use is determined assuming replacement with the component/product that was originally used in the calculations. For this calculation, only complete (integer) replacement is permitted (no partial replacements). The frequency of replacement is determined by dividing the reference period by the expected duration of use of the component/product. In the event of a calculated partial replacement (non-integer values), the resulting value must be rounded up. For this process, it is important to ensure that the technical framework conditions of the replacement are calculated as realistically as possible. This applies above all to the accessibility of components that may require additional layers to be removed and replaced.

The frequency of replacement is determined as follows:

$$\mathbf{n_{Replacement} = rounded\ up\ (t_R/t_D) - 1 \quad [-]}$$

where

- $n_{Replacement}$: Frequency of replacement; if the result is a decimal (partial replacement), the result must be rounded up to the next whole number
- t_R: Reference period [a]
- t_D: Duration of use of a component in [a]

The recovery and disposal of the replaced components/products must be calculated in a suitable quantity with the appropriate "end-of-life data sets" and recorded in the overall assessment (see Calculation method for end-of-life phase scenario). Transportation to the construction site and to recovery and disposal facilities is to be ignored.

The plausibility of the approaches must be demonstrated. It must be ensured that the assumptions made are the same as those made for the calculation of the irregular maintenance costs for life cycle costs.

Please note: If determination of quantities is calculated using the partial calculation method calculation method, the indicator results for the scenario for maintenance and replacement must be multiplied by a **factor of 1.4**. If comprehensive passive measures are taken into account and recognised in criterion TEC1.4, indicator 1, the factor of 1.4 for the partial method can be reduced to a factor of 1.35 for passive buildings. If determination of quantities is carried out using the simplified calculation method, the indicator results for the scenario maintenance and replacement must be multiplied by a factor of 1.2. If comprehensive passive measures are taken into account and recognised in criterion TEC1.4, indicator 1, the factor of 1.2 for the simplified method can be reduced to a factor of 1.1 for passive buildings.

1.3.4 Calculation method for end-of-life phase (modules C3, C4) and benefits and liabilities outside of the system limits (module D)

Recovery and disposal of all materials/construction materials listed in the production phase must be included in the calculation of the life cycle assessment results for the end-of-life scenario (EoL) for the building. To simplify this process, the calculation can also be carried out for groups of materials with the same EoL scenario.

Materials must be divided into the following material groups for the calculations and evaluations:

(1) Metals for recovery
(2) Mineral materials for recovery
(3) Materials for thermal recovery (with a calorific value, e.g. wood, plastics, etc.)
(4) Materials that can only be deposited at a landfill
(5) Heating and cooling systems and air conditioning systems[7]

- For (1), the following applies: The disposal/recycling path "Recycling/recovery" must be selected. The datasets for the corresponding "metal recycling potential" that contain modules C and D must be selected. Precise allocation must be ensured. If an unambiguously suitable dataset is not available, a similar dataset must be selected. It should be noted that only metals with proportions produced via primary manufacturing can be demonstrated as having a recycling potential corresponding to such proportions (this is usually found in EoL datasets calculated in accordance with DIN EN 15804). If a product consists entirely of recycled material, no further recycling potential can be assessed (e.g. reinforcing steel).
- For (2), the following applies: The disposal/recycling path "Recycling/recovery" must be selected. The process "Construction rubble reprocessing" (part of module C) must be selected for mineral materials that are demonstrably usually recoverable (materials such as concrete used for backfilling in road or landfill construction) and must be linked to a credit note (negative dataset) for a corresponding quantity of gravel (part of module D).
- For (3), the following applies: The disposal option "Thermal recovery" must be selected. The datasets can be summarised by material groups (wood, wooden materials, plastics, etc.) and must be represented with the corresponding datasets for thermal recovery. Documentation is carried out in module C4 (in the event of thermal recovery without energy generation) or in module C3 and D if thermal recovery with energy generation can be applied (in accordance with the definition of the dataset).
- For (4), the following applies: The recycling path "Disposal at landfill" must be selected if no other recovery option aside from depositing at a landfill is typically used for the materials. This applies, for instance, to glass, mineral wool, bitumen sheeting, plasterboard, etc. Suitable datasets or mixed material datasets must be selected for this. The results are part of module C.
- For (5), the following applies: The dataset that corresponds to the production must be assessed. Here, it is important to ensure the correct scaling of the quantities and the correct unit of reference for the life cycle assessment datasets used (same as the statements listed under "Construction").

[7] Not included in the PCM

- Where the building service installations are taken into account in detail in the life cycle assessment, suitable EoL scenarios must be provided accordingly. Here, it is recommended to fractionate the material mix of building service installations to enable the use of available EoL scenarios and datasets.

Note 1: If determination of quantities is calculated using the partial calculation method, the indicator results for the EoL scenario must be multiplied by a **factor of 1.4** (see above). If comprehensive passive measures are taken into account and recognised in criterion TEC1.4, indicator 1, the factor of 1.4 for the partial method can be reduced to a factor of 1.35 for passive buildings. If determination of quantities is calculated using the simplified calculation method, the indicator results for the EoL scenario must be multiplied by a **factor of 1.2** (see above). If comprehensive passive measures are taken into account and recognised in criterion TEC1.4, indicator 1, the factor of 1.2 for the simplified method can be reduced to a factor of 1.1 for passive buildings.

Note 2: If EoL scenarios are taken from EPDs for specific construction products, it must be ensured that multiple alternative scenarios can be specified in EPDs. Generally, a standard scenario is defined that reflects the normal recycling path. This standard scenario can be used even if it deviates from the specifications given above for the EoL scenario that is to be applied. However, this requires that the specific installation location of the product supports the scenario. (Example: A standard scenario of an EPD assumes that the product is installed such that it can be removed, e.g. that it is screwed in place. However, if the product is glued in place in the specific project in question, it may no longer be available for the standard EoL scenario. In this case, a suitable EoL scenario must be used.)

Note 3: The available EoL datasets are generally differentiated in less detail than manufacturing datasets for construction materials (this also applies to generic datasets). As recovery of construction materials using up-to-date methods is rarely carried out on a product-specific basis, but is instead often carried out by fractionating the demolition material into product groups, it is appropriate and sufficiently precise to represent the EoL with a small number of average datasets. For product-specific recovery methods, e.g. due to an established recovery system, it is possible to refer to corresponding EPDs incl. data for the EoL.

1.4 Requirements for data

1.4.1 Data for the building life cycle assessment

In principle, specific and verified life cycle assessment data (e.g. Environmental Product Declaration, EPD) should be preferred over general, generic life cycle assessment data. The DGNB provides DGNB Auditors and Consultants with access to the following LCA databases which include both generic and specific data:

- European Sustainable Construction Database ESUCO
- Chinese Sustainable Construction Database CHISUCO

These databases are suited to the scope and purpose of the LCA calculations. They are consistent in their methodology and provide the required results for each indicator. The methodological consistency, conformity and completeness of specific data from other sources must be verified by independent external experts. These requirements are fulfilled by EPD type III declarations according to ISO 14025 and DIN EN 15804.
The use of manufacturer-specific data sets for products that are not used in the building is only permitted in justified exceptional cases and only if a safety margin of at least 10% is added to the DGNB life cycle assessment indicator results in order to take into account possible deviations in the data sets used. As a general rule, preference should be given to datasets which most precisely reflect the item in question (materials, end-of-life scenario, energy supply, etc.) in terms of technical relevance and assessment date, e.g. generic datasets for design phase assessment, product-specific EPD for final documentation.
Please note: This safety margin is not to be confused with the 20% margin (factor of 1.2) for building construction

that must be applied when using the calculation rules for the simplified calculation method (taking into account only selected constituent parts of the building) (see above).

For other general (generic) data that has not been checked externally, a calculation margin ("safety margin") must be included in the calculations in order to compensate for the possibility of data that does not accurately reflect reality. For classification of such datasets with regard to their quality and representativeness, it is possible to refer to e.g. ESUCO dataset.

The following applies as a general rule for selecting datasets: The dataset must be selected that most accurately represents (in terms of materials, end-of-life scenario, energy supply, etc.) the subject of the assessment (material or component), with reference to conformity to technical specifications and time of assessment (e.g. general data for the concept analysis, company-specific EPDs for final documentation). Project-specific life cycle assessment data that has not been subject to any external verification in accordance with DIN EN 15804 can only be used subject to certain conditions (see "Required documentation").

1.4.2 Data quality and requirements regarding completeness of life cycle assessment data
It is possible to select both aggregate data for assembled components or entire systems such as walls, roof systems, etc. and product-specific or material-specific data for components. In all cases, the data must be representative, regardless of whether it consists of general life cycle assessment data, average values or manufacturer-specific life cycle assessment data. LCA data other than that provided in ESUCO database must match the methodological standards, quality and completeness set by EN 15804 standard and this must be documented comprehensively for verification.
If EPDs are used, these must be in accordance with DIN EN 15804 and must be valid at the time the product is used (or at the time of the decision to purchase the product). Datasets with expired validity can only be used in justified exceptional cases.

Please note: EPDs in accordance with DIN EN 15804 have a validity period of 5 years, but the validity can be extended if necessary in individual cases.

When using data or EPDs not nominally in accordance with DIN EN 15804, it must be ensured that the data or EPDs comply with the same methodological specifications as ESUCO database in terms of quality and completeness.

The cut-off criteria for life cycle assessment data sets must comply with the requirements of DIN EN 15804 and/or with the methodological standards set by ESUCO database.

Note:
DGNB Auditors and Consultants should consult with DGNB if no adequate LCA datasets are locally available.

1.5 Report and presentation of the results
A short project report must be created (see "Required documentation") and information to ensure transparency of the creation of the building model must be provided. The life cycle assessment results must be presented in accordance with the documentation specifications. When doing so, the indicators and parameters listed in the descriptions of the criteria must be evaluated.

The life cycle assessment **results must be presented with reference to a period of one year and one m^2 NFA, excluding driving lines in underground garages**. This must be implemented consistently across all criteria of the life cycle assessment. In the verification documentation, the NFA must be presented separated into usable area (UA), circulation space (CS) and technical plant areas (TPA) for each storey, and the vehicle parking areas must be presented separately from the driving lanes for underground garages. All area calculations must be carried out in accordance with the [T&D_04].

The following applies to industrial buildings: For buildings with ≤ 12 m clear room height, an approach using area in m^2 NFA must be used. For buildings with > 12 m clear room height, the assessment must be carried out with reference to gross volume GV in m^3. The gross volume must be calculated in accordance with the [T&D_04].

2. Methodological basis for the building life cycle assessment

The evaluation includes optimisation of the emissions for construction and operation at the same time throughout the entire life cycle. The determined values are specified as an indicator result relating to the net volume NV: Indicator result in [kg environmental impact equivalent/(m^2NFA*a)][8]. They are calculated as an average annual value for the building and compared to reference values for assessment. Lower values for the emissions equivalents correspond to lower potential environmental impacts. The calculation method described below must be carried out separately for each environmental impact indicator.

2.1 Life cycle assessment results for the actual building

The environmental impacts of the constructed building are summarised as a shared parameter in the form of an environmental impact potential (EIP) as an average annual value across the reference period considered for assessment of the indicators:

$$\mathbf{EIP_T = EIP_C + EIP_U} \qquad \mathbf{(1)}$$

where

- EIP_T Total resulting environmental impact potential for construction (C) and use (U) of the building in [kg environmental impact equivalent/(m^2_{NFA}*a)]
- EIP_C Resulting environmental impact potential during construction, replacement, recovery and disposal of the building including the technical facilities used as an annual average value over the reference period considered for the certification t_d of in [kg environmental impact equivalent/(m^2_{NFA}*a)]
- EIP_U Predicted annual environmental impact potential for **operation** of the implemented building, derived from the final energy demand in accordance with EPC (or standardised energy simulation) plus the environmental impact potential for the user equipment during building operation, derived from the final energy demand of the defined facilities (insofar as required under "Usage-specific description of the method") in [kg environmental impact equivalent/(m^2_{NFA}*a)]

The average annual value for the **construction EIP_C** is determined as follows:

$$\mathbf{EIP_C = (P + D + M) / t_d} \qquad \mathbf{(2)}$$

where

- P Predicted value for the environmental impact potential resulting from **production** (building construction and technical facilities) for the implemented building in [kg environmental impact equivalent/(m^2_{NFA})]
- D Predicted value for the environmental impact potential resulting from **recovery and disposal** (building construction and technical facilities) for the implemented building in [kg environmental impact equivalent/(m^2_{NFA})]

[8] The total primary energy demand and non-renewable primary energy demand indicators are specified in [MJ/(m^2_{NFA}*a)] and the water demand indicator is specified in [m^3/(m^2_{NFA}*a)].

- M Predicted value for the environmental impact potential resulting from **replacement** (building construction and technical facilities) for the implemented building in [kg environmental impact equivalent/(m^2_{NFA}*a)]
- t_d **Reference period** considered for the certification in [a].

The average annual value for the **use EIP_U** is determined as follows:

$$EIP_U = EIP_{UE} + EIP_{UH} + EIP_{UF} \quad (3)$$

where

- EIP_{UE} Environmental impact potential of the **electricity demand during use**, calculated in accordance with EPC (or standardised energy simulation), multiplied by the EIP factor of the electricity mix from the relevant LCA dataset in [kg environmental impact equivalent/(m^2_{NFA}*a)]
- EIP_{UH} Environmental impact potential of the **heating and, where applicable, cooling demand during use**, calculated in accordance with EPC (or standardised energy simulation), multiplied by the EIP factor of the selected energy source from the relevant LCA dataset in [kg environmental impact equivalent/(m^2_{NFA}*a)]
- EIP_{UF} Only for selected schemes: Predicted annual environmental impact potential for the **user equipment during building operation**, derived from the final energy demand of the defined facilities in [kg environmental impact equivalent/(m^2_{NFA}*a)]

2.2. Reference values for the building life cycle assessment

The reference values (30 and 40 sub-points) for the environmental indicators (EIP_{Gref}) are generally derived from

- a fixed proportion for the construction-related value of the environmental impacts of emissions for construction, maintenance and recovery/disposal, as well as
- a variable proportion for the use-related value of the environmental impacts of emissions at the level of the reference building used as a basis in EPC (or standardised energy simulation). The variable proportion is calculated from the electricity and heating demand (final energy) determined in accordance with EPC (or standardised energy simulation), multiplied by defined factors (values of the environmental profiles for the electricity mix and a representative thermal energy mix).

$$R_{EIP} = EIP_{Gref} = EIP_{Cref} + EIP_{Uref} \quad (5)$$

where

- EIP_{Cref} Reference value for the annual average value of the environmental impact potential for **construction, replacement, recovery and disposal** of the building including the technical facilities used across the reference period considered t_d, in [kg environmental impact equivalent/(m^2_{NFA}*a)]
- EIP_{Uref} Reference value for the annual environmental impact potential resulting from **operation** of the building, derived from the final energy demand of the reference building in accordance with EPC (or standardised energy simulation) or – for selected schemes – reference value for the annual environmental impact potential resulting from the **user equipment** during building operation, derived from the final energy demand of the defined facilities in [kg environmental impact equivalent/(m^2_{NFA}*a)]

The reference values for the **construction EIP_{Cref}** are determined as follows:

EIP_{Cref} = constant (6)

The EIP_{Cref} values are determined using parameters derived from statistical studies.

The reference values for the **use EIP_{Uref}** are determined as follows:

$EIP_{Uref} = EIP_{UEref} + EIP_{UHref} + EIP_{UFref}$ (7)

where

- EIP_{UEref} Environmental impact potential of the annual **electricity demand (final energy) of the reference building** in accordance with EPC (or standardised energy simulation) in [kg environmental impact equivalent/(m^2_{NFA}*a)]
- EIP_{UHref} Environmental impact potential of the annual **heating and, where applicable, cooling demand (final energy) of the reference building** in accordance with EPC (or standardised energy simulation) in [kg environmental impact equivalent/(m^2_{NFA}*a)]
- EIP_{UFref} only for selected schemes: Reference value for the annual environmental impact potential of the **user equipment during building operation**, derived from the final energy demand of the defined facilities in [kg environmental impact equivalent/(m^2_{NFA}*a)]

The calculation of the final energy demand is based on either Building EPC or a standardised energy simulation.

The reference period t_d is 50 years. A reference period of 20 years must be selected for the **Production** and **Logistics** schemes.

The following influencing parameters have already been taken into account in the conversion table (reference):
For the construction-related value of the environmental impacts of emissions and resource demands:

(1) Relevant statistical research for manufacture, maintenance, and end-of-life phases.
(2) Results of the DGNB certifications
(3) Long-term objective of the DGNB for the environmental indicators

For the use-related value of the environmental impacts of emissions:

(4) Current factors for electricity environmental profile and representative mix for thermal energy

Life cycle assessment results for the actual building and reference values

The achieved values and the reference values must be determined in accordance with the "General description of the evaluation method".

Table 2: Reference values for construction, maintenance and recovery/disposal ("construction") as well as use: GWP, ODP, POCP, AP, EP

	GWP	ODP	POCP	AP	EP
Unit	[kg CO_2 equiv./(m^2_{NFA}*a)]	[kg R11 equiv./(m^2_{NFA}*a)	[kg C_2H_4 equiv./(m^2_{NFA}*a)]	[kg SO_2 equiv./(m^2_{NFA}*a)]	[kg PO_4^3 equiv./(m^2_{NFA}*a)]
Office **Education** **Residential** **Hotel** **Consumer markets** **Shopping centre** **Department store** **Assembly buildings** Type I Construction	GWP_{Cref} = 9.4	$ODP_{Cref} = 5.3 \cdot 10^{-7}$	$POCP_{Cref}$ = 0.0042	AP_{Cref} = 0.037	EP_{Cref} = 0.0047
Logistics **Production** **Assembly buildings** Type II Construction (per m³ GV)	GWP_{Cref} = 1.2/(m^3_{GV}*a)	$ODP_{Cref} = 1.9 \cdot 10^{-8}$ /(m^3_{GV}*a)	$POCP_{Cref}$ = 0.0005 /(m^3_{GV}*a)	AP_{Cref} = 0.003 /(m^3_{GV}*a)	EP_{Cref} = 0.0004 /(m^3_{GV}*a)
Logistics **Production** **Assembly buildings** Type II Construction (per m²NFA)	GWP_{Cref} = 12/($m^2_{S\ NFA}$*a)	$ODP_{Cref} = 1.9 \cdot 10^{-7}$ /($m^2_{S\ NFA}$*a)	$POCP_{Cref}$ = 0.005/($m^2_{S\ NFA}$*a)	AP_{Cref} = 0.03/($m^2_{S\ NFA}$*a)	EP_{Cref} = 0.004/($m^2_{S\ NFA}$*a)
Use	$GWP_{Uref} = GWP_{UEref} + GWP_{UHref} + GWP_{UF,ref}$ where GWP_{UEref} = GWP factor el.mix * E_{ref} GWP_{UHref} = GWP factor heat * H_{ref}	$ODP_{Uref} = ODP_{UEref} + ODP_{UHref} + ODP_{UF,ref}$ where ODP_{UEref} = ODP factor el.mix * E_{ref} ODP_{UHref} = ODP factor heat * H_{ref}	$POCP_{Uref} = POCP_{UEref} + POCP_{UHref} + POCP_{UF,ref}$ where $POCP_{UEref}$ = POCP factor el.mix * E_{ref} $POCP_{UHref}$ = POCP factor heat * H_{ref}	$AP_{Uref} = AP_{UEref} + AP_{UHref} + AP_{UF,ref}$ where AP_{UEref} = AP factor el.mix * E_{ref} AP_{UHref} = AP factor heat * H_{ref}	$EP_{Uref} = EP_{UEref} + EP_{UHref} + EP_{UF,ref}$ where EP_{UEref} = EP factor el.mix * E_{ref} EP_{UHref} = EP factor heat * H_{ref}
Office **Education** **Residential** **Hotel** **Consumer markets** **Shopping centre**	$GWP_{UF,ref}$ = 0	$ODP_{UF,ref}$ = 0	$POCP_{UF,ref}$ = 0	$AP_{UF,ref}$ = 0	$EP_{UF,ref}$ = 0

Department stores **Assembly buildings** Type I and II					
Consumer markets **Shopping centre** **Department stores**	GWP_{UFEref} = GWP factor el.mix * E_{UFref}	ODP_{UFEref} = ODP factor el.mix * E_{UFref}	$POCP_{UFEref}$ = POCP factor el.mix * E_{UFref}	AP_{UFEref} = AP factor el.mix * E_{UFref}	EP_{UFEref} = EP factor el.mix * E_{UFref}

where

- E_{ref} Electricity demand (final energy) of the reference building in accordance with EPC (or standardised energy simulation) in [kWh/(m^2_{NFA} *a)]
- H_{ref} Heating demand (final energy) of the reference building in accordance with EPC (or standardised energy simulation) in [kWh/(m^2_{NFA} *a)]
- E_{UFref} Electricity demand of the user equipment in [kWh/(m^2_{NFA} *a)]
- GWP, ODP, POCP, AP and EP factors for electricity mix and heat coming from the LCA datasets ESUCO/CHISUCO, or alternatively in any other LCA dataset which complies with the ISO 14025 and DIN EN 15804. The external datasets must be agreed with DGNB in system adaptation process.

Table 3: Reference values for construction, maintenance and recovery/disposal ("construction") as well as use: PEnr, PEtot and PEr/PEtot ratio

	PE_{NR}	PE_{TOT}	PE_R/PE_{TOT}
Unit	[MJ/(m^2_{NFA}*a)]	[MJ/(m^2_{NFA}*a)]	[%]
Office **Education** **Residential** **Hotel** **Consumer markets** **Shopping centre** **Department stores** **Assembly buildings** Type I and II Construction	$PE_{nr,Cref}$ = 123	$PE_{tot,Cref}$ = 151	[-]
Logistics **Production** **Assembly buildings** Type I and II Construction (per m³ GV)	$PE_{nr,Cref}$ = 12.3	$PE_{tot,Cref}$ = 13.7	[-]
Logistics **Production** Construction (per m² NFA)	$PE_{nr,Cref}$ = 123	$PE_{tot,Cref}$ = 137	[-]
Use	$PE_{nr,Uref}$ = ($PE_{nr,UEref}$ + $PE_{nr,UHref}$ + $PE_{nr,UFref}$) where $PE_{nr,UEref}$ = factor $PE_{nr,E}$ MJ * E_{ref} kWh	$PE_{tot,Uref}$ = ($PE_{tot,UEref}$ + $PE_{tot,UHref}$ + $PE_{tot,UFref}$) where $PE_{tot,UEref}$ = factor $PE_{tot,E}$ MJ * E_{ref} kWh	[-]

	$PE_{nr,UHref}$ = factor $PE_{nr,H}$ MJ * H_{ref} kWh	$PE_{tot,UHref}$ = factor $PE_{tot,H}$ MJ * H_{ref} kWh	
Office Education Residential Hotel Consumer markets Shopping centre Department stores Assembly buildings Type I and II	$PE_{nr,UFref}$ = 0	$PE_{tot,UFref}$ = 0	
Consumer markets Shopping centre Department stores	$PE_{nr,UFref}$ = factor $PE_{nr,E}$ MJ * E_{UFref} kWh	$PE_{tot,UFref}$ = factor $PE_{tot,E}$ MJ * E_{UFref} kWh	
All building types:			15% (use and construction)

where

- E_{ref} Electricity demand (final energy) of the reference building in accordance with EPC or from a standardised thermal energy simulation in [kWh/(m²$_{NFA}$*a)]
- H_{ref} Heating demand (final energy) of the reference building in accordance with EPC or from a standardised thermal energy simulation in [kWh/(m²$_{NFA}$*a)]
- E_{UFref} Electricity demand of the user equipment in [kWh/(m²$_{NFA}$*a)]
- factor $PE_{nr,E}$ Primary energy (not renewable) for electricity from relevant LCA dataset (e.g. ESUCO, CHISUCO, national etc.)
- factor $PE_{tot,E}$ Primary energy (total) for electricity from relevant LCA dataset (e.g. ESUCO, CHISUCO, national etc.)
- factor $PE_{nr,H}$ Primary energy (not renewable) for heat from relevant LCA dataset (e.g. ESUCO, CHISUCO, national etc.)
- factor $PE_{tot,H}$ Primary energy (total) for heat from relevant LCA dataset (e.g. ESUCO, CHISUCO, national etc.)

Note: all national or global (beside ESUCO and CHISUCO) LCA datasets must be in compliance with the ISO 14025, DIN EN 15804 and must be agreed with DGNB in system adaptation process.

Limit value and target value calculation

Limit values G and target values Z, which are also required for evaluation of the criterion, are generally defined as a factor applied to the reference values for the various environmental impact potentials, expressed mathematically as follows:

$$G_{EIP} = X_{EIP} * R_{EIP}$$
$$Z_{EIP} = Y_{EIP} * R_{EIP}$$

The associated variables X and Y must be formulated for the various environmental indicators as shown in Table 4.

Table 4: Target and limit values of the various environmental indicators

LIMIT AND TARGET VALUE	GWP	POCP	AP	EP	PE_{NR}	PE_{TOT}	PE_R/PE_{TOT}	ODP	LS	ADP_E
X	1.4	2.0	1.7	2.0	1.4	1.4	5%	-	-	-
Y	0.7	0.7	0.7	0.7	0.7	0.7	30%	-	-	-
Y+ (overfulfil-ment)	0.55	0.55	0.55	0.55	0.55	0.55	37.5%	-	-	-

Please note: The reference value (15%) for the proportion of renewable primary energy is derived from the current proportion of renewable primary energy in the German energy mix in accordance with *Ökobau.dat* (German LCA dataset) 2017; The limit value (5%) is derived from a lower proportion of energy throughout the life cycle of the building and an energy source for heat with no proportion of renewable energy sources.

Table 5: Conversion table and sub-points for environmental indicators

SUB-POINTS	GWP	POCP	AP	EP	PE_{NR}	PE_{TOT}	PE_R/PE_{TOT}	ODP	WU	ADP_E
0	$GWP_B \geq 1.4 * GWP_{tot,ref}$	$POCP_B \geq 2.0 * POCP_{tot,ref}$	$AP_G \geq 1.7 * AP_{tot,ref}$	$EP_B \geq 2.0 * EP_{tot,ref}$	$PE_{nr} \geq 1.4 * PE_{nr,ref}$	$PE_{tot} \geq 1.4 * PE_{tot,ref}$	$PE_r/PE_{tot} = 5\%$	Values for ODP_B and ODP_{Bref} provided	Values for WU_B and WU_{Bref} provided	Values for ADP_B and ADP_{Bref} provided
40 (30 for PCM)	$GWP_B = GWP_{tot,ref}$	$POCP_B = POCP_{tot,ref}$	$AP_B = AP_{tot,ref}$	$EP_B = EP_{tot,ref}$	$PE_{nr} = PE_{nr,ref}$	$PE_{tot} = PE_{tot,ref}$	$PE_r/PE_{tot} = 15\%$	n/a	n/a	n/a
80 (60 for PCM)	$GWP_B < 0.70 * GWP_{tot,ref}$	$POCP_B < 0.70 * POCP_{tot,ref}$	$AP_B < 0.70 * AP_{tot,ref}$	$EP_B < 0.70 * EP_{tot,ref}$	$PE_{nr} < 0.70 * PE_{nr,ref}$	$PE_{tot} < 0.70 * PE_{tot,ref}$	$PE_r/PE_{tot} < 30\%$	n/a	n/a	n/a
90 (70 for PCM) (over-fulfil-ment)	$GWP_B < 0.55 * GWP_{tot,ref}$	$POCP_B < 0.55 * POCP_{tot,ref}$	$AP_B < 0.55 * AP_{tot,ref}$	$EP_B < 0.55 * EP_{tot,ref}$	$PE_{nr} < 0.55 * PE_{nr,ref}$	$PE_{tot} < 0.55 * PE_{tot,ref}$	$PE_r/PE_{tot} < 37.5\%$	n/a	n/a	n/a

Weighting of the indicators for assessing the weighted environmental impacts

Table 6: Weighting key for the environmental indicators (W)

W_{GWP}	W_{POCP}	W_{AP}	W_{EP}	W_{PENR}	W_{PETOT}	$W_{PENR/PETOT}$
40%	10%	10%	10%	15%	10%	5%

To calculate the weighted environmental impacts (= points) for indicator 3 "Life cycle assessment comparison calculation", the sub-points regarding target, reference and limit values from Table 4 and Table 5 must be assessed separately for each environmental indicator. The sub-points (SP) must then be weighted using the weighting key from Table 6. The total of the weighted sub-points is the total of the possible points in the indicator. Depending on the LCA calculation method. the target value (Y) amounts to 80 (60) points in the indicator, and an overfulfilment of the target value (Y+) can be awarded up to 100 (80) points. Fulfilment of the reference value amounts to 40 (30) points.

Points for indicator 3 =
$SP_{GWP}*W_{GWP} + SP_{POCP}*W_{POCP} + SP_{AP}*W_{AP} + SP_{EP}*W_{EP} + SP_{PEnr}*W_{PEnr} + SP_{PEtot}*W_{PEtot} + SP_{PEnr/PEtot}*W_{PEnr/PEtot}$

Other definitions: Life cycle assessment indicators

(1) Global warming potential (GWP)
The accumulation of greenhouse gases in the atmosphere results in warming of air layers close to the ground (greenhouse effect). The global warming potential of a substance is always indicated in comparison to the global warming potential of carbon dioxide (CO_2), meaning that emissions that contribute to the greenhouse effect are expressed as carbon dioxide (CO_2) equivalents. As greenhouse gases persist in the atmosphere for different lengths of time, the GWP value must be specified in relation to a period of time. A period of 100 years is used as a basis for characterising contributions to the GWP. In addition, impact factors are used to describe the extent to which different substances contribute to the global warming potential. Considered over a period of 100 years, a given mass of methane has an impact factor 25 times greater in comparison to an equal mass of CO_2. This means that the CO_2 equivalent of methane is 25. This means that a given mass of methane contributes 25 times as much to the greenhouse effect as an equal mass of CO_2 (with a GWP value of 1).

(2) Ozone depletion potential (ODP)
Ozone is only present in the atmosphere in low concentrations, but is extremely important for life on Earth. It can absorb short-wave UV radiation and then emit it again with a greater wavelength, regardless of direction. The ozone layer shields the Earth from a large part of the UV-A and UV-B radiation from the sun, preventing excessive warming of the Earth's surface and protecting flora and fauna. The accumulation of harmful halogenated hydrocarbons in the atmosphere contributes to the destruction of the ozone layer. The consequences of this include tumours in humans and animals and disruption of photosynthesis. The ozone depletion potential is specified in [kg R11 equivalent/m^2_{NFA}*a]; the ODP values refer to the chlorofluorocarbon comparison substance CFC-11. All substances with a value of less than 1 have a lower ozone depletion effect while substances with a value of greater than 1 have a higher ozone depletion effect, in comparison to CFC-11 (also referred to as R11; chemical formula CCl_3F).

(3) Photochemical ozone creation potential (POCP)
The photochemical ozone creation potential indicates the equivalent amount of harmful trace gases in relation to the mass. These trace gases, such as nitrogen oxides and hydrocarbons, contribute to the formation of ground-level ozone in conjunction with UV radiation. This contamination of the ground-level air layers with a high concentration of ozone is also known as summer smog. Summer smog attacks the respiratory organs and harms plants and animals.

The concentration of ground-level ozone is regularly determined by air quality measuring stations and recorded in pollution maps.

(4) Acidification potential (AP)
The acidification potential indicates the impact of acidifying emissions; it is measured in sulphur dioxide (SO_2) equivalents. Air pollutants such as sulphur compounds and nitrogen compounds react with water in the air to form sulphuric or nitric acid; this falls to earth as "acid rain" and enters the soil and bodies of water. This harms living creatures and buildings. For instance, nutrients in acidified soil are rapidly chemically broken down and washed out more quickly. Poisonous substances can also form in the soil, attacking root systems and disrupting the water balance of plants. Taken together, the wide range of individual impacts of acidification result in two serious consequences: Forest dieback and fish mortality. However, acid rain also attacks buildings. Sandstone used in historical buildings is particularly susceptible to this.

(5) Eutrophication potential (EP)
Eutrophication refers to waters and soils changing from a low-nutrient (oligotrophic) state to a high-nutrient (eutrophic) state. This is caused by the influx of nutrients, particularly phosphorous and nitrogen compounds. These compounds can enter the environment via the manufacturing of construction products and the leaching of combustion emissions. If the concentration of available nutrients in bodies of water increases, algae growth also increases. This can lead to fish mortality, among other consequences.

(6) Non-renewable primary energy demand (PEnr)
The demand for non-renewable primary energy is determined for construction, repair, operation and dismantling/disposal of the building over its life cycle.
The demand for non-renewable primary energy is determined in relation to area and year and specified in [MJ/m^2_{NFA}*a]. The values required for calculation can (as in criterion ENV1.1 "Life cycle impact assessment") be determined from the energy performance certificate (EPC). The environmental impacts of the construction and the technical facilities can be derived from the life cycle assessment for the materials used.

(7) Total primary energy demand (PEtot)
The required calculation values for the use phase are obtained from the energy certificate. The life cycle assessments for the materials and components used are consulted in order to determine the environmental impacts of construction and technical facilities. Reference values for an average building help with assessment of the construction and technical facilities.

(8) Proportion of renewable primary energy
This indicator assesses the proportion of the total primary energy demand covered by renewable energy. To do so, the average proportion of the total primary energy demand for the building in question covered by renewable primary energy is compared to the values of a reference building in accordance with EPC. If the value for the building is more than 30% below the reference value in accordance with EPC, the requirement for the proportion of renewable primary energy can be reduced proportionally. This enables designers to achieve the overarching objective – an overall reduction in the demand for primary energy – using a variety of different concepts.

(9) Abiotic resource consumption (ADP elements)
ADP (abiotic depletion potential), as an impact category, accounts for the consumption and scarcity of non-renewable (abiotic) resources. These are mineral resources, as opposed to resources from the biosphere. Mineral resources include fossil raw materials, designated as "ADP fossil fuels", and other minerals, designated as "ADP elements". It is important to note that uranium, as a non-fossil fuel, is assigned to the "ADP elements" group. The characterisation factors for fossil raw materials represent the lower calorific value of each raw material. It is assumed that these raw

materials share the same level of scarcity, as they are interchangeable.
The characterisation factors for the remaining mineral resources take the available quantity of the resource in question and its annual extraction rate into account. The estimation of the quantity depends on how much of the raw material can be found in the Earth's crust, or how much can be provided in a technologically and economically practical manner. A variety of calculation approaches are used for this: The "ultimate reserve" only takes into account the total amount found in the Earth's crust. The "reserve base" takes into account the amount available in a technologically and economically practical manner, while the "economic reserve" takes into account the amount that is economically viable to extract. DIN EN 15804 and DIN EN 15978 incorporate the "ultimate reserve" approach.

(10) Water use (WU)
Water consumption or water use refers to any extraction caused by humans, whether temporary or permanent, from a water catchment area, where the extracted water is not deposited back into the same water catchment area. Water consumption can include evaporation, transpiration, inclusion in products/materials or deposition into a different water catchment area or into the sea. Evaporation from a water reservoir can also be counted as consumption, as can irrigation water that evaporates, if the water does not remain in the same water catchment area.
The term used was chosen with the intention that water that is merely used but remains in the same catchment area, such as for water turbines for electricity generation, waterways for shipping, or cooling water, is not counted as consumption. Rainwater that evaporates as a result of natural processes is likewise not counted as consumption.
The standards EN 15978 and EN 15804, which are relevant to the DGNB criteria, contain the indicator "net use of fresh water".
When the EN standards were adopted, ISO 14046 "Environmental 100 management — Water footprint — Principles, requirements and guidelines" had not yet been sufficiently discussed. It was only completed in May 2014. The intention was to use the terms from ISO 14046. The guidance document (which is currently under development) for implementation of EN 15804 describes the indicator in more detail, taking ISO 14046 into account. The standards EN 15978 and EN 15804 generally differentiate between consumption/depletion and use. However, "net use of fresh water" refers to the use of fresh water in the sense of consumption, which the term "net use" is intended to convey.
In the life cycle assessment software systems, e.g. GaBi ts, this indicator is in some cases designated as "Blue water consumption" and specified in [kg].

IV. Usage-specific description

Consumer markets
Shopping centre
Department stores
The reference values must be determined in accordance with the "General description of the evaluation method".
The reference values must be determined in accordance with the "General description of the method". For the reference building in accordance with EPC, the following maintained illuminance values should be included in the calculations:

- Low illuminance: 500 lux, corresponding to approx. 13 W/m² (*)
  (Retail sectors: General, foodstuffs, bakery, furniture, household goods, etc.)
- Medium illuminance: 750 lux, corresponding to approx. 20 W/m² (*)
  (Retail sectors: Mall, textiles, cleaning, perfumery, leather goods, etc.)
- High illuminance: 1000 lux, corresponding to approx. 26 W/m² (*)
  (Retail sectors: Jewellery, lighting, radio and television, etc.)
- Very high illuminance: 1500 lux, corresponding to approx. 39 W/m² (*)
  (Tenant fit out)

(*) "Compact fluorescent lamps with external electronic ballast" are used as a basis (directly) as an average value from high-efficiency T5/T8 lighting and less efficient spotlights.

The reference specifications for electricity consumption for refrigeration facilities for users can be found in Appendix 3 and onwards.

Assembly buildings
Assembly buildings, according to the building volume, to be assigned to one of the following building types:

- Type I: Buildings predominantly without “hall character” (e.g. congress centres, libraries)
- Type II: Buildings largely with “hall character” (such as exhibition halls, town halls)

Appendix 1: System boundaries for the life cycle assessment in the DGNB system

Legend:

x = taken into account
(x) = partly taken into account
= not taken into account
(grey) = not relevant

	A 1–3 PRODUCTION PHASE			A 4–5 ERECTION PHASE		B 1–7 USE PHASE							C 1–4 END OF THE LIFE CYCLE				D BENEFITS AND LIABILITIES OUTSIDE OF THE SYSTEM LIMITS
	RAW MATERIALS PROCUREMENT	TRANSPORT	PRODUCTION	TRANSPORT	ERECTION/INSTALLATION	USE	MAINTENANCE	REPAIR	REPLACEMENT	MODERNISATION	ENERGY CONSUMPTION DURING OPERATION	WATER CONSUMPTION DURING OPERATION	DISMANTLING/DEMOLITION	TRANSPORT	WASTE RECYCLING	DISPOSAL	POTENTIAL FOR RE-USE, RECOVERY AND RECYCLING
System Boundaries included in the LCA of the construction	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Structural components and construction works																	
Excavation																	
Excavation work																	
Support work																	

Dewatering										
Excavation, other items										
Foundations										
Soil improvement	x	x	x					x	x	x
Shallow foundations	x	x	x					x	x	x
Deep foundations	x	x	x					x	x	x
Subfloors and base slabs	x	x	x			(x)[1]		x	x	x
Floorings	x	x	x		(x)[2]	(x)[1]		x	x	x
Waterproofing of structure	x[6]	x[6]	x[6]			(x)[1]		x[6]	x[6]	x[6]
Drainage	x	x	x			(x)[1]		x	x	x
Foundations, other items	x[7]	x[7]	x[7]			(x)[1]		x[7]	x[7]	x[7]
External walls										
Load-bearing external walls	x	x	x			(x)[1]		x	x	x
Non-load-bearing external walls	x[7]	x[7]	x[7]			(x)[1]		x[7]	x[7]	x[7]
External columns	x	x	x			(x)[1]		x	x	x
External doors and windows	x[6]	x[6]	x[6]		(x)[2]	(x)[1]		x[6]	x[6]	x[6]
Cladding units	x[6]	x[6]	x[6]		(x)[2]	(x)[1]		x[6]	x[6]	x[6]
Internal linings (of external walls)	x[6]	x[6]	x[6]		(x)[2]	(x)[1]		x[6]	x[6]	x[6]
Prefabricated façade units	x[7]	x[7]	x[7]			(x)[1]		x[7]	x[7]	x[7]
Solar protection	x[6]	x[6]	x[6]			(x)[1]		x[6]	x[6]	x[6]
External walls, other items	x[7]	x[7]	x[7]			(x)[1]		x[7]	x[7]	x[7]
Internal walls										
Load-bearing internal walls	x	x	x			(x)[1]		x	x	x

Non-load-bearing internal walls	x^7	x^7	x^7			$(x)^1$		x^7	x^7	x^7
Internal columns	x	x	x			$(x)^1$		x	x	x
Internal doors and windows	x^6	x^6	x^6		$(x)^2$	$(x)^1$		x^6	x^6	x^6
Internal linings (of internal walls)	x^6	x^6	x^6		$(x)^2$	$(x)^1$		x^6	x^6	x^6
Prefabricated wall units	x^7	x^7	x^7			$(x)^1$		x^7	x^7	x^7
Internal walls, other items	x^7	x^7	x^7			$(x)^1$		x^7	x^7	x^7
Floors and ceilings										
Floor structures	x	x	x			$(x)^1$		x	x	x
Floorings	x^7	x^7	x^7		$(x)^2$	$(x)^1$		x^7	x^7	x^7
Ceiling linings	x^7	x^7	x^7		$(x)^2$	$(x)^1$		x^7	x^7	x^7
Floors and ceilings, other items	x^7	x^7	x^7			$(x)^1$		x^7	x^7	x^7
Roofs										
Roof structures	x	x	x			$(x)^1$		x	x	x
Roof lights, roof openings	x^6	x^6	x^6		$(x)^2$	$(x)^1$		x^6	x^6	x^6
Roofing	x^7	x^7	x^7			$(x)^1$		x^7	x^7	x^7
Roof coverings	x^7	x^7	x^7			$(x)^1$		x^7	x^7	x^7
Roofs, other items	x^7	x^7	x^7			$(x)^1$		x^7	x^7	x^7
Structural construction installations										
General installations	x^7	x^7	x^7			$(x)^1$		x^7	x^7	x^7
Special installations	x^7	x^7	x^7			$(x)^1$		x^7	x^7	x^7
Structural construction installations, other	x^7	x^7	x^7			$(x)^1$		x^7	x^7	x^7

Other construction-related activities													
Site equipment													
Scaffolding													
Safety measures													
Demolition work													
Repair work													
Final disposal of materials													
Additional work													
Temporary construction work													
Other construction-related activities, other items													
Technical building components													
Sewerage, water and gas systems													
Sewerage systems	x^6	x^6	x^6				(x)[1]			(x)[3]	x^6	x^6	x^6
Water supply systems	x^6	x^6	x^6				(x)[1]			(x)[3]	x^6	x^6	x^6
Gas supply systems	x^6	x^6	x^6				(x)[1]		x		x^6	x^6	x^6
Sewerage, water and gas systems, other items	x^6	x^6	x^6				(x)[1]				x^6	x^6	x^6
Heat supply systems	x^6	x^6	x^6								x^6	x^6	x^6
Heat generators	x^6	x^6	x^6				(x)[1]		x		x^6	x^6	x^6
Heat distribution networks	x^6	x^6	x^6				(x)[1]		x		x^6	x^6	x^6
Space heating	x^6	x^6	x^6				(x)[1]				x^6	x^6	x^6
Heat supply systems, other items	x^6	x^6	x^6				(x)[1]				x^6	x^6	x^6

Air treatment systems	x^6	x^6	x^6					x^6	x^6	x^6
Ventilation systems	x^6	x^6	x^6		$(x)^1$	x		x^6	x^6	x^6
Partial air conditioning systems	x^6	x^6	x^6		$(x)^1$	x		x^6	x^6	x^6
Air conditioning systems	x^6	x^6	x^6		$(x)^1$	x		x^6	x^6	x^6
Refrigerating plants	x^6	x^6	x^6		$(x)^1$	x		x^6	x^6	x^6
Air treatment systems, other items	x^6	x^6	x^6		$(x)^1$			x^6	x^6	x^6
Power installations	x^6	x^6	x^6					x^6	x^6	x^6
High and medium voltage plants	x^6	x^6	x^6		$(x)^1$	x		x^6	x^6	x^6
Independent power supply installations	x^6	x^6	x^6		$(x)^1$	x		x^6	x^6	x^6
Low-voltage switchgears	x^6	x^6	x^6		$(x)^1$	x		x^6	x^6	x^6
Low voltage installation equipment	x^6	x^6	x^6		$(x)^1$	$(x)^5$		x^6	x^6	x^6
Lighting systems	x^6	x^6	x^6		$(x)^1$	x		x^6	x^6	x^6
Lightning protection and earthing systems	x^6	x^6	x^6		$(x)^1$			x^6	x^6	x^6
Power installations, other items	x^6	x^6	x^6		$(x)^1$			x^6	x^6	x^6
Telecommunications and other communications systems	x^6	x^6	x^6					x^6	x^6	x^6
Telecommunications systems	x^6	x^6	x^6		$(x)^1$			x^6	x^6	x^6
Search and signalling equipment	x^6	x^6	x^6		$(x)^1$			x^6	x^6	x^6
Time metering systems	x^6	x^6	x^6		$(x)^1$			x^6	x^6	x^6
Electroacoustic equipment	x^6	x^6	x^6		$(x)^1$			x^6	x^6	x^6
Television and aerial systems	x^6	x^6	x^6		$(x)^1$			x^6	x^6	x^6
Security systems	x^6	x^6	x^6		$(x)^1$			x^6	x^6	x^6

Transmission networks	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Telecommunications and other communications systems, other items	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Transport systems	x[6]	x[6]	x[6]			x[6]	x[6]	x[6]
Lifts	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Escalators, moving pavements	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Inspection and maintenance conveyors	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Conveying plants	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Cranes	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Transport systems, other items	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Function-related equipment and fitments	x[6]	x[6]	x[6]			x[6]	x[6]	x[6]
Kitchen fitments	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Laundry and dry cleaning equipment	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Media supply systems	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Medical and laboratory equipment	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Fire-fighting installations	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Swimming baths equipment	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Process heat plants, refrigeration plants, process air plants	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Disposal facilities	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]
Function-related equipment and fitments, other items	x[6]	x[6]	x[6]		(x)[1]	x[6]	x[6]	x[6]

Building automation	x^6	x^6	x^6												x^6	x^6	x^6
Automated systems	x^6	x^6	x^6						$(x)^1$		$(x)^5$				x^6	x^6	x^6
Control cabinets	x^6	x^6	x^6						$(x)^1$		$(x)^5$				x^6	x^6	x^6
Management and operator facilities	x^6	x^6	x^6						$(x)^1$		$(x)^5$				x^6	x^6	x^6
Room control systems	x^6	x^6	x^6						$(x)^1$		$(x)^5$				x^6	x^6	x^6
Transmission networks	x^6	x^6	x^6						$(x)^1$		$(x)^5$				x^6	x^6	x^6
Building automation, other items	x^6	x^6	x^6						$(x)^1$		$(x)^5$				x^6	x^6	x^6
Other services-related work																	
Site equipment																	
Scaffolding																	
Safety measures																	
Demolition work																	
Repair work																	
Final disposal of materials																	
Additional work																	
Temporary construction work																	
Other services-related work, other items																	

1) Only includes the production and disposal of the replaced product, not the replacement process itself (same as for construction process).
2) Maintenance processes are partially represented as water consumption in ENV1.1.
3) Water consumption of the building is represented in ENV1.1.
4) Photovoltaic systems are not represented due to insufficient data.
5) User electricity consumption is not recorded in full, as it is not completely determined in DIN V 18599.
6) Not included in the partial calculation method (PCM) of the building components
7) Only concrete, incl. reinforcement (and when applicable, perimeter insulation) to be considered in case of PCM

System boundaries for the life cycle assessment in the DGNB system

(Use phase detailed)

Legend:

- x = taken into account
- (x) = partly taken into account
- = not taken into account
- [grey] = not relevant

	A 1–3			A 4–5		B 1–7							C 1–4				D
	PRODUCTION PHASE			ERECTION PHASE		USE PHASE							END OF THE LIFE CYCLE				BENEFITS AND LIABILITIES OUTSIDE OF THE SYSTEM LIMITS
	RAW MATERIALS PROCUREMENT	TRANSPORT	PRODUCTION	TRANSPORT	ERECTION/INSTALLATION	USE	MAINTENANCE	REPAIR	REPLACEMENT	MODERNISATION	ENERGY CONSUMPTION DURING OPERATION	WATER CONSUMPTION DURING OPERATION	DISMANTLING/DEMOLITION	TRANSPORT	WASTE RECYCLING	DISPOSAL	POTENTIAL FOR REUSE, RECOVERY AND RECYCLING
System boundaries in the usage phase	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Operating costs																	
Supply																	
Water											x						
Oil											x						

Gas						x		
Solid fuels						x		
Urban district heating						x		
Electricity						x		
Technical media								
Supply, other items								
Repair costs								
Structural repairs								
Foundations			(x)[1)]	(x)[3)]	(x)[2)]			
External walls			(x)[1)]	(x)[3)]	(x)[2)]			
Internal walls			(x)[1)]	(x)[3)]	(x)[2)]			
Floors and ceilings			(x)[1)]	(x)[3)]	(x)[2)]			
Roofs			(x)[1)]	(x)[3)]	(x)[2)]			
Structural fitments			(x)[1)]		(x)[2)]			
Structural repairs, other items			(x)[1)]		(x)[2)]			

Repair of installations[4]						
Sewerage, water and gas systems			$(x)^{2)}$	x		
Heat supply systems			$(x)^{2)}$	x		
Air treatment systems			$(x)^{2)}$	x		
Power installations			$(x)^{2)}$	x		
Telecommunications and other communications systems			$(x)^{2)}$			
Transport systems			$(x)^{2)}$			
Function-related equipment and fitments			$(x)^{2)}$	x		
Building automation			$(x)^{2)}$			
Repair of installations, other items			$(x)^{2)}$			
Repair of external works						
Ground surfaces						
Hard surfaces						
External construction works						
External services						
External fitments						
Repair of external works, other items						
Repair of equipment						
Equipment						

Works of art							
Repair of equipment, other items							

1) Taken into account by other criteria such as indoor air quality. Not included in ENV1.1.

2) Only includes the production and disposal of the replaced product, not the replacement process itself (same as for construction process).

3) Maintenance processes are partially represented as water consumption in ENV1.1.

4) not included in the PCM

Appendix 2

Building energy demand during operation (Module B6)

As an alternative to the default standard DIN V 18599 (German standard for calculation of the net, final and primary energy demand for heating, cooling, ventilation, domestic hot water and lighting), the final energy demand can be determined via country specific building EPC or building dynamic energy performance simulation. DGNB refers to the several calculation and simulation standards to specify a general framework for the assessment of overall energy use of a building and the calculation of energy performance assessments in terms of primary energy or other energy related metrics. The following boundary conditions for EPC calculation and building energy performance simulation standards have to be considered when doing so. Table 7 below shows the graphical demonstration of optional pathways towards a building energy demand calculation (option 1) and simulation (option 2).

Table 7: options for energy simulation or calculation

Option 1		**Option 2**	
National Energy Performance Certificate (EPC)		**Building dynamic energy performance simulation**	
a	b	a	b
DIN 18599*	**The local Standard**	**EN ISO 52000**	**ASHRAE 90.1**
Detailed description in Appendix 2.2		Detailed description in Appendix 2.1	

*instead of DIN 18599 standard other compatible calculation methods are allowed to be used, e.g. PHPP – Passive House Planning Package, which offers a sophisticated Excel tool for building energy demand calculation together with relatively large worldwide climate data:
https://passipedia.org/planning/calculating_energy_efficiency/phpp_-_the_passive_house_planning_package

Appendix 2.1: Basic principles and relevant standards for the dynamic building simulation

For simulation purposes, DGNB refers to the overarching energy efficiency of buildings (EPB), EN ISO 52000: 2017 family standards (for details see also the following table 8 under the boundary conditions and Appendix 4 for the default choices) that offers choices to tailor the assessment to any national situation, worldwide. In general, the holistic approach must be used in order to calculate the energy demand of the building. Holistic approach means that the energy performance is assessed as the total energy used for heating, cooling, lighting, ventilation, domestic hot water and in some cases, appliances. It ensures that all technologies are treated equally and balanced. Simulation standards have to contain specifications for the assessment of thermal zones in the building or in the part of a building. The calculations are performed per thermal zone. In the calculations, the thermal zones can be assumed to be thermally coupled or not. As an alternative to the EN ISO 52000 family standards, ASHRAE Energy Standard 90.1-2013 (or latest) can be applied. The simulation program shall be tested according to ASHRAE 140: 2011 (or latest) Standard. Assessment have to be performed using the microclimate of the building site location (e.g. "urban heat island" for inner city locations), using typical meteorological climate data in hourly values for the location (test reference year), adopted to the local climate known from the past 30 years.

Boundary conditions
The overarching EPB standard EN ISO 52000 has a modular structure (described in EN ISO 52000-1: 2017) which contains the following four main areas:

- M1 Overarching standards
- M2 Building (as such)

- M3 - M11 Technical Building Systems under EPB
- M12 - M13 Other systems or appliances (non-EPB)

Table 8: modular structure of the EN ISO 52000-1

Overarching		Building (such as)		Technical Building Systems										
	Descriptions		Descriptions		Descriptions	Heating	Cooling	Ventilation	Humidification	Dehumidification	Domestic Hot water	Lighting	Building automation & Control	Electricity production
Sub1	**M1**	Sub1	**M2**	Sub1	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**

Table 8 shows the relative position of this document within the set of EPB standards in the context of the modular structure as set out in EN ISO 52000-1.
Note 1. In ISO/TR 52000-2 the same table can be found, with, for each module, the numbers of the relevant EPB standards and accompanying technical reports that are published or in preparation.
Note 2. The modules represent EPB standards, although one EPB standard could cover more than one module and one module could be covered by more than one EPB standard, for instance, a simplified and a detailed method respectively

Modules **M3** to **M11** together with the overarching descriptions from **M1** and **M2**, have to be considered as the boundary conditions which have to be taken into a consideration for the comprehensive and holistic building energy performance simulation, using dynamic weather data from the local (national) Meteorological Office. More information regarding the validation of calculation procedures given in the standard are provided in the Technical Report accompanying overarching main document ISO/TR 52000-2. Appendix 4 provides information about the default standards, informative default choices and references to other EPB standards.

Calculation boundary
The calculation boundary for operating conditions data for measured energy performance are determined according to modules:

- M3-10 for heating;
- M4-10 for domestic hot water;
- M4-10 for cooling;
- M5-10 for ventilation;
- M9-10 for lighting;
- M10-10 for building automation and control;
- M11-10 for electricity production.

Considering overarching definitions and regulations from EN ISO 52000-1: 2017 (e.g. Measurement intervals and measurement period, Zoning, etc.). The simulation program shall be capable of performing design load calculations to determine required HVAC equipment capacities and air and water flow rates in accordance with generally accepted engineering standards (e.g. standards listed in Appendix 4) and handbooks (e.g. ASHRAE Handbook-Fundamentals) for both, the proposed design and baseline building design.

Appendix 2.2: country specific EPC

In general, building energy performance simulation is necessary when no national regulation is available. In case the local standard is used in context of national or regional legal requirements, it can be accepted from DGNB as a valid document for building energy performance calculation. In any case the national/regional standard must be communicated with the DGNB office for eventual validation. Even if it is expected, that national/regional standards are not corresponding fully with the default values, choices and references of EPB standards (EN ISO 52000 standard family) listed in Appendix 4 or ASHRAE 90.1 followed due to national regulations, policy or traditions, etc. the following boundary conditions must be taken in account:

- The holistic approach must be used in order to calculate the energy demand of the building
- The calculations are performed per thermal zone
- Assessment have to be performed using the microclimate of the building site location
- Energy performance calculation must be based at least on monthly calculations

Calculation boundary

To verify the country specific national/regional EPC of the building, the following set of services must be considered while calculating the overall building energy performance:

a) The (sensible) energy need for heating and cooling;
b) The latent energy need for (de-)humidification;
c) The energy need for lighting (incl. lighting controls)
d) The energy need of ventilation and air conditioning systems
e) The energy need for domestic hot water
f) The energy need for building automation and control[9]
g) Auxiliary energy requirement
h) Energy production - renewable energy sources (on site)

The calculation methods can be used for residential or non-residential buildings, or a part of it, referred to as "the building" or the "assessed object".
However, if the iterative calculation method is essentially replaced by a thermal building simulation (mentioned above) using dynamic weather data, this will mean that the same calculation methodology will be used for evaluation of criterion "ENV 1.1 – Life cycle assessment" as for criterion "SOC 1.1 – Thermal comfort". With regard to the electricity demand, the calculation is also linked to criterion "SOC 1.4 – Visual comfort".

Reference building implementation

In general the whole LCA calculation is based on the comparative performance of the baseline (reference) building, which complies with local building regulations, and the actual (designed) building. The actual building performance and baseline building performance must be calculated using the following:

- the same simulation program
- the same weather data
- the same geometrical and area properties
- the same occupancy and use profile

there are two design options (the default values) for the reference building:

- Baseline building design characteristics in accordance with the national regulation[10]
- Baseline building design characteristics in accordance with the Appendix 5 or characteristics specified in Section G3 of the ASHRAE 90.1 – 2013 (or latest) standard.

[9] If considered by the national standard.

[10] National standard for reference building to be communicated with DGNB during adaptation process.

Simulation environment

The program used for creating the verification documentation and a summary of the key information entered into the simulation for the actual building and the reference building must be included in the documentation for the thermal building simulation.

Appendix 3

Appendix 3.1: User profile for food department with refrigerated products and commercial refrigeration

Table 9: User profile for food department with refrigerated products and commercial refrigeration

Use periods		**From**	**To**	Basis: Profile no. 7
Daily use period	Time	08:00	20:00	
Annual days of use $d_{use,a}$	d/a	300		
Annual hours of use during the day t_{day}	h/a	2999		
Annual hours of use during the night t_{night}	h/a	601		
Daily operating period for indoor air ventilation (HVAC) and cooling systems	Time	06:00	20:00	
Annual days of operation for indoor air ventilation (HVAC), cooling and heating systems respectively $d_{op,a}$	d/a	300		
Daily operating period for heating systems	Time	06:00	20:00	
Room conditions (if conditioning is available)				
Room target temperature for heating	°C	21		
Room target temperature for cooling	°C	24		
Minimum temperature for heating design	°C	20		
Maximum temperature for cooling design	°C	26		
Temperature decrease with reduced operation	K	4		
Requirements for humidity		with tolerance		
Minimum outside air flow V_E				
By number of persons	m³ / h * persons	20		
By area	m³ / h * m²			
Mechanical fresh air flow rate (in practice)		**From**	**To**	
Air exchange rate h^{-1}				
Air exchange rate, air only h^{-1}				
Lighting				
Maintained illuminance value E_m	lx	500	Low illuminance (foodstuffs), note: A value of 500 lx is averaged across the usable space, and corresponds to approx. 1000 lx in the shelves	
Height of the working plane h_{wp}	m	0.8		
Reduction factor k_A		0.93		
Relative absence C_A		0		
Room index k		2.5		
Reduction factor for the building operating period F_1		1		

Occupancy		**Low**	**Medium**	**High**
Maximum occupancy rate	m³ / person	6	5	4
Internal heat sources	**Hours in full use (h/d)**	**Max. specific output (W/m²)**		
		Low	Medium	High
Persons (70 W per person)	6	12	14	18
Work aids [a]	17	-12	-10	-8
Heat supply per day ($q_{I,p}+q_{I,fac}$)	Wh/(m².d)	-132	-86	-28

[a] Refrigerated cabinets are heat sinks if the thermal load is dissipated outside of the room (e.g. central commercial cooling system); otherwise, the standard value for the specific output of 5 W/m² applies (instead of -10 W/m²). Refrigerated cabinets have a lower full operating period at the weekend, which is taken into account with 300 days of use, each with full operating periods of 17 h/d.

Appendix 3.2: User profile for food department with refrigerated products without commercial refrigeration

Table 10: User profile for food department with refrigerated products without commercial refrigeration

Use periods		**From**	**To**	Basis: Profile no. 7
Daily use period	Time	08:00	20:00	
Annual days of use $d_{use,a}$	d/a	300		
Annual hours of use during the day t_{day}	h/a	2999		
Annual hours of use during the night t_{night}	h/a	601		
Daily operating period for indoor air ventilation (HVAC) and cooling systems	Time	06:00	20:00	
Annual days of operation for indoor air ventilation (HVAC), cooling and heating systems respectively $d_{op,a}$	d/a	300		
Daily operating period for heating systems	Time	06:00	20:00	

Room conditions (if conditioning is available)		
Room target temperature for heating	°C	21
Room target temperature for cooling	°C	24
Minimum temperature for heating design	°C	20
Maximum temperature for cooling design	°C	26
Temperature decrease with reduced operation	K	4
Requirements for humidity		with tolerance

Minimum outside air flow V_E		
By number of persons	m³ / h * persons	20
By area	m³ / h * m²	

Mechanical fresh air flow rate (in practice)	**From**	**To**
Air exchange rate h^{-1}		
Air exchange rate, air only h^{-1}		

Lighting			
Maintained illuminance value E_m	lx	500	Low illuminance (foodstuffs), note: A value of 500 lx is averaged across the usable space, and corresponds to approx. 1000 lx in the shelves
Height of the working plane h_{wp}	m	0.8	
Reduction factor k_A		0.93	
Relative absence C_A		0	
Room index k		2.5	
Reduction factor for the building operating period F_1		1	

Occupancy		**Low**	**Medium**	**High**
Maximum occupancy rate	m³ / person	6	5	4

Internal heat sources	**Hours in full use (h/d)**	**Max. specific output (W/m²)**		
		Low	Medium	High
Persons (70 W per person)	6	12	14	18
Work aids [a]	17	-12	5	-8

Heat supply per day ($q_{I,p}+q_{I,fac}$)	Wh/(m².d)	-132	169	-28

[a] Refrigerated cabinets are heat sinks if the thermal load is dissipated outside of the room (e.g. central commercial cooling system); otherwise, the standard value for the specific output of 5 W/m² applies (instead of -10 W/m²). Refrigerated cabinets have a lower full operating period at the weekend, which is taken into account with 300 days of use, each with full operating periods of 17 h/d.

Appendix 3.3: 500 lux user profile

Table 11: 500 lux user profile

Use periods		**From**	**To**	
Daily use period	Time	08:00	20:00	Basis: Profile no. 6
Annual days of use $d_{use,a}$	d/a	300		
Annual hours of use during the day t_{day}	h/a	2999		
Annual hours of use during the night t_{night}	h/a	601		
Daily operating period for indoor air ventilation (HVAC) and cooling systems	Time	06:00	20:00	
Annual days of operation for indoor air ventilation (HVAC), cooling and heating systems respectively $d_{op,a}$	d/a	300		
Daily operating period for heating systems	Time	06:00	20:00	
Room conditions (if conditioning is available)				
Room target temperature for heating	°C	21		
Room target temperature for cooling	°C	24		
Minimum temperature for heating design	°C	20		
Maximum temperature for cooling design	°C	26		
Temperature decrease with reduced operation	K	4		
Requirements for humidity		with tolerance		
Minimum outside air flow V_E				
By number of persons	m³ / h * persons	20		
By area	m³ / h * m²			
Mechanical fresh air flow rate (in practice)		**From**	**To**	
Air exchange rate h^{-1}				
Air exchange rate, air only h^{-1}				
Lighting				
Maintained illuminance value E_m	lx	500	Low illuminance (general, foodstuffs, bakery, furniture, household goods, etc.)	
Height of the working plane h_{wp}	m	0.8		
Reduction factor k_A		0.93		
Relative absence C_A		0		
Room index k		2.5		
Reduction factor for the building operating period F_1		1		
Occupancy		**Low**	**Medium**	**High**
Maximum occupancy rate	m³ / person	6	5	4
Internal heat sources	**Hours in full use (h/d)**	**Max. specific output (W/m²)**		
		Low	Medium	High
Persons (70 W per person)	6	12	14	18
Work aids	12	1	2	3
Heat supply per day ($q_{I,p}$+$q_{I,fac}$)	Wh/(m².d)	84	108	144

Appendix 3.4: 750 lux user profile

Table 12: 750 lux user profile

Use periods		**From**	**To**	
Daily use period	Time	08:00	20:00	Basis: Profile no. 6
Annual days of use $d_{use,a}$	d/a	300		
Annual hours of use during the day t_{day}	h/a	2999		
Annual hours of use during the night t_{night}	h/a	601		
Daily operating period for indoor air ventilation (HVAC) and cooling systems	Time	06:00	20:00	
Annual days of operation for indoor air ventilation (HVAC), cooling and heating systems respectively $d_{op,a}$	d/a	300		
Daily operating period for heating systems	Time	06:00	20:00	
Room conditions (if conditioning is available)				
Room target temperature for heating	°C	21		
Room target temperature for cooling	°C	24		
Minimum temperature for heating design	°C	20		
Maximum temperature for cooling design	°C	26		
Temperature decrease with reduced operation	K	4		
Requirements for humidity		with tolerance		
Minimum outside air flow V_E				
By number of persons	m³ / h * persons	20		
By area	m³ / h * m²			
Mechanical fresh air flow rate (in practice)		**From**	**To**	
Air exchange rate h^{-1}				
Air exchange rate, air only h^{-1}				
Lighting				
Maintained illuminance value E_m	lx	750	Medium illuminance (mall, textiles, cleaning, perfumery, leather goods, etc.)	
Height of the working plane h_{wp}	m	0.8		
Reduction factor k_A		0.93		
Relative absence C_A		0		
Room index k		2.5		
Reduction factor for the building operating period F_1		1		
Occupancy		**Low**	**Medium**	**High**
Maximum occupancy rate	m³ / person	6	5	4

Internal heat sources	**Hours in full use (h/d)**	**Max. specific output (W/m²)**		
		Low	Medium	High
Persons (70 W per person)	6	12	14	18
Work aids	12	1	2	3
Heat supply per day ($q_{I,p}+q_{I,fac}$)	Wh/(m².d)	84	108	144

Appendix 3.5: 1000 lux user profile

Table 13: 1000 lux user profile

Use periods		**From**	**To**	
Daily use period	Time	08:00	20:00	Basis: Profile no. 6
Annual days of use $d_{use,a}$	d/a	300		
Annual hours of use during the day t_{day}	h/a	2999		
Annual hours of use during the night t_{night}	h/a	601		
Daily operating period for indoor air ventilation (HVAC) and cooling systems	Time	06:00	20:00	
Annual days of operation for indoor air ventilation (HVAC), cooling and heating systems respectively $d_{op,a}$	d/a	300		
Daily operating period for heating systems	Time	06:00	20:00	
Room conditions (if conditioning is available)				
Room target temperature for heating	°C	21		
Room target temperature for cooling	°C	24		
Minimum temperature for heating design	°C	20		
Maximum temperature for cooling design	°C	26		
Temperature decrease with reduced operation	K	4		
Requirements for humidity		with tolerance		
Minimum outside air flow V_E				
By number of persons	m³ / h * persons	20		
By area	m³ / h * m²			
Mechanical fresh air flow rate (in practice)		**From**	**To**	
Air exchange rate h^{-1}				
Air exchange rate, air only h^{-1}				
Lighting				
Maintained illuminance value E_m	lx	1000	High illuminance (jewellery, lighting, radio and television, etc.)	
Height of the working plane h_{wp}	m	0.8		
Reduction factor k_A		0.93		
Relative absence C_A		0		
Room index k		2.5		
Reduction factor for the building operating period F_1		1		
Occupancy		**Low**	**Medium**	**High**
Maximum occupancy rate	m³ / person	6	5	4
Internal heat sources	**Hours in full use (h/d)**	**Max. specific output (W/m²)**		
		Low	Medium	High
Persons (70 W per person)	6	12	14	18
Work aids	12	1	2	3
Heat supply per day ($q_{I,p}$+$q_{I,fac}$)	Wh/(m².d)	84	108	144

Appendix 3.6: 1500 lux user profile

Table 14: 1500 lux user profile

Use periods		**From**	**To**	
Daily use period	Time	08:00	20:00	Basis: Profile no. 6
Annual days of use $d_{use,a}$	d/a	300		
Annual hours of use during the day t_{day}	h/a	2999		
Annual hours of use during the night t_{night}	h/a	601		
Daily operating period for indoor air ventilation (HVAC) and cooling systems	Time	06:00	20:00	
Annual days of operation for indoor air ventilation (HVAC), cooling and heating systems respectively $d_{op,a}$	d/a	300		
Daily operating period for heating systems	Time	06:00	20:00	
Room conditions (if conditioning is available)				
Room target temperature for heating	°C	21		
Room target temperature for cooling	°C	24		
Minimum temperature for heating design	°C	20		
Maximum temperature for cooling design	°C	26		
Temperature decrease with reduced operation	K	4		
Requirements for humidity		with tolerance		
Minimum outside air flow V_E				
By number of persons	m³ / h * persons	20		
By area	m³ / h * m²			
Mechanical fresh air flow rate (in practice)		**From**	**To**	
Air exchange rate h^{-1}				
Air exchange rate, air only h^{-1}				
Lighting				
Maintained illuminance value E_m	lx	1500	Very high illuminance (tenant fit out, shopping centre)	
Height of the working plane h_{wp}	m	0.8		
Reduction factor k_A		0.93		
Relative absence C_A		0		
Room index k		2.5		
Reduction factor for the building operating period F_1		1		
Occupancy		**Low**	**Medium**	**High**
Maximum occupancy rate	m³ / person	6	5	4
Internal heat sources	**Hours in full use (h/d)**	**Max. specific output (W/m²)**		
		Low	Medium	High
Persons (70 W per person)	6	12	14	18
Work aids	12	1	2	3
Heat supply per day ($q_{I,p}$+$q_{I,fac}$)	Wh/(m².d)	84	108	144

Appendix 3.7: Reference specifications for user electricity for refrigeration facilities

Consumer markets and shopping centres feature a very high electricity consumption for refrigeration facilities for users. As the refrigeration facilities interact directly with the indoor climate concept and energy concept of the building, they are incorporated into the life cycle assessment and into the life cycle cost assessment. The electricity consumption for refrigeration facilities for users is therefore integrated into the LCC, but the envisaged manufacturing costs and maintenance costs are not, as there is no validated data currently available for them.

Table 15: Reference specifications for user electricity for refrigerated counters

	UNIT	TOTAL
Electricity consumption per linear metre	kWh/(a * linear metre)	3000 **
Operating hours/year	h/a	8760

** in accordance with German Federal Environment Agency (*Umweltbundesamt – UBA*) report (average total of normal refrigeration+deep freezing)

Appendix 4: Reference standards

Table 16: The reference standards, identified by the module code number

Reference	Reference document	
	Number	**Title**
M1-4	EN ISO 52003-1	Energy performance of Buildings – Indicators, requirements and certification – Part 1: General aspects and application to the overall energy performance
	EN W16798-1 or EN 15251	Energy performance of Buildings – Part 1: Indoor environmental input parameters for design and assessment of energy performance of Buildings addressing indoor air quality, thermal environment, lighting and acoustics – Module M1-6; (revision of EN 15251)
M1-13	EN ISO 52010-1	Energy performance of Buildings – Overarching Assessment Procedures. External environment conditions – Part 1: Calculation Procedures
M1-14	EN 15459-1	Economic evaluation procedure for energy systems in Buildings
M2-2	EN ISO 52016-1	Energy performance of Buildings – Building and Building Elements – Calculation of Sensible and Latent Thermal Energy Needs in a Building or Building Zone – Part 1: Calculation Procedures
M2-3	EN ISO 52017-1	Energy performance of Buildings – Building and Building Elements – Calculation of the Dynamic Thermal Balance in a Building or Building Zone – Part 1: Detailed procedures
M2-4	EN ISO 52018-1	Energy performance of Buildings – Building and building elements – Ways to Express Energy Performance and Energy Performance Requirements – Part 1: Expressions and Procedures
M2-5	EN ISO 13789	Thermal performance of Buildings – Transmission and ventilation heat transfer coefficients – Calculation method
	EN ISO 13370	Thermal performance of Buildings – Heat transfer via the ground – Calculation methods
	EN ISO 6946	Building components and building elements – Thermal resistance and thermal transmittance – Calculation method
	EN ISO 10211	Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations

	EN ISO 14683	Thermal bridges in building construction – Linear thermal transmittance – Simplified methods and default values
	EN ISO 10077-1	Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 1: General
	EN ISO 10077-2	Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 2: Numerical method for frames
	EN ISO 12631	Thermal performance of curtain walling – Calculation of thermal transmittance
M2-9	EN ISO 13786	Thermal performance of building components – Dynamic thermal characteristics – Calculation methods
M2-8	EN ISO 52022-3	Energy performance of Buildings – Building and Building Elements – Solar and Visual Characteristics – Detailed calculation method
	EN ISO 52022-1	Energy performance of Buildings – Building and Building Elements – Solar and Visual Characteristics – Simplified calculation method
M3-1	EN 15316-1	Energy performance of Buildings — Modules M3-1, M8-1— Heating and DHW systems in Buildings – Part 1: General and Energy performance expression
M3-3	EN 12831-1	Heating systems in Buildings — Method for calculation of the design heat load
M3-5	EN 15316-2	Energy performance of Buildings, modules M3-5, M4-5 – Space emission systems (heating and cooling)
M3-6	EN 15316-3	Energy performance of Buildings, Modules M3-6, M4-6, M8-6 – Distribution systems (DHW, heating and cooling)
M3-7	EN 15316-5	Energy Performance of Buildings – Modules M3-7; M8-7 – Part 5-1: Storage systems for heating and domestic hot water
M3-8	EN 15316-4-1	Energy performance of Buildings, modules M3-8-1, M8-8-1 – Heating and DHW generation systems, combustion systems (boilers, biomass)
	EN 15316-4-2	Energy performance of Buildings – Module M3-8:1 - Heating systems

		– Part 4.2:1: Generation and control – Heat pumps systems
	EN 15316-4-3	Energy performance of Buildings, modules 3-8-3, 8-8-3, 11-8-3 – Heat generation systems, thermal solar and photovoltaic systems
	EN 15316-4-4	Energy performance of Buildings – Modules M3-8-4, M8-8-4, M11-8-4 – Heat generation systems, building integrated cogenerations systems
	EN 15316-4-5	Energy performance of Buildings, Modules M3-8-5; M4-8-5; M8-8-5; M11-8-5 – District heating and cooling
	EN 15316-4-8	Energy performance of Buildings – Heating systems and water based cooling systems in Buildings - Module M3-8-8 – Space heating generation, air heating and overhead radiant heating systems, stoves (local)
M3-10	EN 15378-3	Energy performance of Buildings – Module M3-10 and M8-10 – Heating and domestic hot water measured energy performance
M3-11	EN 15378-1	Energy performance of Buildings – Heating systems in Buildings – Inspection of heating and domestic hot water systems
M4-1	EN 16798-9	Energy performance of Buildings – Part 9: Ventilation for Buildings – Module M4- 1 – Calculation methods for energy requirements of cooling systems – General
M4-3	EN 16798-11	Energy performance of Buildings – Part 11: Module M4-3 – Calculation of the design cooling load
M4-7	EN 16798 – 15	Energy performance of Buildings — Part 15: Module M4-7 – Calculation of cooling systems – Storage – General
M4-8	EN 16798-13	Energy performance of Buildings – Part 13: Module M4-8 – Calculation of cooling systems – Generation
M4-11	EN 16798-17	Energy performance of Buildings — Part 17: Ventilation for Buildings – Module M4-11, M5-11, M6-11, M7-11 – Guidelines for inspection of ventilation and air conditioning systems;
M5-1	EN 16798-3	Energy performance of Buildings – Part 3: Ventilation for non-residential Buildings – Performance requirements for ventilation and room-conditioning systems
M5-5	EN 16798-7	Energy performance of Buildings – Module M5-5 – Ventilation for Buildings – Calculation methods for energy requirements of ventilation and air conditioning systems – Part 7: Emission (determination of

		air flow rates)
M5-6	EN 16798-5	Energy performance of Buildings – Modules M5-6, M5-8, M6-5, M6-8, M7-5, M7- 8 – Ventilation for Buildings – Calculation methods for energy requirements of ventilation and air conditioning systems – Part 5-1: Distribution and generation– Method 1
M8-2	EN 12831-3	Domestic hot water systems heat load and characterisation of needs
M9-1	EN 15193-1	Energy performance of Buildings – Module M9 – Energy requirements for lighting – Part 1: Specifications
M10-1	EN 15232	Energy performance of Buildings – Contribution of Building Automation, Controls and Building Management
M10-11		Energy Performance of Buildings – Inspection for Building Automation and Control
M10-12		Energy Performance of Buildings – Building Management System

Appendix 5

Reference Building

This appendix provides the factors to be considered for developing the global reference building in case local values are not available.

Appendix 5.1: Use and Operation

*D = daylight sensor
*M = manual (lighting switched on/off considering user behaviour)
*P = presence / motion sensor

		USE AND OPERATION									OPERATION									
													COOLING: REQUIRED TEMPERATURE			VENTILATION		LIGHTING		
	SPACE TYPE	START OF USE	END OF USE	DAILY HOURS OF USE [HOUR S/DAY]	YEARLY HOURS OF USE (MONDAY TO FRIDAY, MINUS HOLIDAY) [HOURS/A]	DAILY OPERATION HOURS HVAC	YEARLY OPERATION HOURS HVAC	MEDIUM OCCUPANCY NUMBERS [M3/P]	THERMAL DISCHARGE BY PERSON (SENSITIVE) [WH/M2 DAY]	THERMAL DISCHARGE BY EQUIPMENT AND MACHINERY [WH/M2 DAY]	HEATING : REQUIRED TEMPERATURE [°C]		[°C]	OFF-TIME [°C]	PRIMARY ENERGY [%]	MINIMUM FRESH AIR EXCHANGE RATE [M3/M2H]	MINIMUM HUMIDITY DEMAND	ILLUMINATION [LUX]	FACTOR LIGHTING	LIGHTING CONTROL
1	SINGLE / CLUSTER OFFICE	07:00	18:00	11	2750	13	3250	14	30	42	21	17	24	no demand	50	4	none	500	0.7	D*
2	OPEN SPACE OFFICE	07:00	18:00	11	2750	13	3250	10	42	60	21	17	24	no demand	50	6	none	500	1	D*
3	CONFEREN	07:00	18:00	11	2750	13	3250	3	96	8	21	17	24	no demand	-	15	none	500	1	P*

	CE, MEETING, SEMINAR																			
4	COUNTER HALL	07:00	18:00	11	2750	13	3250	12	36	24	21	17	24	no demand	-	2	none	200	1	M*
5	CANTEEN	08:00	15:00	7	1750	9	2250	1.2	177	10	21	17	24	no demand	-	18	none	200	1	M*
6	RESTAURANT	10:00	00:00	14	4200	16	4800	1.2	236	14	21	17	24	no demand	-	18	none	200	1	M*
7	KITCHEN	10:00	23:00	13	3250	15	4500	10	56	1800	21	17	24	no demand	-	90	none	500	1	M*
8	KITCHEN – PREPARATION, STORAGE	10:00	23:00	13	3250	15	4500	10	56	180	21	17	24	no demand	-	15	none	300	1	P*
9	LAVATORY, BATHROOMS	07:00	18:00	11	2750	13	3250	-	0	0	21	17	24	no demand	50	15	none	200	1	P*
10	ADJACENT AREAS (WITHOUT RECREATION AREAS)	07:00	18:00	11	2750	13	3250	-	0	0	21	17	24	no demand	50	0.15	none	100	1	P*
11	CIRCULATION SPACES	07:00	18:00	11	2750	13	3250	-	0	0	21	17	24	no demand	50	0	none	100	1	P*
12	STORAGE, SERVICE ROOM	07:00	18:00	11	2750	13	3250	-	0	0	21	17	24	no demand	50	0.15	none	100	1	M*
13	SERVER ROOM	00:00	00:00	24	8760	24	8760	30	15	1800	21	17	24	no demand	-	1.3	none	500	0.5	P*

14	PARKING GARAGE (OFFICE AND PRIVATE USE)	07:00	18:00	11	2750	13	3250	-	0	0	-	-	-	no demand	-	8	none	75	1	M*
15	PARKING GARAGE (PUBLIC USE)	09:00	00:00	15	5475	17	6205	-	0	0	-	-	-	no demand	-	16	none	75	1	M*

Appendix 5.2: Building Envelope

NO.	BUILDING ELEMENT	PROPERTIES	VALUES FOR REFERENCE BUILDING
1.1	OUTSIDE WALL, FLOOR SLAP EXPOSED TO AIR	Coefficient of heat transmission	U_W = 0.28 W/(m² K)
1.2	CURTAIN FAÇADE (SEE ALSO NO. 1.14)	Coefficient of heat transmission	U_W = 1.40 W/(m² K)
		Coefficient of thermal conductivity for glazing	g = 0.48
		Luminous transmission index of glazing	T_{D65} = 0.72
1.3	WALL EXPOSED TO SOIL, BASE PLATE, WALLS AND CEILINGS CONNECTED TO NON-HEATED ROOMS (BESIDES BUILDING ELEMENTS ACCORDING TO NO. 1.4)	Coefficient of heat transmission	U_W = 0.35 W/(m² K)
1.4	ROOF (AS FAR AS NOT CONSIDERED IN NO. 1.5), TOP FLOOR SLAP, WALLS IN DIRECTION OF NAVE AISLE	Coefficient of heat transmission	U_W = 0.20 W/(m² K)
1.5	GLASS ROOF	Coefficient of heat transmission	U_W = 2.70 W/(m² K)
		Coefficient of thermal conductivity for glazing	g = 0.63
		Luminous transmission index of glazing	T_{D65} = 0.76
1.6	LIGHTING ROW	Coefficient of heat transmission	U_W = 2.40 W/(m² K)
		Coefficient of thermal conductivity for glazing	g = 0.55
		Luminous transmission index of glazing	T_{D65} = 0.48
1.7	LIGHT CUPOLA	Coefficient of heat transmission	U_W = 2.70 W/(m² K)
		Coefficient of thermal conductivity for glazing	g = 0.64
		Luminous transmission index of glazing	T_{D65} = 0.59
1.8	WINDOWS, GLAZED DOORS (SEE ALSO NO. 1.14)	Coefficient of heat transmission	U_W = 1.30 W/(m² K)
		Coefficient of thermal conductivity for glazing	g = 0.60

		Luminous transmission index of glazing	T_{D65} = 0.78
1.9	ROOF LIGHT, SKY LIGHT (SEE ALSO NO. 1.14)	Coefficient of heat transmission	U_W = 1.40 W/(m² K)
		Coefficient of thermal conductivity for glazing	g = 0.60
		Luminous transmission index of glazing	T_{D65} = 0.78
1.10	OUTSIDE DOOR	Coefficient of heat transmission	U_W = 1.80 W/(m² K)
1.11	BUILDING ELEMENTS FROM NO. 1.1 AND 1.3 TO 1.10	Thermal bridge adjustment	ΔU_W = 0.05 W/(m² K)
1.12	LEAK TIGHTNESS OF BUILDING	Related value n_{50}	with ventilation: n_{50} = 1.0 h^{-1} without ventilation: n_{50} = 1.5 h^{-1}
1.13	DAYLIGHT SUPPLY BY SUN SHADING AND/OR GLARE SHIELD	Daylight supply factor $C_{TL,Vers,SA}$	No sun shading or glare shield provided: 0.70 Glare shield provided: 0.15

1.14	SUN SHADING DEVICE	Sun shading devices of the constructed building need to be taken into account for calculating the reference building. This refers to the insulation from heat during summer days according to criterion TEC1.3, Indicator 6 “Solar Heat Protection”.
		If solar glass is used to fulfil this Indicator, the following values need to be taken into account for the used solar glass:
		▪ Instead of NO. 1.2
		  ▪ Coefficient of thermal conductivity for glazing: g = 0.35
		  ▪ Luminous transmission index of glazing: T_{D65} = 0.58
		▪ Instead of values of NO. 1.8 and 1.9:
		  ▪ Coefficient of thermal conductivity for glazing: g = 0.35
		  ▪ Luminous transmission index of glazing: T_{D65} = 0.62	

Appendix 5.3: Heating, Ventilation, Air-Conditioning, Lighting

NO.	SYSTEM	VALUES FOR REFERENCE BUILDING
2.1	LIGTHING TECHNIQUE	Direct / Indirect, each with electronic ballast and fluorescent tube
2.2	LIGHTING CONTROL	See Table of Appendix 5.1, column "Lighting control"
3.1	HEATING (CEILING HEIGHT ≤ 4 M) – HEAT GENERATORS	Considering boiler, forced-air burner, domestic fuel oil, placed outside of the thermal envelope, water content > 0.15 l/kW
3.2	HEATING (CEILING HEIGHT ≤ 4 M) – HEAT DISTRIBUTION	▪ In case of radiator heating and hot-air heating (decentralised re-heater of the ventilation system): Double-pipe network, external distribution pipes in unheated areas, internal ascending pipes, internal supply lines, system-temperature 55/45 °C, hydraulic aligned, Δp constant, pump designed by its demand, pump with intermittent operation, no overflow valves, calculating the length of the reference building, 70% of the standard length as well the ambient temperature can be chosen according to DIN V 18599-5. ▪ In case of central ventilation system: Double-pipe network, system-temperature 70/55 °C, hydraulic aligned, Δp constant, pump designed by its demand, for calculating the reference building the lengths and position of pipes must be assumed the same as for the actual building.
3.3	HEATING (CEILING HEIGHT ≤ 4 M) – HEAT TRANSFER	▪ In case of radiator heating: Free heating surfaces fixed to outside walls with glass surfaces and radiation protection, P-controller (1K), no auxiliary energy. ▪ In case of hot-air heating (decentralised re-heater of the ventilation system): Room temperature as controlled variable, high control quality.
3.4	HEATING (CEILING HEIGHT > 4 M)	Heating system: Hot-air heating with standard induction outlet, air outlet sideways, P-controller (1K) according to DIN V 18599-5.
4.1	DOMESTIC HOT WATER – CENTRAL SYSTEM	▪ Heat generator: Solar collector according to DIN V 18599-8, Section 6.4.1, including ▪ flat-plate collector: $A_C = 0.09 \cdot (1.5 \cdot NFA_a{}^*)^{0.8}$

		▪ volume of beneath solar part of storage system: $V_{S,SOL} = 2 \cdot (1.5 \cdot NFA_a^*)^{0.9}$ ▪ in case of NFA_a^* > 500 m² "large scale solar plant" Remaining demand is supplied by heat generator of heating system. Note: is the net floor area of zones supplied by central system ▪ <u>Heat storage:</u> Indirect heated storage system (upright), placed outside of the thermal envelope. ▪ Heat distribution: Including circulation, Δp constant, pump designed by its demand, for calculating the reference building the lengths and position of pipes must be assumed the same as for the actual building.
4.2	HOT WATER – DECENTRAL WATER SYSTEM	Electrical instantaneous water heater, one tap and 6 meters of pipe per unit.
5.1	HVAC SYSTEMS – EXHAUST AIR SYSTEM	Specific fan power: P_{SFP} = 1.0 kW/(m³/s)
5.2	HVAC SYSTEMS – SUPPLY AND EXHAUST AIR SYSTEM WITHOUT RE-HEAT AND COOLING FUNCTION	Specific fan power: ▪ supply-air fan: P_{SFP} = 1.5 kW/(m³/s) ▪ exhaust-air fan: P_{SFP} = 1.0 kW/(m³/s) Extra adjustments according to DIN EN 13799, Section 6.5.2 can only be taken into account if the following components are available: HEPA-filter, gas filter or heat recovery systems class H1 or H2. ▪ Heat recovery via heat plate exchangers (cross-counter flow) with: ▪ recovered heat coefficient: $\eta_t = 0.6$ ▪ pressure ratio: $f_P = 0.4$ ▪ air duct routing inside the building
5.3	HVAC SYSTEMS – SUPPLY AND EXHAUST AIR SYSTEM WITH CONTROLLED AIR CONDITIONING	Specific fan power: ▪ supply-air fan: P_{SFP} = 1.5 kW/(m³/s) ▪ exhaust-air fan: P_{SFP} = 1.0 kW/(m³/s) Extra adjustments according to DIN EN 13799, Section 6.5.2 can only be taken into account if the following components are available: HEPA-filter, gas filter, or heat recovery systems class H1 or H2. ▪ Heat recovery via heat plate exchangers (cross-counter flow) with: ▪ recovered heat coefficient: $\eta_t = 0.6$

		▪ pressure ratio: $f_P = 0.4$ ▪ supply-air temperature: 18 °C ▪ air duct routing inside the building
5.4	HVAC SYSTEMS – AIR HUMIDIFYING SYSTEM	For calculating the reference building the humidifying unit must be assumed in the same way as for the actual building.
5.5	HVAC SYSTEMS – PURE AIR CONDITIONING	In case of installation of a variable air volume system: ▪ pressure ratio: $f_P = 0.4$ ▪ air duct routing inside the building
6	ROOM COOLING	▪ <u>Cooling system:</u> ▪ Chilled water fan-coil, parapet unit ▪ Cold water temperature: 14/18 °C ▪ <u>Chilled water circuit room cooling:</u> ▪ Overflow: 10% ▪ Specific electric power of distribution: $P_{d,spec} = 30\ W_{el}/kW_{cooling}$ ▪ Hydraulic aligned, controlled pump, pump hydraulic decoupled, seasonal and night/weekend switch off
7	COOLING GENERATING SYSTEM	▪ <u>Generator:</u> Piston/scroll compressor multi-level shiftable, R134a, air cooled ▪ <u>Chilled water temperature:</u> ▪ If NFA cooled via room cooling > 5,000 m2 system temperature for this area: 14/18 °C ▪ Otherwise: 6/12 °C ▪ <u>Chilled water circuit generator inclusive HVAC cooling:</u> ▪ Overflow: 30% ▪ Specific electric power of distribution: $P_{d,spez} = 20\ W_{el}/kW_{cooling}$ ▪ Hydraulic aligned, uncontrolled pump, pump hydraulic decoupled, seasonal and night/weekend switch off ▪ Distribution outside the conditioned zone

APPENDIX B – DOCUMENTATION

I. Required documentation

A range of different forms of documentation is listed below. The documentation submitted must comprehensively and clearly demonstrate compliance with the requirements for the target evaluation of the individual indicators.

Indicator 1: Life cycle assessments in planning

- Confirmation by the auditor and by other specialist planners involved in the planning process that life cycle assessments were used in the planning process, via the documentation for commissioning
- Excerpts from life cycle assessment comparisons with clear reference to the building
- Short description of the methodology used and the scope of the analysis
- The various pieces of documentation must demonstrate their relationship to the work phases
- Confirmation of the participation of the planning team and of communication of the life cycle assessment results (e.g. via planning logs)

Indicator 2: Life cycle assessment optimisation

- Confirmation by the auditor that life cycle assessments were evaluated for important decisions, via the documentation for commissioning
- Verification of life cycle assessment calculation and classification of whether the calculation was performed in accordance with the full consideration or partial analysis method
- Description of the alternatives considered, including content
- Clear demonstration of the relationship between the assessments and the work phases (with data)
- Confirmation of the participation of the planning team and of communication of the life cycle assessment results (e.g. via planning logs)

Indicator 3: Life cycle assessment comparison calculation
Documentation of the calculation for construction in accordance with the simplified calculation method

- Description of the building model including origin of the primary data for site plan, urban design concept and aerial photograph
- Components or surfaces/materials (quantities and estimated durations of use); if components are grouped together, this must be clearly disclosed;
- Building areas and volumes;
- Determination of quantities for the enveloping surfaces (external walls incl. windows/façades, base slab, roof) from the national EPC calculation or simulation model and allocation to the components included in the assessment;
- Windows/window doors/post and beam façades (type and area, including proportion of the frame) and description of the main profile system on average;
- Determination of quantities for the internal walls and supports; proof of plausibility via floor plans including types of internal walls/supports;
- Internal doors: Quantity (number and area) and specification of the most important types, description of the calculation;
- Determination of quantities for the ceilings of storeys;
- Description of components as layer sequence with layer thicknesses, estimated bulk densities and allocation to the data set used;
- Description of the determination of quantities for the foundations;
- For reinforced concrete, the rebar proportion must be stated in kg/m^3 or kg/m^2 of component. Alternatively, the reinforcing steel can be documented via a complete list for the project.

- Documentation of heating and cooling systems and air conditioning systems without pipes;
- Ignored processes/components must be documented.
- Life cycle assessment data basis used. If a country specific dataset was used, this data basis or the corresponding part of the conformity check must be disclosed (e.g. compliance with the EN15804). If product-specific EPDs were used, confirmation by the auditor regarding their use must be provided.

Documentation of the calculation for construction in accordance with the complete calculation method

- Building areas and volumes;
- All components or surfaces/materials that do not fall under the cut-off criteria (quantities and estimated durations of use);
- Mass excerpt for the structural and technical components;
- The completeness of the determination of quantities must be verifiably demonstrated and proven.
- Life cycle assessment data basis used. If a country specific dataset was used, this data basis or the corresponding part of the conformity check must be verifiably disclosed.

Documentation of the use scenario calculation method

- Electricity and heating demand (final energy) for the building under certification and for the reference building in accordance national EPC or simulation. The calculation must correspond to the implemented building and the energy certificate must be enclosed with a valid signature. Specification of the specific electrical efficiency from detailed technical plan for lighting for calculation of the artificial light demand, otherwise calculation in accordance with methods listed in Appendix 2;
- Type of the heating and cooling systems and air conditioning systems as well as energy sources;
- For long-distance district heating, the proportion of renewable energy used must be proven via a corresponding certificate (but the certificate must not only account for the primary energy factor) or statement from the supplier; if the data set for the national long-distance district heating mix from relevant verified dataset is used for simplification, this is not necessary
- Estimated durations of use for the components and surfaces;
- Description and supply values in accordance with the German Renewable Energy Sources Act (EEG) for the building energy systems;
- Proof of the origin of waste heat, and how it is provided in the case of use of waste heat.
- For project-specific calculations of life cycle assessment data, it must be demonstrated that the methodological requirements of DIN EN 15804 are complied with. In this case, two forms of proof must be provided:
- Confirmation that the calculation methodology is compliant with DIN EN 15804 (provided by a recognised expert on DIN EN 15804, recognised experts include, for instance, experts who work in verifying EPD programmes compliant with DIN EN 15804 or data providers who provide data that is verifiably compliant with DIN EN 15804).
- Confirmation that the project-specific data corresponds to the input data in the calculation by an independent internal or external third party, such as a quality manager or recognised expert.
- If tools are used for calculation of project-specific life cycle assessment data, the following proof must be provided:
- If required by the DGNB conformity check, proof must be presented that the calculation method complies with the requirements of DIN EN 15804. In the case of tools, this can be a confirmation by a recognised expert on DIN EN 15804. Recognised experts include experts who work in verifying EPD programmes recognised as compliant with DIN EN 15804, such as the Institute for Building and Environment (*Institut Bauen und Umwelt e.V. - IBU*).
- In addition, if tools are used, it must be ensured that the solution actually installed/used in the building corresponds to the calculations. This can be ensured by presenting the input values entered

into the tool and the actual technical project-specific values, including proof that the input values correspond to the achieved values ("input value A corresponds to achieved value B"). This proof must be confirmed by an independent internal or external third party (e.g. signature of a quality manager, architect or site manager on the delivery note).

Documentation of the end-of-life scenario calculation method

- Allocation of the documented components to a disposal/recycling path.

Documentation of the results of the life cycle assessment

The indicator results must be presented for the entire life cycle and per m^2 NFA and year, divided into:

- Construction
- Use (electricity and heating)
- Use (maintenance)
- End-of-life (recovery/disposal)

A breakdown of the results for the construction in accordance with Appendix 1 and by the 10 structural elements with the largest contributions to the indicator results is assessed as a reasonable form of documentation. To ensure consistent summarisation, the building life cycle assessment form provided by the DGNB for the life cycle assessment must be filled out.

Project report for creating the building life cycle assessment

A project report should contain the following:

- General information:
  - Designation of the building (address, etc.);
  - Author of the building life cycle assessment (name and qualifications);
  - Calculation and evaluation method used;
  - Point in the life cycle of the building at which the life cycle assessment was created;
  - Date of creation.
- General information regarding the building and the building model:
  - Building type;
  - Structure of use;
  - Required duration of use;
  - Reference period;
  - Other information regarding the building, such as: Technical type of the building (support structure type); Year of commissioning; Verification of EPC calculation, including information regarding the final energy of the reference building;
  - Energy producers and energy sources used for supplying the building with heat, cooling and warm water;

  In addition, for scheme **Assembly buildings**:
  - Evidence of the building assignment to a type I or II;
- Specification of the limits and scenarios that apply to the evaluation:
  - For the building under evaluation, it must be declared that the calculation methodology (key assumptions and scenarios) has been applied in accordance with the requirements described above.
- Data sources:
  - The data sources, type and quality of the data used must be declared qualitatively. This applies to both the building model and the life cycle assessment data.

Verification of the results

In order to ensure verifiability, all information and options used and all decisions made must be presented in a transparent form. The verification comprises the following points:

- Completeness and proof of completeness for quantification at the building level;
- Traceability of the data used for the products;
- Conformity of the data with the requirements of DIN EN 15804;
- Consistency between the scenarios that apply at the building level and the scenarios used for the products.

The parameters and calculation specifications required for calculation can be found in the following documents:

- Calculations in accordance with national EPC or energy simulation with detailed information regarding the final energy demand of the reference building, divided into energy sources and energy production methods.
- Life cycle assessment for the physical building components of the building under certification in accordance with EN ISO 14040 and 14044, containing all life cycle phases that are to be taken into account.
- LCA Datasets from 2015 or a more recent version.
- Duration of use of components (Guideline for Sustainable Building, Federal Office for Building and Regional Planning, Ministry of Transport, Building and Housing Germany, 2001) or from the Environmental Product Declarations in accordance with DIN EN 15804).

If software tools are used, it must be ensured that the requirements listed in the criterion are implemented and that the described data basis is applied.

Indicator 4: Agenda 2030 bonus – climate protection goals

- Scenario calculation results for CO_2 equivalents of the energy demand, user and/or construction
- Demonstration of climate neutrality in accordance with the recognised standard (note: The DGNB is developing its own standard for defining a "climate-neutral building", which is expected to be published by mid-2018)
- Description of the assessment of energy-related user activities and the selected method

Indicator 6: Halogenated hydrocarbons in refrigerants

- Proof of the refrigerant used, specifying the GWP factor

APPENDIX C – LITERATURE

I. Version

Change log based on version 2018

PAGE	EXPLANATION	DATE
all	General and evaluation: scheme „Assembly buildings" has been added	16.09.2021
50	Note has been added regarding the variability of the total score	16.09.2021
53	Agenda bonus 2030: requirements adaptation to the DGNB "Framework for carbon-neutral buildings and sites" and inclusion of the "Climate action Roadmap"	16.09.2021
62	Indicator 6: link and formulation corrected for the GWP factors of the refrigerants.	16.09.2021
65	Partial calculation method (PCM): formulation has been amended for more clarification	16.09.2021
all	LCA calculation methodology for indicator 3: correction of the listed modules	16.09.2021
84	Usage-specific description: definition of the "assembly buildings" Type I and II have been added	16.09.2021
122	Appendix B: list of the necessary documentation for the scheme "Assembly buildings" has been added	

II. Literature

- „Framework for carbon neutral buildings and sites" – German sustainable building council, 2020: https://www.dgnb.de/en/council/publications/#iframe-3
- DIN EN ISO 14040:2009-11 Environmental management – Life cycle assessment – Principles and framework. Berlin: Beuth publisher. November 2009
- DIN EN ISO 14044:2006-10 Environmental management – Life cycle assessment – Requirements and guidelines. Berlin: Beuth publisher. October 2006
- DIN V 18599: Energy efficiency of buildings – Calculation of the energy needs, delivered energy and primary energy for heating, cooling, ventilation, domestic hot water and lighting. Berlin: Beuth publisher. May 2013
- DIN EN 15804:2014-07 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products. Berlin: Beuth publisher. July 2014
- DIN EN 15978:2012-10 Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method. Berlin: Beuth publisher. October 2012
- German Federal Ministry of Transport, Building and Urban Development (BMVBS): *Baustoff- und Gebäudedaten [Construction material and building data]. Ökobau.dat. Berlin*
- Kreißig, J., Binder, M. *Methodische Grundlagen – Ökobilanzbasierte Umweltindikatoren im Bauwesen* [Methodical principles – Environmental indicators based on life cycle assessments in construction]. Methodology report for the BMVBS project *"Aktualisieren, Fortschreiben und Harmonisieren von Basisdaten für das nachhaltige Bauen"* [Updating, continuing and harmonising basic data for sustainable construction] (reference number 10.06.03–06.119) May 2007
- Guideline for Sustainable Building, Federal Office for Building and Regional Planning, Ministry of Transport, Building and Housing Germany, 2001
- "Guideline for sustainable buildings" on behalf of Ministry of Transport, Building and Housing, Germany 2001, 1st reprint (with editorial amendments)

- ASHRAE 140: 2011 - Building Thermal Envelope and Fabric Load Tests
- ANSI/ASHRAE/IES Standard 90.1-2013 Energy Standard for Buildings Except Low-Rise Residential Buildings
- EN ISO 52000-1: 2017 Energy performance of buildings — Overarching EPB assessment

EN ISO/TR 52000-2: 2017 Energy performance of buildings — Overarching EPB assessment Explanation and justification.

- http://files.designbuilder.cl/200000036-348f735887/DesignBuilder_v4.2_ASHRAE140_2.pdf
- http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.361.4714&rep=rep1&type=pdf