



Federal Ministry
of the Interior, Building
and Community

Guideline for Sustainable Building

Future-proof Design, Construction and Operation of Buildings



Contents

Preface to the 3rd edition	4	Appendix.....	167
Introduction to this Guideline	5	Glossary	168
1. Sustainable planning, construction, use and operation of buildings.....	7	References	169
2. Scope of the Guideline for Sustainable Building	8	Abbreviations	172
Part A – Principles of Sustainable Building	13	Annexes	174
1. Dimensions and principles of sustainable building	15	Picture Credits	174
2. Sustainability assessment using the BNB	20	Imprint	175
3. Qualities of sustainable building	29		
4. BNB – system variants and module applications.....	49		
Part B – Sustainable Building Projects	55		
1. Integration of sustainability aspects into the planning process	57		
2. Project preparation.....	60		
3. Design and approval planning.....	74		
4. Final planning, contracting and construction....	82		
5. Commissioning and as-built documentation	86		
6. Optimising operations	88		
Part C – Recommendations for the Sustainable Use and Operation of Buildings	89		
1. Sustainable use and operation	91		
2. Stakeholders during the use phase	92		
3. Criteria for sustainable use and operation.....	94		
4. Consideration of sustainability criteria during the use phase	121		
Part D – Refurbishment of Buildings.....	131		
1. Sustainable development of building stock	133		
2. Terminology of sustainable building stock development	134		
3. Principles of refurbishment	138		
4. Specific criteria for sustainable building refurbishment	140		
5. Sustainability assessment of refurbishment measures.....	163		

Preface to the 3rd edition

Sustainable building has been an integral part of planning and construction processes in Federal building projects for many years. It is a core element of the German Sustainable Development Strategy, which was updated in 2017. This is important in part due to the Federal State's duty to serve as a role model in its function as the largest public builder in Germany, but also because it is an essential component of current policy objectives. Key factors here are environmentally sound and climate-sensitive construction, energy and resource efficiency, cost-effectiveness, and the need to adapt to demographic change.

The methods set out in the Guideline for Sustainable Building have been mandatory for civilian construction projects carried out by the Federal Government since 2001. The comprehensive revision of the Guideline in 2013 introduced far-reaching changes to quality requirements for Federal Government building projects and specified the practical application of these. The quality requirements have to evolve constantly to keep pace with the standards for modern Federal Government building projects. Building measures are to be documented and evaluated in a transparent way based on the criteria and assessment standards set out in the Assessment System for Sustainable Building. Certification obtained by the Federal Government up to now shows that a high level of sustainability can be achieved economically. The Federal Government remains committed to these high sustainability standards.

There is also growing awareness and appreciation of the approach set out in the Guideline for Sustainable Building even beyond its application in Federal Government construction projects. Some federal states have implemented the Assessment System for Sustainable Building in their areas of responsibility, while others are looking into its application or are already gathering experience with the help of pilot projects. The growing acceptance of the approach among decision-makers and project heads at local authority level is also a very positive development. A range of very interesting examples, such as schools, childcare centres and administrative buildings, can be held up as very persuasive precedents at this level.

The Federal Ministry of the Interior, Building and Community very much welcomes these developments. We are committed to continuing to be a reliable partner for all stakeholders in our shared efforts to create and maintain a built environment that is a pleasure to live in.

Sustainable building is and will remain a priority.

Introduction to this Guideline



Introduction to this Guideline

- 1. Sustainable planning, construction, use and operation of buildings..... 7
- 2. Scope of the Guideline for Sustainable Building..... 8
 - 2.1 Rationale..... 8
 - 2.2 Application and scope11
 - 2.3 Layout of the Guideline11

1. Sustainable planning, construction, use and operation of buildings

On a national and international scale, sustainability is one of the most important challenges for the future. Sustainable action means paying equal attention to ecological, economic and social aspects so that we can pass on an intact environment and the same opportunities in life to future generations. This is an extremely important topic, especially for the building sector due to the materials and monetary resources consumed here and the related impacts on the environment. This will become even more important for the building sector due to climate change and the growing shortage of resources. Buildings are complex systems that fulfil defined tasks and functions. They also provide both living space and a work environment, and they affect their users' well-being, health and satisfaction as well as the quality of social life. While they represent commercial and economic values and help to create added value, they also trigger energy and substance flows that affect the global and local environment.

The aim of our actions should hence be to create a building that ensures maximum sustainability and also saves energy and resources. The extensive inclusion of sustainability aspects in the life cycle of a building, for instance during planning, erection, use and modernisation, as well as demolition, should be proactively designed and influenced. The building's structural and technical concept must generally take standards and legal requirements into account as well as the generally accepted state of the art. In particular, the use requirements that are normally specified by the customer must be fulfilled under defined boundary conditions. Furthermore, sustainability requirements, in other words ecological, economic and social qualities, must be defined in order to ensure that buildings fulfil their function in relation to the environment and society and to warrant economic efficiency.

As a tool for day-to-day activities of the federal building administrations¹ and other stakeholders, the Federal Building Ministry published the Guideline for Sustainable Building for the first time in 2001.

The underlying ideas of this Guideline for Sustainable Building are:

- The inclusion of principles of sustainable development as an integral part of all planning and decision-making processes throughout the life cycle of a property. This includes setting targets and checking and evaluating whether these targets are reached.
- In order to support stakeholders, specific requirements, approaches and tools must be made available depending on the respective work, responsibility and influence spheres and the respective life cycle phase.
- Furthermore, general consideration must be given to planning, building and operation while suitable consideration must be given to the evaluation of sustainability embedded in the customary decision-making process. At the same time, manageable solutions must be developed that involve a reasonable amount of time and money.

The Guideline is designed for all stakeholders in the planning and execution phase of buildings and their outdoor facilities, and offers support for the use and operation phase of the building. Due to the high quality of planning and building as well as regulatory density, many of the individual aspects of sustainable building are already considered a standard feature in Germany. Furthermore, sustainable building describes additional requirements, especially for environmental protection, and calls for holistic and equal consideration of the different qualities. With this Guideline, stakeholders can recognise, assess and, in a positive sense, influence their role in shaping the sustainability of a building. In order to live up to the model role of the public sector, binding rules for applying the Guidelines should be drawn up beyond the scope of federal buildings.

1 Federal building administrations: BBR and the federal-state administrations working on behalf of the federal government

2. Scope of the Guideline for Sustainable Building

2.1 Rationale

Based on the resolutions of the Rio de Janeiro Conference in 1992, the German federal government adopted in 2002 the National Sustainability Strategy² titled “Perspectives for Germany”. In addition to measures and projects, this strategy also contains political guidelines for sustainable development. Progress is continuously recorded and currently assessed on the basis of 21 indicators and targets.

Germany’s federal government uses this progress report to upgrade its National Sustainability Strategy. The basis is a concept of sustainability which links economic performance to ecological responsibility and social fairness [...]. It is about a policy and concept of economic management [...] that replaces short-term thinking with a long-term, integrated policy of responsibility.”³ These goals cannot be achieved on a political level alone. Instead, the business community, society and every citizen should contribute towards the process. “The guiding principle of sustainable development is especially applicable to administrative measures. The

public sector must live up to its model role and with its overall budget for procurement can influence demand for and the development of sustainable products.”⁴

The Federal Committee of State Secretaries for Sustainable Development monitors and upgrades the implementation of the sustainability strategy. The “Green Cabinet” is also the point of contact for the Parliamentary Advisory Council on Sustainable Development, for the federal-state administrations and local authorities’ national associations. With a continuously updated measures programme, the Federal Committee of State Secretaries determines how the national sustainability strategy is implemented at the administrations of the federal government. The first action programme adopted on 6 December 2010 titled “Concrete implementation of sustainability in administrative action” and its update from 30 March 2015 demands as an important sub-measure that federal buildings be based on the requirements of the Assessment System for Sustainable Building (BNB).

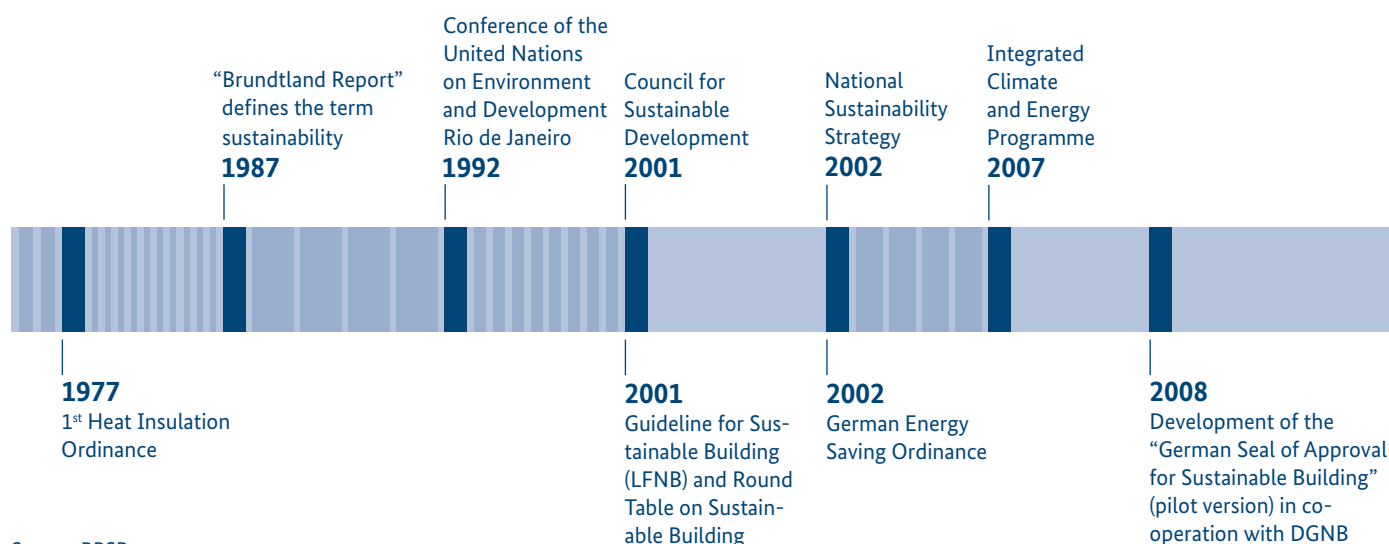
2 See Nationale Nachhaltigkeitsstrategie (2002)

3 See Fortschrittsbericht 2012

4 See Fortschrittsbericht 2012

MILESTONES OF SUSTAINABILITY

FIGURE 1



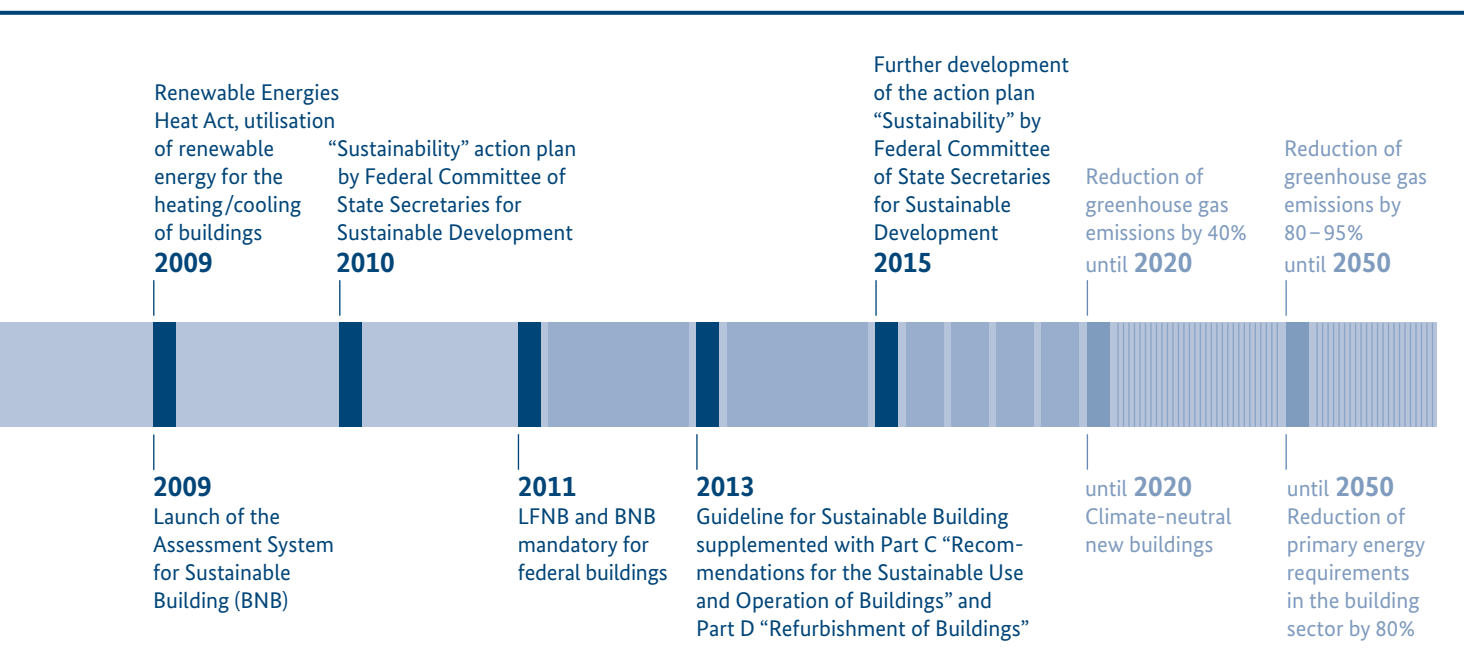
Source: BBSR

With a view to the buildings sector, the “sustainability of buildings [...] is to be increasingly made transparent, measurable and verifiable during the life cycle by including ecological, economic and social aspects whilst at the same time addressing the quality of urban planning and design along with technical and functional requirements. The assessment must be based on recognised scientific methods of eco-balancing and life cycle costing”⁵.

As a logical consequence, the Federal Building Ministry has developed further the Guideline for Sustainable Building of 2001 and operationalised the above-mentioned general requirements for the construction sector. Since it was updated in 2013, the Guideline now covers not only new buildings, but also refurbishment and building conversion projects. Recommendations are also provided for the sustainable use and operation of buildings.

Sustainable building also means making the best possible use of the natural resources available in terms of careful extraction, efficient use and avoidance of environmental pollution. The adoption of the German Resource Efficiency Programme 2012 and its update⁶ was another important step by the German government towards uniform and future-orientated action.

- 5 See Staatssekretärsausschuss für nachhaltige Entwicklung (Federal Committee of State Secretaries for Sustainable Development)
- 6 German Resource Efficiency Programme (ProgRes), BMUB (2015 b)





Top: Complete refurbishment of the listed Federal Constitutional Court building in Karlsruhe
 Bottom: First federal building to apply BNB in all work phases, the Federal Environment Agency's Haus 2019 building

2.2 Application and scope

The Guideline for Sustainable Building explains the generally valid principles and methods for sustainable planning, construction, use and operation and can be used as a tool for taking aspects of sustainability throughout the life cycle of buildings and properties into account within the sense of the building and property as one unit.

FEDERAL BUILDING The Guideline for Sustainable Building must be applied to federal-government construction projects by the administrations under the responsibility of the Federal Ministry of the Interior, Building and Community (BMI)⁷ according to the rules of the “Federal Construction Guidelines” (RBBau Guidelines)⁸ and taking into account the current regulatory status. In the case of funded building projects, the Guideline is applied as agreed to with the funding parties. When it comes to federal-government building projects abroad, the Guideline for Sustainable Building must be applied analogously. Generally, no certificate is issued. Exceptions are determined by decree.

For public building projects at federal-state, municipal and private sector level, this Guideline serves as a set of recommendations. The version of the Guideline published on the information portal (www.nachhaltigesbauen.de) is the relevant version in each case.

With regard to the standards mentioned in this Guideline as well as the applicable documents and technical requirements for products and test methods, the following should be noted: On condition that the specified protection level is permanently achieved with a view to safety and fitness for use, products and test methods may also be used which comply with standards or other regulations and/or technical rules of other EU member states, EFTA states or Turkey.

2.3 Layout of the Guideline

This Guideline on Sustainable Building is broken down into the following parts:

- Part A – Principles of Sustainable Building
- Part B – Sustainable Building Projects
- Part C – Recommendations for the Sustainable Use and Operation of Buildings
- Part D – Refurbishment of Buildings
- Annexes

Part A contains the general principles and methods of sustainable planning, construction, use and operation. These can be applied to both public sector and private construction projects. For this purpose, the document describes the principles of sustainable development as applied to the construction and real property sector, procedures for assessing sustainability with the BNB as well as the qualities of sustainable building, use and operation.

Part B “Sustainable Building Projects” explains the task-related principles, the life cycle scenarios to be considered and the planning principles for new construction projects. They are based on the chronological sequence of planning that is geared to sustainability. Part B is basically also applicable to refurbishment projects.

Part C refers to the operating tasks of the responsible property managers and describes recommendations for optimising use and management processes. In this way, it can be ensured that the requirements for sustainable building are fulfilled throughout the entire life cycle of a building project.

⁷ In view of the special characteristics of military buildings, the Federal Ministry of Defence (BMVg) has issued its own specific guidelines regarding the form and extent to which this Guideline is to be applied in the Ministry’s sphere of responsibility.

⁸ BMUB (2016)



Sustainable Building Information Portal

Part D “Refurbishment of Buildings” addresses the specific aspects of sustainable refurbishment. With its comments, specifications and recommendations, Part D addresses the many special features of existing buildings and thereby complements Parts A and B. The refurbishment of existing buildings is treated separately for two reasons. On the one hand, the planning and construction processes in refurbishment projects differ in many ways from those in new construction projects. On the other hand, certain sustainability aspects must be looked at from a different perspective when dealing with existing buildings.

The annexes to the Guideline (see overview of annexes, page 174) lists the documents needed to implement the Guideline which can be downloaded from the Sustainable Building Information Portal (www.nachhaltigesbauen.de). This concept enables the ongoing updating of the information, tools and other documents which supplement this Guideline and thereby ensures that these documents are as up to date as possible. These annexes include verification requirements during the individual planning phases, target agreement tables and the sample for the Energy Target Specifications. The annexes to the Guideline (apart from Annexes A1 and B7) are generally designed as recommendations and can be adapted for each specific project. Stakeholders who use the eBNB (the electronic assessment and documentation tool for sustainable building, see section A2.3) have access to the tools provided there.



Part A

Principles of Sustainable Building

Part A – Principles of Sustainable Building

1.	Dimensions and principles of sustainable building	15	4.	BNB – system variants and module applications	49
2.	Sustainability assessment using the BNB	20	4.1	System variants.....	49
2.1	Assessment System for Sustainable Building.....	20	4.1.1	Office and administration buildings (BNB_B)	49
2.2	Sustainability assessment of the planning, design and construction process according to the BNB.....	24	4.1.2	Educational buildings (BNB_U).....	49
2.3	Instruments to support implementation of sustainable building.....	25	4.1.3	Laboratory buildings (BNB_L).....	50
3.	Qualities of sustainable building	29	4.1.4	Inter-company vocational training facilities (BNB_ÜBS)	51
3.1	Ecological quality	29	4.1.5	Outdoor facilities (BNB_AA)	51
3.1.1	Protection of the ecosystem.....	30	4.1.6	Analogous application of the Assessment System for Sustainable Building (BNB)	52
3.1.2	Protection of natural resources	31	4.2	Modules and their application	53
3.1.3	Eco-balancing.....	32			
3.2	Economic quality.....	33			
3.2.1	Life cycle cost analysis	33			
3.2.2	Economic efficiency	35			
3.2.3	Value stability	36			
3.3	Socio-cultural and functional quality	38			
3.3.1	Health, comfort and user satisfaction	38			
3.3.2	Functionality	41			
3.3.3	Ensuring design quality.....	42			
3.4	Technical quality	43			
3.5	Process quality.....	45			
3.5.1	Planning quality	45			
3.5.2	Construction quality.....	46			
3.5.3	Quality of preparations for operations management	46			
3.6	Location profile	47			

1. Dimensions and principles of sustainable building

The overarching concept of a policy of sustainable and future-enabled development – based on the three dimensions of sustainability ecology, economy and socio-culture (figure A1) – is the starting point for developing principles and assessment criteria for sustainable building. This concept simultaneously addresses ecological, economic and socio-cultural requirements as equally important aspects and includes future generations in the analysis. Furthermore, the concept also underlines the responsibility of the individual and, in particular, the function of the public sector as a role model.

DIMENSIONS OF SUSTAINABILITY
FIGURE A1



Source: BBSR

In a first step, generally protected assets, as well as protection goals, can be derived from the three dimensions of sustainability. These are then adapted for buildings in order to meet the interests of sustainable building and its specific working and decision-making processes and evaluation methods (figure A2).

When it comes to the **ecological dimension** of sustainability, the primary protection goal is to save resources by optimising the use of construction materials and products, to reduce land use, to maintain and promote biodiversity and to minimise energy and water consumption. All the necessary energy and material flows are examined, from extraction to transport and installation right through to demolition. This examination also includes the global and local environmental effects that result from the energy used to produce the building materials and during building use. The aim of this exercise is to minimise environmental burdens at both local and global levels.

The **economic dimension** of sustainability goes beyond the procurement and erection costs and focuses especially on the follow-up costs of a building. The emphasis is therefore on building-related life cycle costs, economic efficiency and value stability. As has been demonstrated in practice, the follow-up costs of a building can exceed the erection costs several times over. An extensive life cycle cost analysis can identify significant potential for savings during planning. Particular attention is given to building construction costs and building utilisation costs as life cycle costs (LCCs).

Protection goals are assigned to the **social and cultural dimension** that affect both social and cultural identity as well as people's sense of value. During an identification process, the individual perceives and either consciously or unconsciously assesses their environment. The resultant positive or negative feelings are expressed by the degree of comfort and motivation felt. The individual's social needs and expectations are just as important here as the cultural values of a social system. These include, above all, intangible assets, such as health, mobility and quality of life, as well as equal opportunities, participation, education and cultural diversity. This dimension of sustainability hence focuses not just on user needs and functionality, but also on the cultural and aesthetic importance of the building.

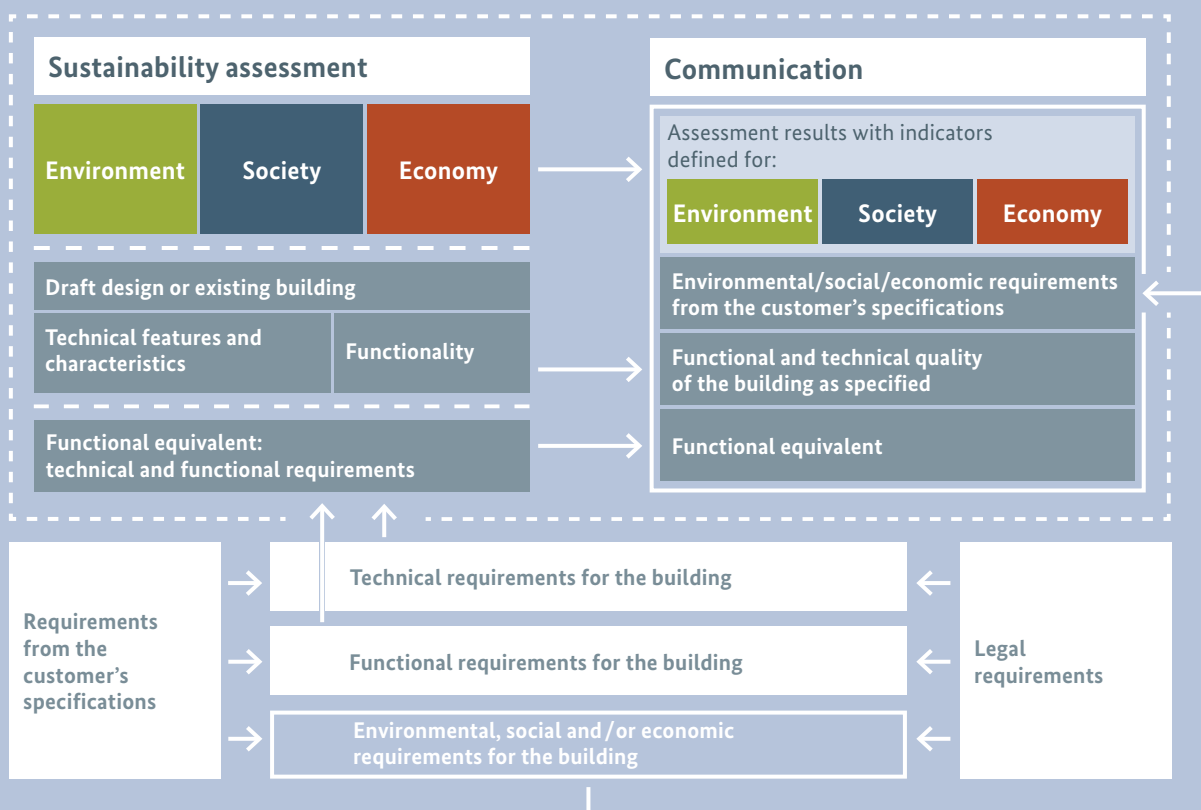
**PROTECTED ASSETS AND PROTECTION GOALS IN GENERAL
AND FOR THE CONSTRUCTION AREA IN PARTICULAR**
FIGURE A2

PROTECTED ASSETS		ECOLOGY	ECONOMY	SOCIO-CULTURAL ASPECTS
	Sustainability in general	<ul style="list-style-type: none"> ■ Natural resources ■ Natural environment 	<ul style="list-style-type: none"> ■ Capital/assets ■ Economic performance 	<ul style="list-style-type: none"> ■ Human health ■ Social and cultural values
	Sustainable building	<ul style="list-style-type: none"> ■ Natural resources ■ Global and local environment 	<ul style="list-style-type: none"> ■ Capital/assets 	<ul style="list-style-type: none"> ■ Health ■ User satisfaction ■ Functionality ■ Cultural value
PROTECTION GOALS	Sustainability in general	<ul style="list-style-type: none"> ■ Protection of natural resources/sustainable use and management of natural resources ■ Efficiency improvement ■ Reduction of pollution exposure/environmental influences ■ Protection of atmosphere, soil, groundwater and waters ■ Promotion of environmentally compatible production 	<ul style="list-style-type: none"> ■ Reduction of life cycle costs ■ Reduction of subsidy volume ■ Reduction of debt ■ Promotion of responsible entrepreneurship ■ Creation of sustainable consumption patterns ■ Creation of dynamic and co-operative international economic conditions 	<ul style="list-style-type: none"> ■ Protection and promotion of human health ■ Reinforcing inclusion and solidarity ■ Protection of cultural assets and values ■ Equal opportunities ■ Protection of capacity to work and jobs ■ Fight against poverty ■ Education/training ■ Equal rights ■ Integration ■ Safety/liveable environment
	Sustainable building	<ul style="list-style-type: none"> ■ Protection of natural resources ■ Protection of the ecosystem 	<ul style="list-style-type: none"> ■ Decreasing life cycle costs ■ Improvement of economic efficiency ■ Protection of capital/assets 	<ul style="list-style-type: none"> ■ Protection of health, safety and comfort ■ Maintenance of functionality ■ Protection of aesthetic and urban development quality

Source: BBSR

CONCEPT FOR ASSESSING THE SUSTAINABILITY OF BUILDINGS

FIGURE A3



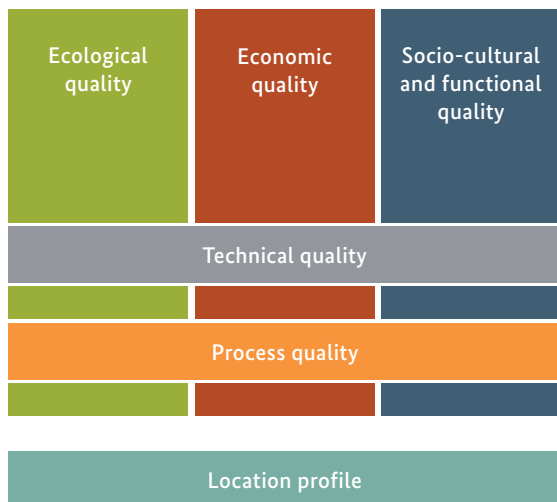
Source: BBSR, with reference to DIN EN 15643-2:2011

According to DIN EN 15643 “Sustainability of construction works – Assessment of buildings”, the three dimensions must be assessed at the same time and to the same extent (figure A3). This European standard additionally calls for consideration and evaluation of functional and **technical qualities**. Based on this, the technical quality is included in the national approach as a cross-sectional quality because the technical properties of a building have a strong impact on sustainability quality. The same applies to the process-related aspects of planning and execution. While **process quality** already strongly influences the other sustainability qualities in the early planning phase, it also determines the degree to which the planned quality is actually implemented during execution. A building’s degree of sustainability can be described and evaluated using the five sustainability criteria identified (figure A4). These parameters typically interact, so that an holistic assessment is obtained.

In addition, information regarding the location profile is also examined because a building is always a response to the conditions of its location. When it comes to evaluating the sustainability of outdoor facilities, the location profile is not only shown as information, but as location criteria it forms an integral part of the evaluation.

QUALITIES OF SUSTAINABLE BUILDING

FIGURE A4



Source: BBSR

Integrated design

Future-enabled and sustainable building and operation call for holistic and integrated planning. In the early planning phase, the way is already paved for the future sustainability quality of a building. That's why aspects of sustainability must be taken into account in all planning, construction and management processes in order to achieve (new buildings), maintain (operation) and improve (refurbishment) the quality of the building. The focus is placed on the entire life cycle of the building "from the cradle to the grave". It should, however, be noted that conventional planning already includes many aspects of integrated planning. That being said, however, this is limited to a host of individual aspects in individual life cycle phases without addressing any mutual dependencies or interactions that may exist. One example is the focus on the construction phase with usually "capped" investment costs or the energy efficiency calculations pursuant to the Energy Saving Ordinance (EnEV) which are restricted to the use phase. Integrated planning links and sensibly supplements these individual aspects from an interaction perspective, optimises them and uses the results to develop future-enabled complete solutions.

Life cycle assessment

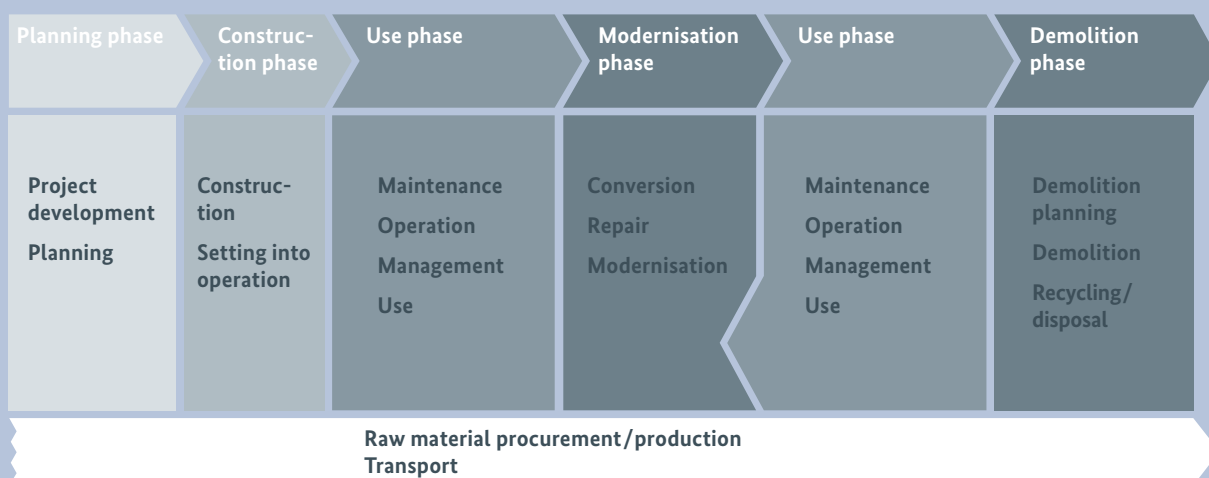
Assessing the building over its life cycle provides an insight into the real quality of the building because buildings are usually used over a very long period of time. The main phases of the life cycle of a building are: planning/design, construction, use including maintenance, rehabilitation as well as demolishing, recycling and disposal (figure A5). The phases of a building's life cycle must be analysed with a view to the different sustainability aspects and optimised with regard to their interaction.

The application of the life cycle analysis is based on the following conditions:

- The building and its life cycle must be suitably modelled and it must be both adequately and completely described according to the given assessment task.
- The necessary decisions and actions must be defined along a time line and assigned to the different phases of the life cycle.
- The relevant stakeholders must be identified in each case.
- An examination framework must be defined to match the stakeholders and their areas of action, responsibility and influence. In this context, the perspective must be clarified (focus on the current situation, prognosis, retrospective analysis).

The aim is to achieve an objectifying and quantifying assessment method for comparing variants of different building designs in order to achieve the best-possible building and utilisation quality with the lowest possible expenditure and environmental impacts and to maintain this on a long-term basis. Before deciding in favour of a new building, the option of using an existing building should be generally examined. The advantage of continued use or new forms of using an existing building is that significantly lower energy and material flows are usually required for the construction measures needed, hence resulting in lower consumption of natural resources and a less intense impact on the environment. There may, however, be some cases when the

SIMPLIFIED PRESENTATION OF THE LIFE CYCLE
FIGURE A5



Source: BBSR, with reference to Lützkendorf, T. (2007)

different variants, for instance conversion, expansion, partial or complete demolition and new construction, have to undergo an holistic comparison because a full stock-taking and balancing exercise covering a defined use period is the only way to determine whether a particular variant will pay off. In the case of maintenance or modernisation measures involving replacement of elements and equipment, the relevant material flows and environmental impacts of demolition, disposal or recycling work must be sufficiently considered. The same applies to the demolition of buildings or parts of buildings.

2. Sustainability assessment using the BNB

In order to implement and quantify the requirements for sustainable building, the Assessment System for Sustainable Building (BNB) has been developed for the integrated assessment of federal buildings. This system is a practical tool for optimising sustainability requirements when planning building projects. The systematic assessment of sustainability qualities, which are geared towards the goals of sustainable building, means that buildings can be fully assessed and compared with a view to the quality of their sustainability.

As a second-generation assessment system, the BNB offers a holistic assessment approach. Unlike other certification systems of the “first generation”, it provides a more far-reaching assessment of the building that covers its entire life cycle, including all sustainability dimensions. The basis for the BNB system is the national catalogue of criteria which was developed together with the associations from the building sector at the Federal Building Ministry’s Round Table on Sustainable Building.

While the Guideline for Sustainable Building provides an explanatory framework document for implementing and operationalising sustainable planning, building, utilisation and operation, the BNB system delivers verification methodology to be applied. The Assessment System transposes the requirements set forth in this

Guideline into a structure of evaluation criteria and assessment benchmarks so that the degree of fulfilment of the Guideline’s requirements can be measured and presented. The aim here is to describe and assess the sustainability quality of buildings and structural complexes in all of their complexity.

As an assessment system, the BNB can only use those aspects for which clear-cut assessment rules can be described. In the interest of higher protection goals, however, detailed planning should address other individual issues which are not expressly covered by the BNB system, such as:

- Protection against radon exposure in buildings
- Electromagnetic radiation (electrosmog)
- Possible urban heating effects
- Social aspects of procurement (social corporate responsibility)
- Transport costs during procurement
- Risk assessment/worst-case scenarios
- Rebound effects

2.1 Assessment System for Sustainable Building

Through a standardised assessment approach, the BNB creates the system transparency which all project stakeholders (owners¹, planners, users² and investors) and other market players need. With its assessment scheme, the system can be used to identify and recognise outstanding planning achievements in the field of sustainable building. The system takes a comprehensive view of the entire life cycle of buildings, giving equal consideration to ecological, economic and socio-cultural qualities as well as technical and process aspects. The Assessment System is both transparent and objective, reflecting international developments in the field of standardisation and other initiatives related to sustainable building.



Gold standard in the context of the development phase of the BNB System, Federal Environment Agency in Dessau

-
- 1 As defined within the scope of the processes in the Guideline for Sustainable Building: project sponsor/owner (legal entity, which assesses the means of a project in its household).
 - 2 User here means the organisation (company, enterprise, office etc.) using the property.

**INTERACTION BETWEEN THE GUIDELINE FOR SUSTAINABLE BUILDING
AND THE ASSESSMENT SYSTEM FOR SUSTAINABLE BUILDING (BNB)**
FIGURE A6



Source: BBSR

The BNB is also a quality management system for planning, building, using and operating buildings. It can be used by owners and planners as a checklist, a decision-making and planning tool as well as a basis for discussion and agreement. The system can also be used as a structure for describing the major building components and features. During the use phase, the BNB system supports owners/operators and users, allowing them to use and manage buildings according to sustainable development goals. It also enables the provision of data, for instance, for the use of environmental management systems or sustainability reports.

System variants

The BNB system provides specific system variants for selected types of buildings and uses so that the respective requirements can be systematically taken into account in the sustainability assessment.

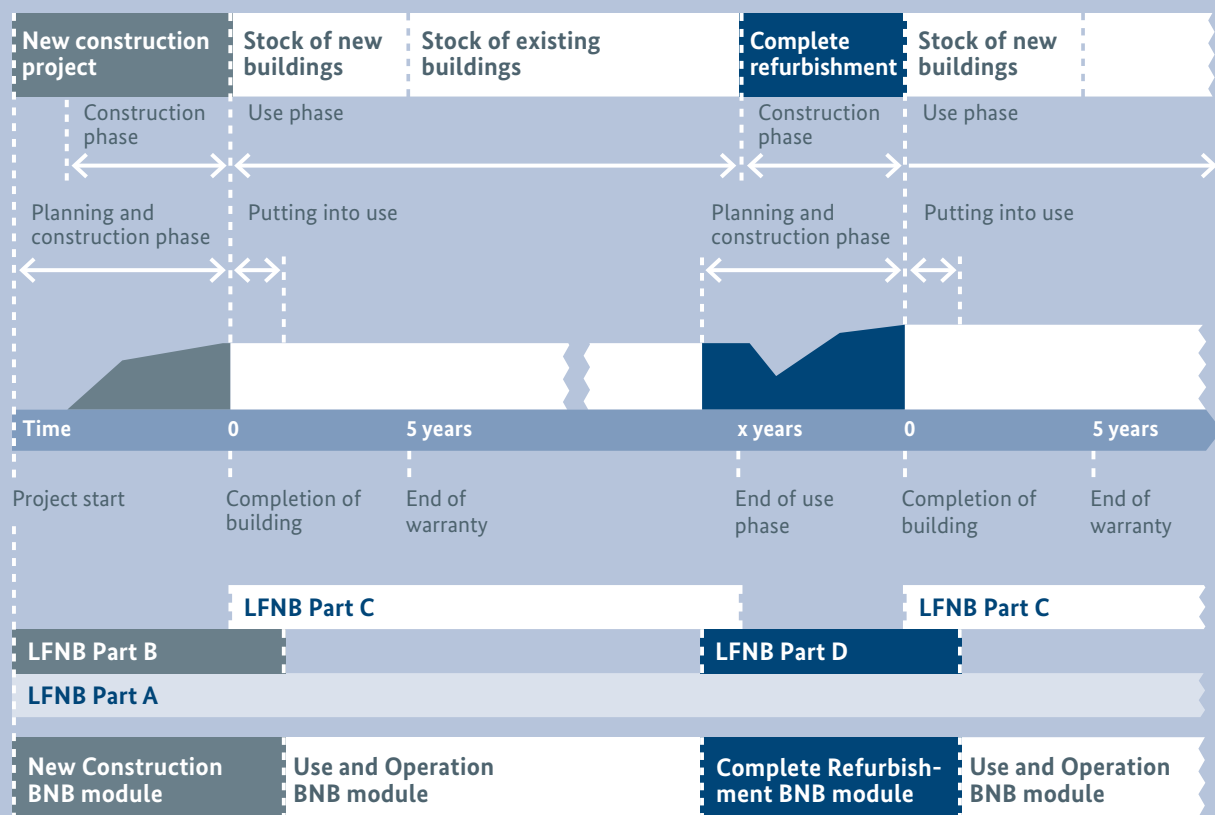
If it is not possible to clearly assign a building to one system variant due to its location (for instance abroad), type of building or use or scope/depth of the project, analogous application is generally possible. In this case, the individual boundary conditions for the respective country, climate zone or building type must be identified. The aim is for all the project stakeholders to include in the project the protection goals of sustainability to the furthest extent possible. Project-specific application is then based on agreement with the Conformity Testing Office.

The system variants, such as

- Office and Administration Buildings
- Educational Buildings
- Laboratory Buildings
- Inter-company Vocational Training Facilities
- Outdoor Facilities

as well as the approach used for analogous application are presented in more detail in section A4.

TIMELINE OF INTERACTION BETWEEN THE GUIDELINE FOR SUSTAINABLE BUILDING (LFNB) AND THE ASSESSMENT SYSTEM FOR SUSTAINABLE BUILDING (BNB) FIGURE A7



Source: BBSR



(A) Description and methodology



(B) Assessment standard



(C) Annexes

Criteria profile example

Modular layout

A building as well as its use and operation processes can undergo multiple sustainability assessments during the life cycle of the building. The Assessment System for Sustainable Building has a modular structure for this purpose. The following three modules are used:

- New Construction module
- Use and Operation module
- Complete Refurbishment module.

The BNB modules reflect the cases dealt with in this Guideline, in other words planning and erecting new buildings, using and operating buildings, as well as planning and performing refurbishment and conversion projects (see also figures A6 and A7). The New Construction and Complete Refurbishment BNB modules address the planned and as-built states of buildings. Part A, “Principles of Sustainable Building” and Part B, “Sustainable Building Projects”, of the Guideline are particularly important for new buildings. Part D of the Guideline, “Refurbishment of Buildings”, applies to construction measures for existing buildings and supplements Parts A and B in this respect. The Use and Operation BNB module serves to identify and assess the concrete quality of a building in use as well as the quality of its use and operating processes. This module is hence directly related to Part C of this Guideline, “Recommendations for the Sustainable Use and Operation of Buildings”. Furthermore, the Use and Operation BNB module enables the analysis of the current state of an existing building which has not yet been analysed under sustainability aspects so that under some circumstances, suitable modernisation measures can be identified as a result of such an analysis. The current state analysis of individual buildings can also serve as a basis for analysing the portfolio of existing buildings.

Criteria profile

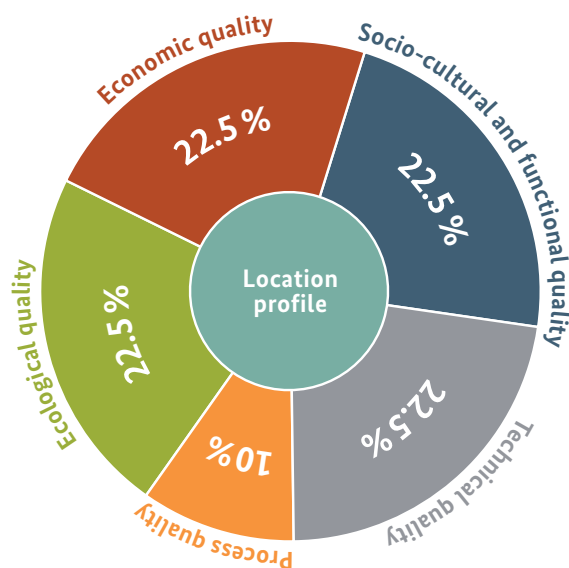
The BNB is divided into three levels: the main criteria groups which are derived from the five sustainability qualities and the location profile, the criteria groups and the individual criteria (figure A8). The individual criteria are precisely defined on the basis of the criteria profile which are essentially structured in terms of (A) description of the individual criterion, (B) assessment standard and (C) annexes (see the exemplary criteria profile alongside). The targets and methods are described for each criterion in the criteria profile, which are rounded off by information regarding rules and technical information, as well as the necessary documents and verification reports. The project-specific qualities are classified on the basis of criteria-specific assessment standards.

LEVELS OF THE BNB
FIGURE A8

Main criteria group	5. Process Quality
Criteria group	5.1 Management and Design
Criterion	5.1.2 Integrated Design
Indicator	Interdisciplinary Project Team
	Qualification of the Project Team
	Integral Planning Process
	User Participation
	Public Participation

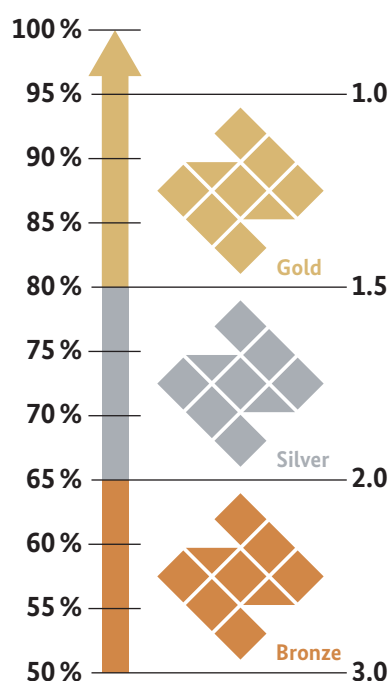
Source: BBSR

**WEIGHTING OF THE MAIN
CRITERIA GROUPS OF THE BNB**
FIGURE A9



Source: BBSR

BNB ASSESSMENT SCALE
FIGURE A10



Source: BBSR

2.2 Sustainability assessment of the planning, design and construction process according to the BNB

Assessments according to the BNB system provide quantitative mapping of the quality of the five main criteria groups on the basis of individual criteria. The assessment is carried out for each individual criterion by assigning an assessment score according to defined rules. The highest possible score in any criterion is 100 points according to the relevant calculation rule while 100 points is always the target value definition. The individual results are compiled within the respective main criteria group while the individual criteria are weighted with a fixed factor of 1 to 3 depending on their respective relevance for the protection goals. The ratio between the maximum possible score and the score actually achieved is used to calculate the degree of fulfilment within the main criteria group (see figure A9). With a defined weighting factor, the results of the main criteria groups are calculated to identify the total degree of fulfilment. The final score is then determined on the basis of the total degree of fulfilment achieved.

The BNB system is based on defined rules: Minimum degrees of fulfilment, so-called limit values in the respective assessment standard, must be observed for each individual criterion. Depending on the type of building (standard building or special building (section B1), with or without monument protection (section D3)) or the type of project (complete or partial refurbishment (section D2)), minimum degrees of fulfilment are also defined for the total degree of fulfilment (see Annex B7). The basic principle is to achieve a balance between all the criteria groups.

The quality standard reached depends on the degree of fulfilment (usually gold, silver or bronze, see also figure A10). This overall rating is used to objectively identify and quantify the sustainability of buildings so that assessed or certified buildings can be compared. Since the five main criteria groups are assessed separately, it is possible to highlight outstanding qualities in individual sub-areas. The location profile, which planning can influence to a limited extent only, is assessed separately for property qualities and serve merely as information. A binding examination of the result documents (conformity test) is subsequently carried out for quality assurance purposes within the scope of certification.

FEDERAL BUILDING This Guideline and the supporting decree on the introduction of the Assessment System for Sustainable Building are the binding basis for the mandatory application of the BNB system. The silver standard of the BNB is the minimum standard that must be adhered to for all federal buildings addressed in the decree. The gold standard should be the target for selected buildings. First model projects by the federal government have shown that the highest sustainability requirements of the gold standard are economically feasible while providing a high level of user comfort.

The BNB is applied during planning and construction and serves both as a tool and as a continuous means of quality control during the execution of the construction project. The BNB system can be downloaded from the information portal (www.nachhaltigesbauen.de) along with its system variants and criteria profiles. It primarily addresses matters related to federal government building projects, however, it can also be used by other building owners to describe and assess the sustainability quality of buildings and structural complexes.

System boundaries

In the assessment of the sustainability of the planning and construction phase, the building – and in certain individual criteria the use aspects of the property in question – is used as the physical system boundary because it is the building that can be directly influenced by the owner.

The underlying time frame is the entire life cycle of the building, including selected aspects of building demolition. The life cycle is examined on the basis of the actual data of the structure which has to be combined with the forecast data for the use and demolition phases. In the case of a new office and administration building, for instance, the first 50 years must be used. The defined observation period is not automatically identical to the building's planned period of use or the maximum utilisation period.

2.3 Instruments to support implementation of sustainable building

Various fundamentals, information and tools are today available for the integrated design, planning and assessment of sustainability aspects in the construction sector. Their purpose is to ensure the integration of sustainability aspects into planning, design and execution. Furthermore, application tools are available to make it easier to calculate, record and comprehensively document sustainability aspects.

These include:

- The Sustainable Building Information Portal as a general platform
- eBNB (Internet-based assessment and documentation tool)
- Data and databases
- eLCA (eco-balance instrument)
- Brochures on different system variants
- System for Sustainability Requirements in Design Competitions (SNAP)
- Procurement tools (sustainability compass)
- Sustainable federal building network

The information portal

The Sustainable Building Information Portal (www.nachhaltigesbauen.de) not only provides general information and basics on sustainable building, but also a host of guides and tools, construction material and building databases along with information about research projects and events. All the criteria profiles of the BNB modules or system variants can also be downloaded from the BNB portal (www.bnb-nachhaltigesbauen.de).

eBNB (Internet-based assessment and documentation tool)

The eBNB was developed as an Internet-based project management system for implementing the BNB system in federal buildings (www.ebnb.bundesbau.de). The central goal is to harmonise verification and documentation processes in the BNB system, to ensure quality in the field of conformity testing and to improve the flow of information at federal building departments. With the eBNB as a central database system, all the information required for a BNB assessment can now be systematically collected and documented. The necessary conformity tests can also be carried out digitally. The federal building departments work in independent project areas, some of which can be individually adapted. The eBNB is a tool that centrally collects for all federal sector buildings complex building information in the form of dynamised building data and stores this information for scientific use and for political consultancy. There are also import interfaces with BNB research tools, such as eLCA, as well as export interfaces with cost databases, such as PLAKODA.

eLCA

eLCA³ was developed by BBSR as a free, Internet-based software solution for creating eco-balances. Based on a dynamic building block editor and a graphic user interface, individual building blocks or even entire buildings can be modelled in a user-friendly manner. The software is directly connected to the national online building material database (ÖKOBAUDAT). Using additional building data, the environmental impacts identified are assessed and compared with the BNB benchmarks. It is also possible to export the calculated data to the eBNB. This software solution provides a uniform basis for global ecological assessments in construction and, in particular, for federal building projects. Go to www.bauteileditor.de to register and use the program.

View of overall assessment in eBNB



Modelling outside wall structure with eLCA

ÖKOBAUDAT

ÖKOBAUDAT⁴, the German online building material database, provides the basic data for eco-balances for buildings with a view to energy consumption, use of resources, as well as global ecological impacts that cause the greenhouse effect, acid rain, smog, eutrophication and so on. In ÖKOBAUDAT, BMI provides the uniform and quality-assured eco-balance data for the main construction product groups, as well as for the use and exploitation paths. Thanks to the high data quality, reliable statements can be made regarding the ecological quality of a building. ÖKOBAUDAT offers DIN EN 15804-compliant data as well as generic and product-specific data from environmental product declarations (EPDs), export of eco-balance data to eco-balance tools, such as eLCA, and rules for recording eco-balance data in ÖKOBAUDAT.

3 www.bauteileditor.de

4 www.oekobaudat.de/en

Environmental product declarations (Type III environmental product declarations) offer manufacturer-related eco-balance data (energy and resource consumption, environmental impacts, technical characteristics) for ecological life cycle assessments. They are audited by independent third parties and are hence a reliable and secure data source for construction product information of environmental and health relevance. Furthermore, other standard-compliant type-III environmental product declarations from industrial sources can be used. In Germany, these are published via the EPD programme owners or third parties with comparable expertise. DIN EN 15804 provides the basis for drawing up environmental product declarations.⁵

WECOBIS information system

The WECOBIS building material information system⁶ supports the holistic ecological selection of building materials by providing product-independent, environmental and health-related data. The description of the ecological quality of building products and basic material groups over the life cycle is supplemented by general planning and tendering tools, as well as text modules for ecological requirements for materials. The contents refer directly to the requirements for building materials as specified in the BNB. WECOBIS hence makes it possible in the design and planning process to define goals and qualities for selecting building materials, to compare building products, to tender and implement while taking the life cycle into account and, finally, to classify the impacts of the building materials on building users and the follow-up use phase.

Service life of building components

When calculating the life cycle costs (LCC) and eco-balances (LCA) of buildings within the scope of applying the BNB system, the “Service Life Table” provides information regarding the use periods of building parts for the defined, building-related 50-year observation period. During the design and planning phase, this service life data can be used to draw up forecast scenarios while applying defined boundary conditions so that the LCC and LCA can be estimated.

PLAKODA

The planning and cost-data module of the federal states and federal government (PLAKODA) provides various PLAKODA modules for public building departments depending on the real construction projects collected in a joint database. The PLAKODA modules are a starting point for calculating investment and use costs for new and existing public buildings according to the net present value method. The “Life Cycle Costs” module also provides a starting point for life cycle orientated design and planning. As part of early cost estimates, it is hence possible to determine investment costs on the basis of selected building projects and furthermore to estimate follow-up costs. The PLAKODA “Life Cycle Costs” module thus directly maps the requirements of the BNB with a view to calculating selected costs in the life cycle and additionally allows for different calculation methods (as cash value method, compound value method.). The PLAKODA modules are issued by the Ministry of Finance and Economics of the State of Baden-Württemberg.



Overview of the building product groups on the www.wecobis.de website

⁵ See DIN EN 15804: 2014-07

⁶ www.wecobis.de

Supporting brochures

The BBSR provides information brochures as BNB application tools on the Sustainable Building Information Portal. Brochures are available for individual system variants, such as Office and Administration Buildings or Educational Buildings.

System for Sustainability Requirements in Design Competitions (SNAP)

The System for Sustainability Requirements in Design Competitions (SNAP)⁷ provides assistance when it comes to considering sustainability requirements in competitions. In addition to customary urban development, architectural and design criteria, the design competition should additionally address further selected sustainability criteria. The selection of the relevant sustainability criteria, the scope of services to be performed and the relevance of the sustainability concept for the decision by the jury members must always reflect the respective competition and the specified BNB quality level. The SNAP brochure compiles detailed recommendations for this, and an Excel-based tool has been developed for pre-examining competition entries.

Procurement tools

Sustainable procurement continues to be an obstacle for many public administrations because frequently there are no procurement documents or tools available. This is why two information platforms on sustainable procurement have been launched. The Centre of Excellence for Sustainable Procurement at the Procurement Office of the Federal Ministry of the Interior (www.nachhaltige-beschaffung.info) and the Sustainability Compass of the Federal Ministry for Economic Cooperation and Development (www.kompass-nachhaltigkeit.de) are just some of the various service modules available for public procurement purposes. The information platforms not only address the building sector and buildings, but also other areas of public procurement and hence help to distribute information in a targeted manner.

Sustainable Federal Building Network

The Sustainable Federal Building Network is made up of qualified BNB sustainability co-ordinators from the federal building administrations along with representatives of BMUB, BBSR, the Institute for Federal Real Estate (BImA) and the federal-state building administrations. The network can access an Internet-based information and exchange platform for information related to experience gained during implementation of the BNB system in the field and participate in a discussion forum dedicated to developing the BNB system further. The annual BNB user meetings organised each year by the Administrative Office for Sustainable Building are an important event for this network as they offer sustainability co-ordinators a regular platform for exchanging experience gained in the respective building administrations with the implementation of the Guideline and the BNB system.

7 BMVBS (2013 b)

3. Qualities of sustainable building

Examples of the qualities of sustainable building are described below on the basis of the Office and Administration Building system variant (New Construction BNB module, version 2015). Depending on the specific requirements and boundary conditions of the individual system variants, deviations may be necessary in individual criteria when assessing other types of buildings. The information provided below also includes additional references to individual aspects that have not yet been described using the BNB methodology but which should be included in the design and planning of a building.

3.1 Ecological quality

Ecological quality refers to protected assets such as “protection of the global and local environment” and “natural resources” with the related protection goals:

- Protection of the ecosystem
- Saving natural resources

Generally speaking, buildings interfere significantly with existing ecosystems due to the energy and raw materials consumed during their design and planning, erection, use and disposal. Buildings therefore generate considerable energy and material flows along with impacts on local and global environments. Sustainable building aims to minimise energy consumption, the use of other resources and impacts on the environment through the optimum choice of components and energy sources. This is very much in line with the goal of the National Sustainability Strategy⁸ which is to boost efficiency while adhering to the standards and requirements of today's buildings. Quantifiable indicators have been determined in order to describe the different ecological goals and measure their level of achievement. These indicators⁹ are based on the eco-balance methodology with the calculation of net effect data as an instrument for the global ecological assessment of buildings.

This form of assessment is less biased than the negative/positive lists traditionally used in the construction industry as a means for assessing building products as placeholders for “environment-friendly building”, enabling now for the first time a more global assessment approach.

In addition to the efficiency approach, which basically focuses on optimisation potential, sufficiency approaches will have a greater role to play in the future of building. In contrast to optimisation, the first step involves critically examining the identified demand. The concept of sufficiency is geared more towards a reduction to what is essential. This paradigm shift among owners and users, especially where social and functional issues are concerned, has direct and positive impacts on the protection of ecosystems and natural resources.

The aims of ecological quality are supported on national level by the following:

- The updating of the national climate protection programme with a commitment of an approximate 85 percent reduction in emissions of the greenhouse gases covered by the Kyoto Protocol¹⁰ by the year 2050 compared to 1990
- The Directive on the energy performance of buildings¹¹
- The federal government's Integrated Energy and Climate Programme¹²
- The federal government's Resource Efficiency Programme

8 See Nationale Nachhaltigkeitsstrategie (2002), Maßnahmenprogramm (2010), BMU (2012)

9 See DIN EN 15643-2: 2011-05

10 See UNO (1997)

11 See EU (2010)

12 See Bundesregierung (2007)

3.1.1 Protection of the ecosystem

With regard to the protection of the ecosystem, a distinction must be made between impacts on the global and the local environment. In order to describe the different environmental impacts, the assessment criteria are defined on the basis of quantitative and qualitative indicators¹³.

IMPACT ON THE GLOBAL AND LOCAL ENVIRONMENT TABLE A1

Criteria*	Impact with a view to
Global Warming Potential (GWP)	BNB 1.1.1 Global warming
Ozone Depletion Potential (ODP)	BNB 1.1.2 Ozone layer depletion
Photochemical Ozone Creation Potential (POCP)	BNB 1.1.3 Creation of ground-level ozone as summer smog
Acidification Potential (AP)	BNB 1.1.4 Acidification of soils and waters
Eutrophication Potential (EP)	BNB 1.1.5 Waters, ground water and soils
Risks to the Local Environment	BNB 1.1.6 Reduction in pollutants in water, soil and air resulting from the processing of materials at the construction site or due to
Sustainable Material Extraction/Biodiversity	BNB 1.1.7 Protection and preservation of the earth's tropical, sub-tropical and boreal forest regions and the related preservation of biological diversity

* Reference to the respective criteria profiles, which can be retrieved at: www.bnb-nachhaltigesbauen.de
Source: BBSR



Targeted use of wood as a renewable resource, the Federal Environment Agency's Haus 2019 building

As part of eco-balancing, the effects on the **global environment** are currently being described with a view to greenhouse effects, ozone layer depletion in the stratosphere, ground-level ozone creation, acidification and eutrophication and assessed on the basis of corresponding equivalent action potentials (BNB 1.1.1 to 1.1.5). This is related to both the production and the use phases.

In line with the concept of the Guideline for Sustainable Building, the subject of sustainable material extraction/biodiversity (BNB 1.1.7) is currently assigned to qualitative global environmental impacts because it has not been possible up to now to sufficiently map this using the eco-balancing method. The threatened forest/tropical forest habitat represents a major globally effective ecosystem which is a significant protected asset due to its biological diversity. By ensuring sustainable forest management, biologically diverse habitats can be protected while continuing to be used on a permanent basis. As descriptive scientific methods advance, other aspects of diversity that need to be assessed must be integrated in the medium term into the "Global and local environment" criteria group of the BNB.

Risks to the **local environment** (BNB 1.1.6) can result from pollutants released from construction products. Especially when these products are processed at the building site or during building use, the pollutants can enter waters, soil and air and can pose a risk to health due to accumulation in the food chain and pollution of indoor air. It is hence imperative during the planning and erection phase to ensure that construction products with low risks are used, and the materials installed must be examined with a view to this. Following completion of the project, the building is examined to confirm the successful use of low-emission construction products (see BNB 3.1.3).

13 See DIN EN 15643-2: 2011-05

Potential pollutants include hazardous and particularly alarming substances, heavy metals, volatile organic compounds, halogenated cooling and blowing agents and biocides. It is important that these substances be avoided because there are a number of products and mixtures in construction that could pose a high risk. It must be taken into account that both chemicals laws and regulations for construction products are being persistently further developed at both European and national levels with a view to labelling obligations as well as product compositions.

Furthermore, other aspects are also the subject of scientific discourse among experts regarding the effects on the local environment. These are, for instance:

- **Micro-climate:** building-specific, heat island effects of urban structures compared to the surrounding area
- **Ecotoxicity:** determining ecotoxicity as part of local eco-balancing and its inclusion in the BNB
- **Demolition:** release of bound pollutants due to the demolition of buildings

However, it has not been possible to include all of the topics, or proven assessment methods are still not available.

3.1.2 Protection of natural resources

The term “natural resources” includes a host of individual resources which must be assessed according to different standards. Resource consumption is closely linked here with shortages of resources. No scientific assessment of available resources has been compiled up to now in one indicator with a view to sustainable action so that, for now, a principle of avoiding/reducing resource consumption must be pursued.

That being said, examining resource consumption is about more than just primary availability, indirectly the aspect of habitat destruction (for instance, through land use) and hence the threat to both global and local biological diversity must also be generally taken into account. While forest, lake, moor, mountain habitats etc. are a resource warehouse for the building sector,

they are also complex ecosystems with a high degree of biological diversity. Unlike the “Protection of the ecosystem” criteria group where impacts on biological diversity are looked at, the habitat itself must also be seen here as a natural resource.

In the building sector, the protection of natural resources must be promoted through the following measures:

Building-material resources

- Longer use of products, structures and buildings
- Use of construction products/materials which can be reused or recycled
- Safe recycling of materials and substances in as far as this makes sense
- Reduced resource demand in conjunction with the construction and operation of buildings
- Use of raw materials from sustainable sources (also with a view to preserving biological diversity)

Non-building material resources

- Use of rainwater or grey water and reduced drinking water consumption

Energy resources

- Fewer transports of construction materials and parts
- Minimised energy demand during the use phase
- Use of regenerative energy

Biologically diverse space resources

- Minimising the use of land for buildings
- Compensatory measures

The “Saving natural resources” protection goal is described and assessed in the following criteria of the BNB:

SAVING NATURAL RESOURCES AND PRESERVATION OF BIOLOGICAL DIVERSITY

TABLE A2

Criteria*	Description and assessment with a view to
Primary Energy Demand BNB 1.2.1	Protecting limited fossil fuels, increasing coverage rate through renewable energy
Fresh Water Demand and Quantity of Waste-water BNB 1.2.3	Reducing fresh water pollution resulting from fresh water and sewage treatment
Land Consumption BNB 1.2.4	Minimising additional soil sealing and measures to re-expose sealed surfaces

* Reference to the respective criteria profiles, which can be retrieved at: www.bnb-nachhaltigesbauen.de

Source: BBSR

The resultant requirements correspond to national goals, for instance, regarding primary energy demand, as well as to the goals of the “Integrated Energy and Climate Programme”.

3.1.3 Eco-balancing

To a large extent, building-specific eco-balancing is a very good method for calculating global and local environmental impacts and mapping the use of resources. All of the calculation steps are subject to standardised methods so that comparable mapping precision can be ensured. When applying the Guideline for Sustainable Building and the BNB, it must be noted that the observation units (function units) are selected at an element or structure level.

An eco-balancing method offers various depths of determination, depending on the specific issue at hand in the project. In addition to the ecological risk analysis (qualitative view) and the material flow analysis (quantification without looking at environmental impacts), building-specific eco-balancing offers the best level of validity because unlike other methods, it includes the quantification of environmental impacts. Eco-balancing (LCA – life cycle assessment¹⁴) is an instrument that enables quantitative calculations of the environmental impact of a system which can be a single product, a structural element or an entire building. Eco-balancing can be used for construction products in order to identify the environmental impacts of the life cycle phases of production, transport, installation, operation, removal and the resultant recycling potential. The results for the individual construction products are compiled in the Environmental Product Declaration (EPD). Furthermore, industry-specific average data for construction products is available in ÖKOBAUDAT.¹⁵ By using these construction product data from manufacturing, it is then possible to perform a quantifying assessment of building parts or entire buildings while taking the environmental impacts of the following life cycle phases into account. Depending on the life cycle phases examined, the permanent nature of the individual building parts/components, in other words the service life to be applied in the calculation, is an essential factor for the results because more frequent replacement cycles usually cause greater environmental impacts. The service life table published on the Sustainable Building Information Portal provides useful information regarding the service life of building components/parts (see also section A2.3).

¹⁴ See DIN EN ISO 14040: 2009-11 and 14044: 2006-10

¹⁵ www.nachhaltigesbauen.de/baustoff-und-gebaeuedaten/oekobaudat.html

3.2 Economic quality

The economic quality of a building is reflected by the degree to which the following protection goals are implemented:

- Minimising life cycle costs
- Improving economic efficiency
- Protecting capital and (building) value

Costs, return and value stability are bundled under the “capital” protected asset and assessed on the basis of various indicators depending on the given project and life cycle phase. The importance and relevance of the individual indicators vary depending on the life cycle phase and the specific general conditions. The economic assessment always aims at holistic optimisation of economic parameters. This means that measures designed to optimise life cycle costs must be reasonably in line with the value of the building and its maintenance. The related long-term timeline focuses on the economic efficiency of the property throughout its entire life and also considers economic factors. The centre of interest is the building and its use which generate costs and at the same time create and preserve asset values.

3.2.1 Life cycle cost analysis

A life cycle cost analysis examines the costs that are generated during the construction, use and, on a case-by-case basis, demolition of a building. In the interest of maximum economic efficiency, this method can ensure that costs are optimised throughout the entire life of a building. One of the results of the life cycle cost analysis is a time-adjusted sum (cash value) per unit of useful or gross floor area in euro per square metre. For this purpose, all foreseeable costs are aggregated, including existing risks and price increase rates. The present value is determined using the net present value method.

LIFE CYCLE COSTS

TABLE A3

Life cycle costs in the sustainability assessment

Costs of manufacture according to DIN 276-1*	Construction costs
Costs of building use according to DIN 18960**	Operating costs
	Costs of cleaning, service and maintenance
	Replacement investment
Demolition costs according to DIN 276-1 (not currently included in the sustainability assessment)	Costs of demolition and disposal

* See DIN 276-1: 2008-12

** See DIN 18960: 2008-02

Source: BBSR

The major challenge when it comes to estimating supply demand and operating costs is that these factors are subject to different influences whose forecast development may at times vary considerably. Such influences include, in addition to the type of building use and service level agreements (SLAs)¹⁶, user behaviour, climatic conditions as well as the functional and technical characteristics of the building. Furthermore, each of these parameters can vary during the observation period. Orientation guidance is available from studies of use-dependent incidental costs or selected cost data in the PLAKODA planning and cost database¹⁷. ISO 15686-5:19, for instance, provides a systematic assessment basis¹⁸.

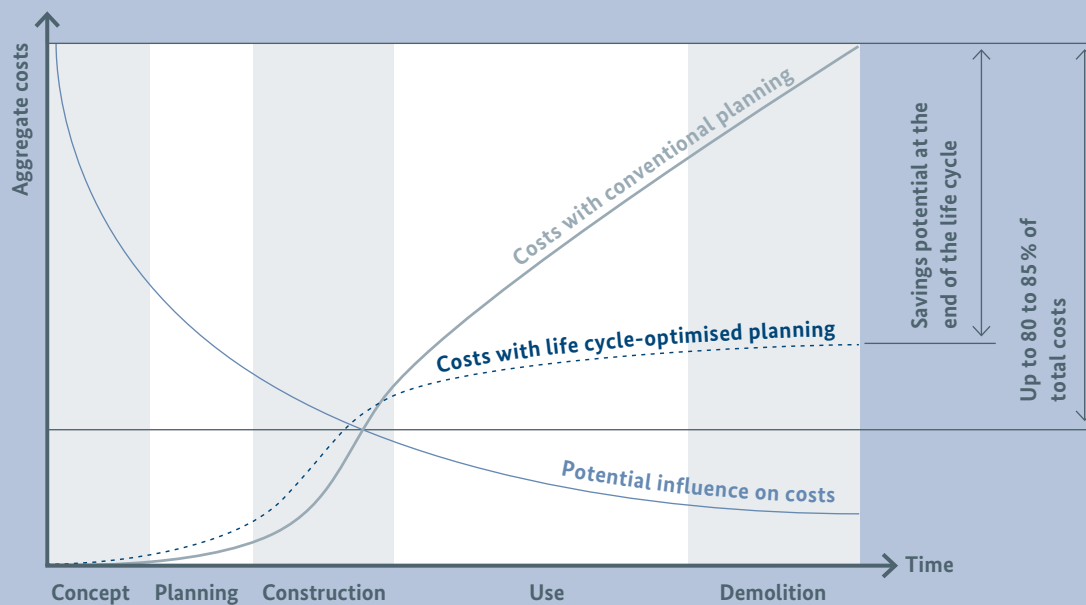
16 Service level agreements are quality standards for services which are defined as service-specific, contractually agreed service parameters, such as response and repair times.

17 PLAKODA planning and cost-data module of Landesbetrieb Vermögen und Bau Baden-Württemberg

18 BS ISO 15686-5: 2008-06

LIFE CYCLE COSTS

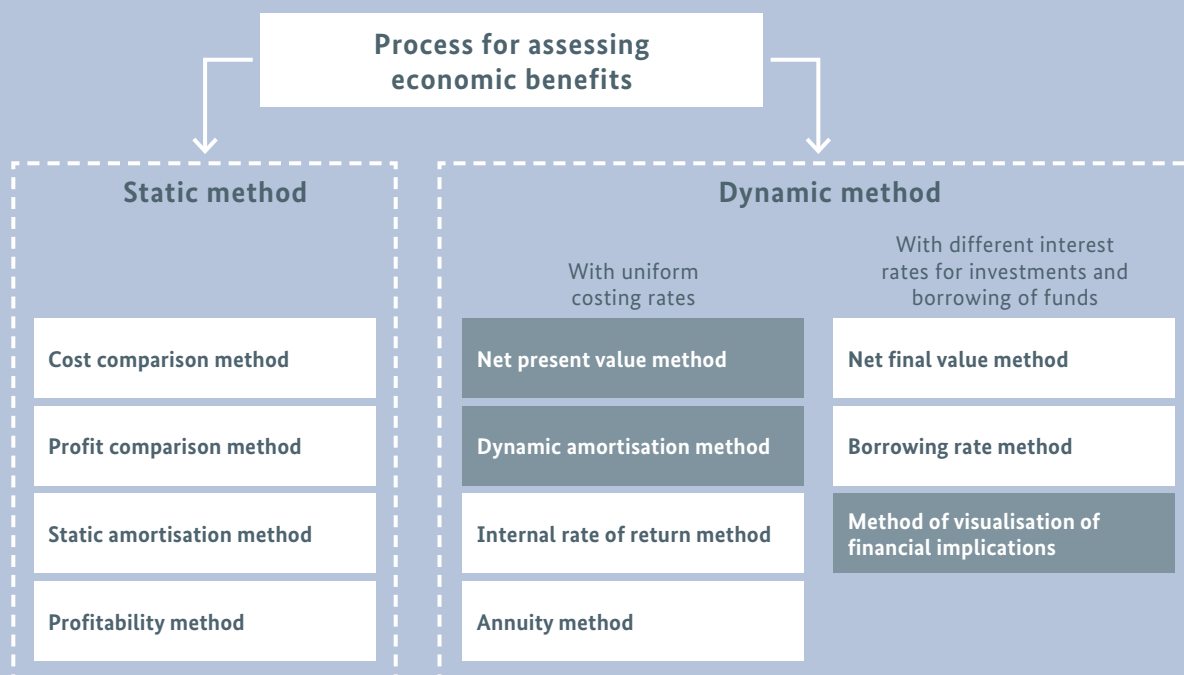
FIGURE A11



Source: BBSR, with reference to Jones Lang LaSalle (2008 b)

INVESTMENT ANALYSIS

FIGURE A12



Source: BBSR, with reference to Pfarr (1984)

Furthermore, all public-sector measures with financial implications must adhere to the principles of economic efficiency and good housekeeping. With a view to the financial consequences of a measure, special attention should also be paid to future revenue and payment streams. In order to do justice to the minimum approach, the costs of a building project must at the very least be considered according to the life cycle cost (LCC) methodology of the BNB.

Future price developments depend on the development of international commodity prices, exchange rates as well as costs for domestic production factors. This means that annual price increase rates must be determined and subsequently applied in a uniform manner. A cost assessment must additionally consider the effects of the use period if this differs from the technical service life of the building, which is usually the case if the building is strongly dependent on specific uses. Figure A11 shows that the consequential costs exceed the costs of construction of a building during its lifetime. A high quality of the finished building should lead to significantly lower costs during the use phase. Depending on the complexity of the planning and design task, this may mean higher construction as well as planning and design costs. A variant comparison based on a life cycle cost analysis can already be used during the planning phase in order to determine the potential for optimisation and savings.

3.2.2 Economic efficiency

The economic efficiency analysis describes the economic advantages of an (investment) project as the ratio between costs and benefits. The aim is to ensure the efficient use of funds in the interest of permanently high resource productivity. In view of the different goals and aims of a project, different methodological approaches can be used to analyse economic efficiency. The type of project and the stakeholders' respective opinions and expectations have a central role to play in this respect. Energy-efficient refurbishment of a building, for instance, means capital investment on the one hand and ongoing savings on the other. These can be compared as part of an evaluation of economic efficiency. Whilst amortisation of costs due to reduced operating costs is the key factor in the case of owner-used property, the focus in the case of property that is rented out would be on increasing base rent and hence return on investment.

Figure A12 shows that microeconomic analyses generally distinguish between static and dynamic methods. Unlike static methods, dynamic approaches consider the development of cash flows over the course of time. The net present value method is the most commonly adopted practical approach when it comes to assessing the economic efficiency of a property. Static methods are generally not suitable for assessing the economic efficiency of property investment. This applies specifically to life cycle-orientated analyses.

FEDERAL BUILDING Relevant provisions for the performance of economic efficiency assessments on a federal level include, in addition to section 7 of the Federal Budget Code (BHO), the related administrative regulation (“Verwaltungsvorschrift” VV), the “Introduction to economic efficiency assessments”¹⁹ guideline, the applicable provisions of the RBBau Guidelines and – specifically with a view to life cycle-orientated economic efficiency analyses – the guidance document “Economic efficiency assessments in PPP projects”²⁰.

3.2.3 Value stability

Protecting economic capital and assets is one of the protection goals of the economic dimension of sustainable development. With regard to the property issue, this means the preservation and protection of the (economic) value of a property over the course of time or a property’s life. The most common definition of the economic value of a property is its fair or market value. Section 194 of the Federal Building Code (BauGB) defines the fair/market value of a property as follows: “The fair value (market value) is determined by the price which could be realised in arm’s-length transactions at the time to which the determination relates according to the legal and factual conditions, the other characteristics and the location of the property or the other subject matter of the value determination regardless of exceptional or personal situations.” The stability of the value of a property can thus be measured or assessed via the development of the fair value of the property over the course of time. The value of a property can hence be called stable if the fair value of the property remains constant or even increases rather than decreases.

Pursuant to the “Ordinance Regarding the Principles for the Determination of the Fair Value of Properties” (ImmoWertV),²¹ three methods are basically available for determining the fair or market value of properties. These methods are shown in the overview on this page. The particular valuation method to be used depends on the purpose of the valuation, the type of property to be valued and the specifics of the property market concerned.

Methods relevant for determining fair and market values of properties pursuant to the ImmoWertV are:

- **Comparative value method (present-orientated):**
Market values are compared directly or indirectly. This means that the comparative value method reflects an arrangement already made between market participants. The comparative value is determined on the basis of prices reached in recent market transactions involving comparable assets.
- **Asset value method (past-orientated):**
This method is based on the cost of reproduction and/or manufacture or construction of the asset to be assessed. The underlying principle of the asset value method is that the purchase price and hence the fair value of a built-up property will reflect the costs necessary to obtain a comparable, undeveloped piece of land and to erect comparable structures on such a property.
- **Discounted cash flow method (future-orientated):**
This method is orientated towards the future cash flow that can be generated on an ongoing basis with a built-up property. The discounted cash flow is the sum of the cash values of all net revenues which can be generated from the property on an ongoing basis, including the cash value of the land, on condition that the property is correctly managed.

19 “Arbeitsanleitung Einführung in Wirtschaftlichkeitsuntersuchungen” (2011), circular by the Federal Ministry of Finance on 12 January 2011

20 “Wirtschaftlichkeitsuntersuchungen bei PPP-Projekten”, communicated in letter Ref. IIA3-H1000/06/0003 by the Federal Ministry of Finance dated on 20 August 2007

21 “Verordnung über die Grundsätze für die Ermittlung der Verkehrswerte von Grundstücken” (ImmoWertV 2010)

The key aspect, however, is that the value and its development and hence the stability of the value of a built-up property are influenced – relatively independent of the specific method used to determine the value – by a host of factors which can be classified as location, market and building-related. Location and market-related factors (external factors) include, for instance, aspects of building law, local amenities, immissions, transport infrastructure, the economic structure and situation and many more. These factors are not constant. Instead, they are subject to change over the course of time and hence to a market and location change risk as well as a resultant risk of a change in value. In order to minimise market and location risks as a whole, detailed market and location analyses are usually conducted before starting any project development measures. However, the degree to which external factors can be influenced during the use phase of a property tends to zero. This means that options to minimise risks and to create the preconditions to maintain a high value of a property must already be ensured during the planning phase through appropriate building-related features and characteristics. Building-related factors include, for instance:

- Space efficiency
- Possibility of conversion and reuse (flexibility and adaptability)
- Resilience
- Durability
- Energy characteristics

These and other factors directly influence the value and its development and hence the stability of the property's value.

It should, however, be noted that building-related factors cannot be considered and assessed separate from location and market-related parameters. A property ideally has features and characteristics that enable it to respond to specific market and location conditions and to adapt or to be adapted to changes in external factors over the course of time with minimal consumption of resources as a key prerequisite for maximum value stability. The guideline titled “Sustainability and Determination of the Value of Properties”²² provides a detailed explanation of the relationships between different sustainability-related building factors and property values.

In this Guideline for Sustainable Building, the examination focuses on the building-related (value-influencing) factors, such as space efficiency and adaptability.

In addition to a general reduction in the use of new space, boosting the efficient use of areas already sealed is another goal of the federal government's National Sustainability Strategy. Increasing space efficiency (BNB 2.2.1) is one important measure to this end.

Adaptability (BNB 2.2.2) is another factor that should not be underestimated when it comes to the sustainability of a building. That's because in light of the long service life that is today expected from new buildings, the challenge now is to meet not only present, but also future use requirements. In this context, it is important to assess which level of flexibility the structures in question permit and/or how complex the required adaptation and conversion work will be if general conditions change. The adaptability of a property influences the total service life and hence the building-specific costs over the life cycle as well as the related material flows.

22 Free copies of the guideline titled “Nachhaltigkeit und Wertermittlung von Immobilien” can be downloaded at: www.zora.uzh.ch/id/eprint/76701/

3.3 Socio-cultural and functional quality

Socio-cultural and functional quality includes all factors that influence the social and cultural identity of people and how they assess their environment. Socio-cultural and functional aspects are very important for how users and society assess a building. This means that a high degree of user satisfaction has a positive impact on the building's sustainability and leads to a high level of acceptance and long-term value of the building. Therefore, all socio-cultural aspects must be geared towards the individual and aim to create high use value.

The socio-cultural protection goals in sustainable building address the following areas:

- Ensuring health, safety and comfort
- Ensuring functionality
- Ensuring design quality

This means that along with user health, comfort and satisfaction, appropriate usability of the building and a high degree of spatial and functional comfort are important factors. Since all of these factors together have a considerable impact on building design, material selection, building construction and technical equipment, suitable targets must already be designed in the planning phase, and concepts must be drawn up. Since the appearance of the building and its direct surroundings influence the socio-cultural identity of those who use the building, urban development integration and exterior design are also important. In order to ensure architectural and urban quality, an evaluating comparison must be carried out by experts. The main contents of the criteria are explained in sections 3.3.1 to 3.3.3.

3.3.1 Health, comfort and user satisfaction

User-related quality goals that are geared to optimise the quality of use and user performance and which take into account health and comfort-related matters are particularly challenging because the result is often impossible to calculate in its entirety and is also open to subjective perception. While these issues are planned and implemented for a new building according to the applicable technical rules for building, occupational health and safety (OHS) regulations and the requirements planning, user-satisfaction surveys can be used to assess the actual situation in existing buildings. Health and comfort-related preparatory steps taken during planning are hence a precondition albeit not a guarantee for future user comfort.

This is accomplished, for instance, by optimising measures to provide health and comfort which can enhance the quality of life and performance of building users.

Health

The primary criterion for avoiding health risks for room users is to ensure clean indoor air (BNB 3.1.3), which is primarily determined by building-related and user-related impacts. These impacts include pollutant emissions from building materials and building products, microbiological contamination due to humidity and high levels of carbon dioxide in room air. Since odours are perceived differently and are not a reliable indicator for higher air pollution, current scientific findings suggest that odours do not offer any insight into related health risks.

The purpose of specifically selecting low-emission building products is to achieve good room air quality without any health risks. Random measurements taken after the building has been completed can be used to verify the success of preventive planning (BNB 3.1.3). Volatile organic compounds can be measured in total and as individual concentrations as well as formaldehyde as a highly volatile organic compound. When it

comes to assessing indoor air quality, the Guide Values of the Committee on Indoor Air²³ list the concentration levels that are classified as safe. With a view to OHS law, these levels must be adhered to for workplaces, and with a view to sustainability, they should not be reached when possible. “Sufficient, healthy air must be available in closed rooms, also taking into account working methods, physical exertion and the number of employees along with other people present.”²⁴

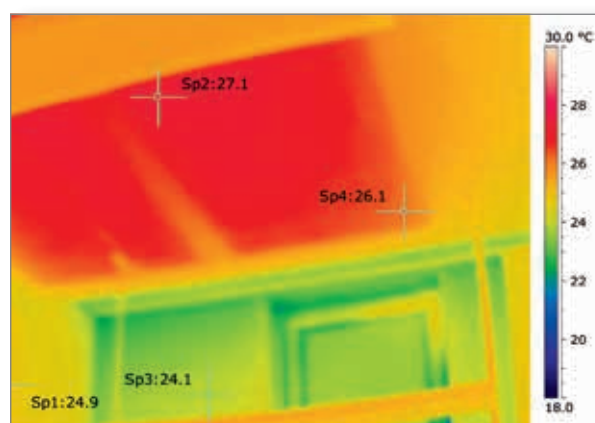
The requirement pursuant to the Workplace Ordinance also refers to standards regarding indoor air pollution from carbon dioxide, which results from air exhaled by room users. These standards have been laid down in the “Technical Rules for Workplaces – Ventilation” from 2012 (ASR A3.6). To ensure that carbon levels are kept as low as possible, the design of the building must consider sufficient air exchange through the supply of fresh air, either naturally or using mechanical ventilation. Since carbon levels depend on room size and the number of people present, the type of ventilation (window ventilation and/or mechanical ventilation) must be designed with care and should not be decided exclusively on the basis of cost-to-benefit benefits.

Generally speaking, any building, even a new building, may have concealed or visible mould growth due to water damage and hence the risk of microbiological contamination of its indoor air. A visual and sensory inspection, both during construction and after completion of the building, can help to prevent microbiological contamination due to design-related or damage-related humidity.

More detailed information regarding carbon dioxide in indoor air, ventilation and mould avoidance can be found in various guidelines²⁵ issued by the Federal Environment Agency.

Comfort and user satisfaction

In order to create a comfortable atmosphere and a high-quality and safe environment in a building, a pleasant indoor climate must be ensured in terms of temperature, sound and visual parameters. Various studies²⁶ have demonstrated that the satisfaction and performance of building users correlate directly with the spatial situation and are also relevant for health.



Example of temperature asymmetry near a heated ceiling and outside wall

23 On behalf of the Conference of Health Ministers, the “Committee on Indoor Guidelines” develops guide values for indoor air uniformly applicable in Germany. This Committee is made up of experts from the Indoor Air Hygiene Commission (IRK) and experts from the permanent working group of the Highest State Health Authorities (AOLG). The guide values are derived on the basis of hygiene/toxicological criteria and published by the Federal Environment Agency at: www.umweltbundesamt.de/themen/gesundheit/kommissionen-arbeitsgruppen/ad-hoc-arbeitsgruppe-innenraumrichtwerte-0

24 See Workplace Ordinance (ArbStättV 2004)

25 www.umweltbundesamt.de/sites/default/files/medien/pdfs/kohlendioxid_2008.pdf
www.umweltbundesamt.de/publikationen/leitfaden-fuer-innenraumhygiene-in-schulgebaeuden
www.umweltbundesamt.de/publikationen/anforderungen-an-lueftungskonzeptionen-in-gebaeuden
 Various brochures for the prevention and remediation of mould under the heading “Schimmel”:
www.umweltbundesamt.de/publikationen

26 See Bosti study (1985), EU-Arbeitsschutzstrategie 2007-2012

Thermal comfort in winter and summer (BNB 3.1.1) is an important basis for efficient working and learning and is closely related to user satisfaction. Important factors include room temperature, humidity, air velocity together with the related risk of draft, radiation temperature asymmetry and floor temperature. When designing a building, it is important to distinguish between mechanically heated and unheated or cooled and uncooled rooms and building parts because there are different comfort models for these areas. Here, once again, various technical measures should be carefully considered and sensibly combined while taking user behaviour into account because the degree of thermal comfort has a significant impact on energy consumption.

With a view to acoustic comfort (BNB 3.1.4), the goal is to optimise acoustic quality according to the respective types of room use. The acoustic quality of a room is key to understanding people talking, to communication conditions and hence to the sense of well-being, as well as to the building users' ability to concentrate and perform. Poor acoustic quality in a room can be difficult and can have an adverse impact on health because it typically results in a higher noise level in the room and this in turn affects spoken communications. One requirement that applies to all forms of use is acoustic insulation of spaces with a use-dependent minimum sound absorption level to be achieved by surrounding walls.

Visual comfort (BNB 3.1.5) is achieved with adequate natural lighting, supplemented by balanced artificial lighting without major sources of disturbance, such as direct light exposure or glare. Sufficient light must be ensured, and it must be possible to adapt lighting to specific needs. The quality of lighting not only affects the ability to see at any particular time, but also impacts concentration and performance. Moreover, poor sight becomes much more obvious when lighting is insufficient. Instead of artificial lighting, natural lighting should be selected because it provides a better quality light and is more pleasant for the human eye. In order to ensure proper lighting, openings (windows and skylights) should create a pleasant level of brightness

and enable sufficient visual contact between interior and exterior spaces, even when sun protection is activated. Early and integrated planning of natural and artificial lighting can help to achieve high-quality lighting with low energy demand. The "Technical Rules for Workplaces – Lighting" (ASR A3.4) contain guide values for minimum lighting levels for various use areas and stipulate values for daylight.

In addition to technical and structural preconditions, a decisive aspect for comfort is the ability of the user to individually influence (BNB 3.1.6) ventilation, sunlight protection, glare protection and temperature during and outside the heating period as well as natural and artificial light control. This not only boosts acceptance, but also performance and satisfaction among users. On the other hand, allowing users to adapt conditions to their actual needs impacts energy consumption.

Public spaces in the building and in the immediate vicinity of the building (BNB 3.1.7) promote the general well-being of users. Areas inside the building that improve communication as well as attractive, weather-protected outdoor areas encourage communication and exchange between employees and help to improve the general well-being of users and boost acceptance of the building. The aim is to offer as many users as possible a host of different high-quality options while in the building and hence to promote room qualities. General requirements for outdoor areas are described in the brochure "Sustainably Designed Outdoor Facilities on Federal Properties"²⁷ and in the BNB system variant for outdoor facilities.

The individual's sense of safety is also an essential part of feeling comfortable in a building. Another goal is to enhance the users' sense of safety by protecting users and assets and by avoiding hazards and accidents (BNB 3.1.8). Measures that enhance the individual's sense of safety are usually also suitable for warding off the risk of unlawful acts by others. Objective safety exists when potential risk situations are avoided in as far as possible or when the effect of an incident, such as the risk of fire gases, is reduced to the furthest extent. In order to achieve a positive sense of safety, suitable

27 See BBSR (2018a)

prevention measures must be taken into account when planning access routes both inside and outside the building, as well as safety/security installations that enable fast intervention by third parties. This is a function of safety/security requirements resulting from the particular use and location of a property.

3.3.2 Functionality

Functionality is the ability of a building to fulfil certain functions that depend on given use requirements. A building is functional, for instance, if the overall design concept, the assigned functions and spaces, detail and interior design, infrastructural accessibility as well as supply and disposal functions are optimally co-ordinated in relation to each other and the use requirements.

Barrier-free access and use of buildings is a precondition for participation in social and occupational activities throughout life.²⁸ For this reason, barrier freedom (BNB 3.2.1) or user-orientated design/planning and implementation of a barrier-free building for people with impaired vision, hearing, cognitive or motor skills are among the most important functional aspects of sustainability. Especially with a view to demographic change in Germany and the resultant growing share of older people, accessibility is becoming more and more important.

Buildings and facilities are defined as being accessible “if they are accessible and usable by all people, with or without handicaps, in the customary manner without any special impediment and generally without any assistance”²⁹. This must be guaranteed for publicly used areas and should also be ensured for areas that are defined as workplaces.

FEDERAL BUILDING The provisions of the barrier-free building are binding for federal-government construction projects (see also the Guideline Accessibility in Building Design³⁰).

Furthermore, the acceptance and integration of buildings within urban quarters, cities and regions is enhanced by increasing the public accessibility (BNB 3.2.4) of the building. Offering a wide range of uses, such as a cafeteria, exhibition space and accessible green areas, can help to enliven the public areas at a building and quarter level. This participation and appreciation by the public contributes to the long-term value of the building. At the same time, external use benefits the economic sustainability of building operations.

Offers that promote the use of bicycles or electric mobility, as well as car sharing offers, make it easier for users to opt for environmentally friendly means of transport to work and hence reduce traditional motorised private transport. The key aspects of the mobility infrastructure (BNB 3.2.5) include providing suitable parking/bicycle racks and quality features that boost user comfort.

28 See Act on Equal Opportunities for Disabled Persons (BGG 2007), Section 1

29 See DIN 18040-1: 2010-10

30 BMI (2019a)

3.3.3 Ensuring design quality

The public sector and its buildings are particularly visible to the general public and hence have a model role to play. Federal buildings should therefore reflect the level of building culture in Germany and how it is perceived whilst additionally protecting existing cultural assets. Ensuring good design quality, especially in government building projects, is hence important. This applies not just to the demanding architectural design of the building and its facilities, which must reflect the respective location and its use, but also to the quality of its integration into the urban space. Sustainable planning not only means that current values have to be considered. Instead, future values must also be taken into consideration in view of the long-term horizon. Planners are thus faced with special challenges in terms of design aspects because sustainability means that design quality has to be ensured for the entire life of the building. It is not possible to lay down standards for architectural and urban development qualities in buildings. Due to the complex nature of these aspects, the focus differs from case to case. A uniform assessment is possible on a very abstract level only.

The implementation of competitions on the basis of the “Design Competition Guideline” (RPW 2013) can provide an initial framework. Design competitions offer an opportunity to not only ensure design quality but also to integrate sustainability protection goals into the building design using the “Design and Urban Quality” criterion (BNB 3.3.1). The process of contracting design services through competitions has proven to be successful when it comes to obtaining the best architectural and structural solution. In this way, the diversity of building culture can be secured while the enormous complexity of a single project can be adequately addressed in conjunction with multidimensional sustainability requirements. Other discursive methods involving independent expert bodies can also help to enhance architectural quality during the planning and design process.



Extension for the UN Campus with BNB Gold requirements in Bonn, revised competition design

Art in architecture (BNB 3.3.2) is an element of building culture which adds to the quality and expressive force of a building. It is hence an integral part of the building project. In this sense, art in architecture³¹ is an element that should be integrated into the building as a natural feature and hence help to enhance building quality.

FEDERAL BUILDING Artists should therefore be commissioned for federal buildings on condition that the purpose and importance of the building justify such a move under the RBBau Guidelines.

31 See “Guideline Art in Architecture” (BMVBS 2012 b), available for retrieval at: www.nachhaltigesbauen.de/leitfaeden-und-arbeitshilfen-veroeffentlichungen/weitere-leitfaeden-und-arbeitshilfen.html

3.4 Technical quality

Technical quality focuses on the quality of the technical features of the building and its equipment. The following aspects are essential during planning and design:

- Fire protection
- Sound protection
- Heat and humidity protection
- Cleaning and maintenance issues
- User and maintenance friendliness of building systems
- Possibility to demolish the building
- Resistance to natural risks

The requirements for structural fire prevention and protection measures are laid down in the applicable federal state building regulations and in the technical construction rules.

FEDERAL BUILDING The federal government's "Fire Safety Guideline"³² is another binding tool for federal buildings that must be considered in planning and design.

The requirements for structural sound insulation (BNB 4.1.1) are subject to the generally recognised codes of practice. The minimum requirements are laid down in DIN 4109³³. This warrants that the minimum sound insulation required by the building regulations is guaranteed. However, these requirements do not automatically rule out all possible annoyances, instead they only rule out unreasonable annoyances. Any further-reaching requirements for sound insulation in office buildings help to avoid noise disturbances, to ensure speech privacy and intelligibility. The aim here, however, is not to boost sound protection measures to an extent that is unreasonable. Recommendations for improved sound protection can be found in supplement 2 to DIN 4109.

In the case of both fire and sound protection, later optimisation of qualities during the construction or use phase means technically complex and usually very costly measures. Special attention should hence be paid to the development of the respective concepts during the early design and planning phases.

The goal of heat insulation and protection against condensate (BNB 4.1.2) is to minimise heat and cold demand for air conditioning in buildings whilst at the same time ensuring a high level of thermal comfort (see section 3.3.1) and avoiding damage to the structure due, for instance, to condensation or mould.

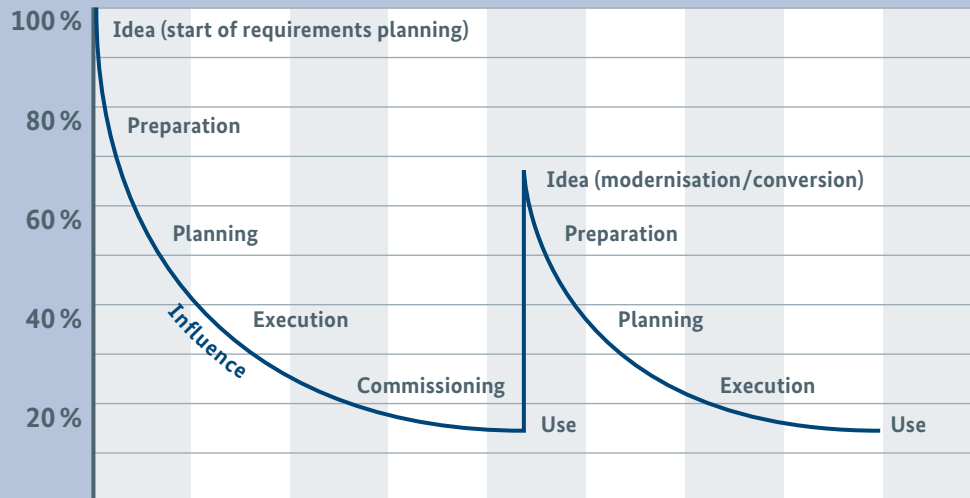
The cleaning and maintenance-friendliness (BNB 4.1.3) of the structure, as well as the user and maintenance friendliness of building systems (BNB 4.1.6), have a significant impact on business organisation, costs and on the ecological footprint of a building during its use phase. Structural elements that are maintained in a perfect condition can reach the maximum useful life. Surfaces that are easy to clean require small amounts of detergents, reduce water consumption and usually cost less to clean. Accessibility and optimisation of the components of the building systems can have a positive impact on the building's usability.

The design should aim at selecting suitable materials and components in order to avoid elements that require intensive cleaning and maintenance. Suitable strategies during the lifetime of the building should also aim to achieve the maximum possible service life of materials and building system components. At the same time, the costs of cleaning and maintenance of the building and the costs of operation and maintenance of the building systems should be kept as low as possible during use of the building. An important aspect is to involve the project sponsor (owner/operator) in the planning and design decisions.

32 See BMVBS (2006) which can also be downloaded at: www.nachhaltigesbauen.de/leitfaeden-und-arbeitshilfen-veroeffentlichungen/weitere-leitfaeden-und-arbeitshilfen.html

33 See (DIN 4109: 1989-11 or new: DIN 4109-1: 2018-01)

**OPTIONS TO CONTROL THE PROPERTIES OF A BUILDING
DURING THE PLANNING AND DESIGN PHASE**
FIGURE A13



Source: BBSR

In view of the fact that around 79 percent of mineral waste in Germany originates from the construction sector³⁴ and that the construction industry accounts for around 52.5 percent of the total waste volume, the suitability of a building for dismantling, waste separation and reuse (BNB 4.1.4) should already be considered during the planning and design phase in the interest of future needs. This approach addresses the costs of dismantling or demolition, the costs of precise separation and the possible recycling of individual building parts. The following priorities should be considered here: Waste avoidance should be given preference over waste reduction, and the reuse of materials should have preference over recycling. If this is not possible, thermal utilisation would follow and, finally, disposal on dumps. Unnecessary coatings on building parts and structural elements should be avoided whenever possible. Furthermore, waste types should be separated as precisely as possible and, most importantly, hazardous substances should be avoided. Concepts for the dismantling of

heterogeneous building structures and structures that are difficult to separate, as well as for the contamination of demolition waste with potentially harmful substances, must also be taken into account.

When it comes to matters related to climate-adapted building, the building must be viewed and, when necessary, optimised with a view to the choice of location and the environmental impacts there, such as extreme weather conditions. This means that, when possible, planning must already take into account sufficient resistance of the structure or the building envelope to strong winds, heavy rain, hail, snow and flood conditions (BNB 4.1.5).

³⁴ Waste volumes by industries according to EU Waste Statistics 2013, Federal Statistics Office, Wiesbaden 2015

3.5 Process quality

The following aspects must be considered in conjunction with process quality:

- Quality of the planning process
- Quality of building construction
- Quality of preparations for operation

3.5.1 Planning quality

Since the decisions made during the early planning and design phase – for instance, within the scope of the Decision-making Documents (ES – Bau) – have a major impact on the future quality of the building, the quality of planning itself is also very important. As figures A11 and A13 show, the greatest possibilities to influence the building features and costs of a measure exist at the beginning of the measure. Decisions with major cost implications are already made at the time the programme is defined (requirements planning) and during the first concept phase. This also applies to related environmental impacts. Aspects such as development and issues of planning law, as well as functional, urban, architectural and legal aspects (most notably structural stability and fire protection), must be identified in their totality and optimised in the interest of sustainability at an early stage during preliminary planning and as part of architectural and engineering competitions. The quality of the planning and design process is described on the basis of five criteria (see table A4).

The quality of a building's sustainability depends on the quality assurance of the planning and design process, from the identification of demand to the development of optimisation concepts, sustainable tendering and contract awarding right through to the documentation of the building.

QUALITY OF PLANNING AND DESIGN PROCESSES

TABLE A4

Criteria
BNB 5.1.1 Project Preparation
Requirements planning
Target agreement
Planning and design competition
BNB 5.1.2 Integrated Design and Planning
Interdisciplinary project team
Qualification of the project team
Integrated design process
User participation
Public participation
BNB 5.1.3 Complexity and Optimisation of Planning
Safety and health protection plan
Supply and disposal concept
Energy concept
Measurement and monitoring concept
Water concept
Concept to avoid environmental and health risks from building products
Ventilation concept
Waste/recycling concept
Optimisation of daylight and artificial light
Concept to ensure cleaning and maintenance friendliness
Concept for conversion, dismantling and recycling
Concept to avoid and contain risks
BNB 5.1.4 Invitation to Tender and Contract Awarding
Integration of sustainability aspects into the tendering process
Quality assurance during contract awarding
BNB 5.1.5 Preconditions for Optimum Utilisation and Management
Preparation of building documentation/building passport during the planning and design process
Preparation of maintenance, inspection, operation and service manuals
Adaptation of plans, drawings and calculations to the as-built condition
Preparation of a user manual

Source: BBSR

3.5.2 Construction quality

The construction process must also be managed with a view of protecting the environment and resources. At the same time, the health of all stakeholders must be protected. In addition to the quality of production site planning, it must hence be ensured that the agreed sustainability qualities are also implemented in the building process in order to warrant targeted planning. This requires comprehensive quality control so that defects and damage to the building can be avoided and the targets set reached. The implementation of the draft design must be monitored and the materials and construction products used must be fully documented. Practical experience confirms that incorrect construction workflow plans, typical, but foreseeable delays or unclear definitions quickly affect building construction and thus lead to considerable deviations from the planned quality.

The following factors determine the quality of a building³⁵:

- Quality of construction supervision by architects and planners
- Degree of construction site attendance on the part of planners
- Co-ordination of the construction process
- Cost control
- Comprehensive documentation of the building materials and products used in construction
- Contractor's quality management system
- Quality of project management services
- Quality assurance and integration of project management into quality assurance processes
- Training and further professional qualification of contractors

The quality of building construction is described on the basis of the following criteria:

QUALITY OF BUILDING CONSTRUCTION
TABLE A5

Criteria	
BNB 5.2.1	Building Site/Building Processes
	Building site with optimised recycling
	Low-noise building site
	Low-dust building site
BNB 5.2.2	Soil/groundwater protection at the building site
	Quality Assurance of Building Construction
	Documentation of the building materials and products used and of the safety data sheets
	Quality control measurements (including, for instance, air tightness check of the envelope)
BNB 5.2.3	Controlled Commissioning
	Commissioning management
	Commissioning/adjustment

Source: BBSR

3.5.3 Quality of preparations for operations management

Controlled commissioning (BNB 5.2.3) co-ordinates and adjusts the individual components of the technical building equipment to operate together after acceptance. Following this, operation of the equipment and technical systems must be re-adjusted and optimised once again no later than after around one year of operation. Regarding the optimisation of operation during the use phase, please see Part C of this Guideline.

The measuring equipment necessary to enable effective and comprehensive monitoring (BNB 5.1.3) by measuring the most important energy and utility parameters must already be considered during the design and planning phase. In this way, the results of the construction and use phases can be measured, documented and assessed as part of the quality assurance programme. Furthermore, monitoring is also an important element of “management of energy and water consumption” during the use phase (see also Part C of this Guideline, section 3.2.3.1, and BNB_BB 5.3.2) and enables permanent monitoring and minimisation of water and energy consumption.

35 See BBR (2002)

Building efficiency must be continuously improved by systematically optimising the necessary planning, design and execution quality as well as the setting into operation of the building. This improvement requires the involvement of the project sponsor (owner/operator) and the user as well as information for the user along with adequate operations management and control. DIN EN ISO 50001³⁶, for instance, contains requirements for the introduction, implementation, maintenance and improvement of an effective energy management system. Efficient operative and commercial building management must include regular evaluations of media consumption during operation in order to identify and assess any non-conformities on the basis of suitable benchmarks and to trigger the necessary remedial measures. The Energy Target Specifications (see Part B, section 2.4.3) address the requirements for the technical concepts which are necessary to these ends.

3.6 Location profile

The political and strategic aspects which are relevant for selecting the location include, for instance:

- Settlement or accommodation concept (centralised/decentralised)
- Administrative or military requirements
- Infrastructure decisions (traffic connections)
- Restructuring of contaminated fallow land
- Regional strengthening of the labour market

Furthermore, the decision considers concrete features of the respective location which reflect interdependencies between the quarter, property and land on the one hand and the planned building on the other. This means that the location and the building always influence each other. Climatic and geological conditions of the location, as well as orientation options of the building on the property, have a crucial impact on the implementation of sustainability goals, such as the use

of regenerative energy in the building, necessary energy-related features of the envelope or structural measures as protection against the elements. The aspects of the location which influence sustainability must hence be described and included in the qualitative evaluation of the location.

Even if the Guideline for Sustainable Building typically focuses on the building itself as the object of interest or the physical system boundary, the final sustainability assessment of the building additionally identifies the location profile which was determined for the pre-assessment of the location. Taking the above-mentioned restrictions into consideration, the location of a building must be judged at least according to the following criteria:

LOCATION ASSESSMENT CRITERIA

TABLE A6

Criteria	Description and assessment with a view to
Risks at the Micro-Site	BNB 6.1.1 Natural risks and anthropogenic disasters
Conditions at the Micro-Site	BNB 6.1.2 Existing pollution with health-damaging potential
Image and Character of Location and Quarter	BNB 6.1.3 Attraction and social quality
Traffic Connections	BNB 6.1.4 Networking of rail, bus, rapid transit railways and connection of the bicycle path network (integrated urban and local transport)
Vicinity to Use-specific Services	BNB 6.1.5 Range, quantity of and distance to selected facilities in the vicinity
Supply Lines/Site Development	BNB 6.1.6 Demand for alternatives with regard to supply and disposal services for developed sites according to the federal government's integrated energy and climate programme from December 2007*

* See Bundesregierung (2007)

Source: BBSR

36 See DIN EN ISO 50001: 2011-12: Energy management systems – Requirements with guidance for use

CRITERIA TABLE – OFFICE AND ADMINISTRATION BUILDINGS SYSTEM VARIANT, VERSION 2015

FIGURE A14

NEW CONSTRUCTION BNB MODULE			
Sustainability criteria		Factor of relevance	Percentage share of overall result
ECOLOGICAL QUALITY			22.5%
Effects on Global and Local Environment			
1.1.1	Global Warming Potential (GWP)	3	3.750%
1.1.2	Ozone Depletion Potential (ODP)	1	1.250%
1.1.3	Photochemical Ozone Creation Potential (POCP)	1	1.250%
1.1.4	Acidification Potential (AP)	1	1.250%
1.1.5	Eutrophication Potential (EP)	1	1.250%
1.1.6	Risks to the Local Environment	3	3.750%
1.1.7	Sustainable Material Extraction/Biodiversity	1	1.250%
Demand of Resources			
1.2.1	Primary Energy Demand	3	3.750%
1.2.3	Drinking Water Demand and Quantity of Wastewater	2	2.500%
1.2.4	Land Consumption	2	2.500%
ECONOMIC QUALITY			22.5%
Life Cycle Costs			
2.1.1	Building-related Life Cycle Costs	3	11.250%
Economic Efficiency and Value Stability			
2.2.1	Space Efficiency	1	3.750%
2.2.2	Adaptability	2	7.500%
SOCIO-CULTURAL AND FUNCTIONAL QUALITY			22.5%
Health, Comfort and User Satisfaction			
3.1.1	Thermal Comfort	3	2.935%
3.1.3	Indoor Air Quality	3	2.935%
3.1.4	Acoustic Comfort	1	0.978%
3.1.5	Visual Comfort	3	2.935%
3.1.6	Influence of the User	2	1.957%
3.1.7	Use Qualities	1	0.978%
3.1.8	Safety	1	0.978%
Functionality			
3.2.1	Barrier-free Building	2	1.957%
3.2.4	Accessibility	2	1.957%
3.2.5	Mobility Infrastructure	1	0.978%
Ensuring Design Quality			
3.3.1	Design and Urban Quality	3	2.935%
3.3.2	Art in Architecture	1	0.978%
TECHNICAL QUALITY			22.5%
Technical Execution			
4.1.1	Sound Insulation	2	4.500%
4.1.2	Heat Insulation and Protection against Condensate	2	4.500%
4.1.3	Cleaning and Maintenance-friendliness	2	4.500%
4.1.4	Dismantling, Waste Separation and Utilisation	2	4.500%
4.1.5	Resistance to Natural Disasters	1	2.250%
4.1.6	Maintenance Friendliness of Building Systems	1	2.250%
PROCESS QUALITY			10.0%
Management and Design			
5.1.1	Project Preparation	3	1.429%
5.1.2	Integrated Design and Planning	3	1.429%
5.1.3	Complexity and Optimisation of Planning	3	1.429%
5.1.4	Invitation to Tender and Contract Awarding	2	0.952%
5.1.5	Preconditions for Optimum Utilisation and Management	2	0.952%
Building Construction			
5.2.1	Building Site/Building Processes	2	0.952%
5.2.2	Quality Assurance of Building Construction	3	1.429%
5.2.3	Controlled Commissioning	3	1.429%
LOCATION PROFILE			
Location Profile			
6.1.1	Risks at the Micro-Site	2	–
6.1.2	Conditions at the Micro-Site	2	–
6.1.3	Image and Character of Location and Quarter	2	–
6.1.4	Traffic Connections	3	–
6.1.5	Vicinity to Use-specific Services	2	–
6.1.6	Supply Lines/Site Development	2	–

Source: BBSR

4. BNB – system variants and module applications

4.1 System variants

Generally speaking, the dimensions, principles and qualities of sustainable building presented here equally apply to all types of buildings. However, different types of buildings have many type-specific characteristics. This may call for a different focus, other individual aspects or a different weighting factor in the sustainability assessment. The specific user requirements in educational buildings are marked by various educational concepts and different user groups in the building. Use-specific requirements must hence be included in more detail in planning and design and taken into greater account than is usually necessary for office and administration buildings. This is why the BNB contains specific system variants for the individual types of buildings frequently required in the public sector. These system variants are listed below.

4.1.1 Office and administration buildings (BNB_B)

Office and administration buildings account for the largest part of federal buildings. That's why this type of building was the starting point for the basic development of the BNB. With the BNB_B variant, the BNB system gives comprehensive consideration to the characteristics of office and administration buildings.

4.1.2 Educational buildings (BNB_U)

Education and hence educational facilities are an important part of our society. Educational buildings are part of the public stage and can act as a link between different social groups with different cultural and social backgrounds. At the same time, educational buildings must adapt continuously to changes in society (such as work-life balance, lifelong learning, handling knowledge). The concept for educational buildings must hence offer sufficient flexibility. Even within an educational facility, there are many different functional requirements, especially with a view to room types, room functions, use times and user groups. Furthermore, the specific user demand for educational buildings is marked by the many different user groups in the building, and the rooms are usually used by many people at the same time. Communication conditions within rooms are hence very important in buildings like these.

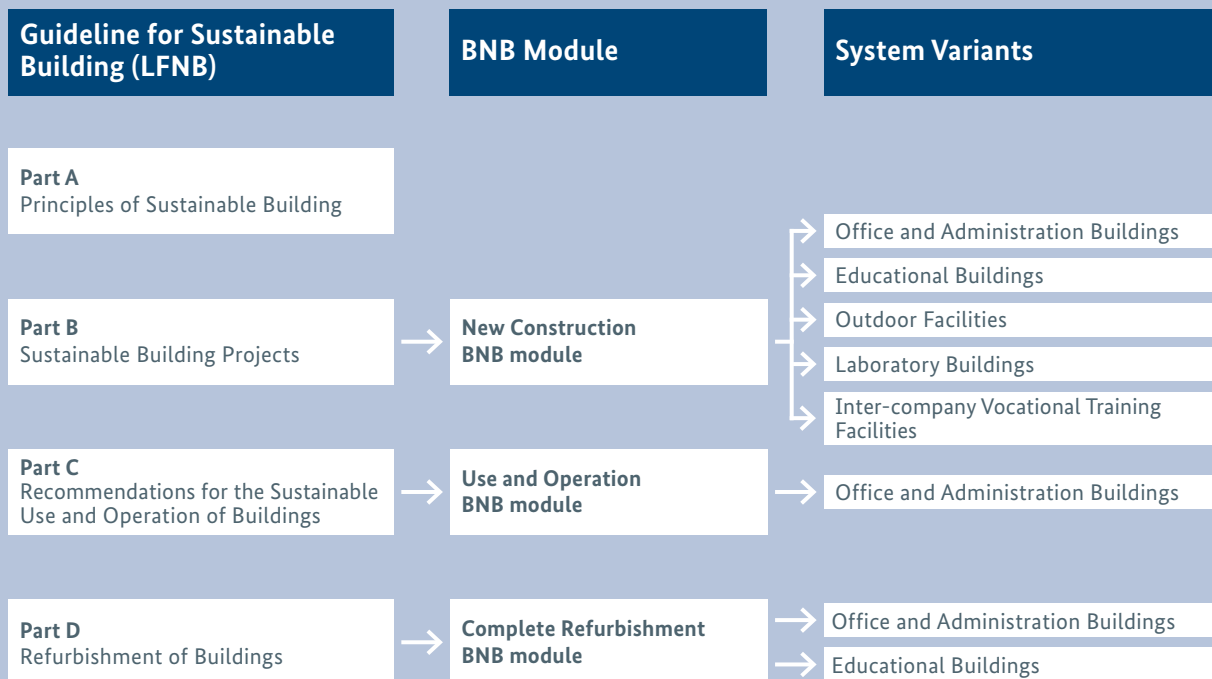
The sustainability assessment for educational buildings pays particular attention to user needs. The aim is to enable the highest possible degree of user satisfaction in the building, flexible and synergistic use of building structures, spatial qualities inside and outside and, through public accessibility, to have the building anchored and accepted in the quarter. Open spaces in educational buildings are regarded as an integral part of the building structure because they should not be separated from the teaching function. Being able to obtain space, high-quality materials and equipment boosts identification with and appreciation of the building and also helps to prevent vandalism and preserve long-term value. The Educational Buildings system variant does not foresee any quantitative assessment of space efficiency because the traffic areas are used as recreational areas and increasingly for informal learning so that their dimensions are usually more generous. When it comes to assessing the location profile, the "Image and Character of Location and Quarter" criterion does not apply because the choice of location for teaching depends on demand and cannot normally be influenced.



Application of the Educational Buildings system variant for the new European School building in Munich

THE BNB AND ITS MODULES AND SYSTEM VARIANTS

FIGURE A15



Source: BBSR

In order to take into account the enormous diversity of building types in the teaching category, the Educational Buildings system variant also has some special methodological features in some criteria. Several criteria, for instance, list different requirements that enable project-specific selection of appropriate measures. Differentiated requirements for different use types are defined in a small number of criteria.

4.1.3 Laboratory buildings (BNB_L)

Buildings for science, research and development activities by government-owned institutes, as well as funded construction projects as part of support for research, are a key building task. The Research and Laboratory Buildings system variant provides binding assessment rules for these building categories along with specially adapted criteria profiles.

The criteria are essentially based on the system variant for office and administration buildings, while the benchmarks and weighting in the overall system are adapted as needed. In order to be able to respond to the special requirements of laboratory buildings, the building to be assessed is compared in the eco-balance assessment and the life cycle costs with a so-called virtual laboratory building. The virtual building has the same cubage and use (similar to the reference building method according to DIN V 18599) and meets with the minimum statutory requirements. Energy demand, as well as investment and operating costs for the virtual building, is defined according to exact standards. The energy-related quality of the building envelope and the building systems, as well as the procedure for identifying costs for the virtual building, are precisely defined in the criteria profiles. What is new here is that process energy is included both in the eco-balance and the life cycle costs. The real building is then assessed on the basis of the extent to which the key performance indicators of the reference building are exceeded or not met. Any improvement compared to the standard required by law is rated as positive.

Furthermore, the quality of the technical building systems is equally included in the system like the eco-balance and life cycle costs. Specially developed criteria profiles are available for this purpose: flexibility, maintenance and ease of operation as well as quality of technical building systems. Since laboratory buildings are typically “high-end” buildings, a large share of technical systems in the overall assessment is justified. An operating concept is also required that precisely defines the planned use and boundary conditions for the building along with at least one safety, explosion-protection and waste disposal concept.

When calculating life cycle costs, the real investment costs of the building are compared to a variable cost benchmark of the virtual building using so-called cost-of-space (KFA – Kostenflächenarten) values. This space and cost data was developed and published by Informationsstelle Wirtschaftliches Bauen in Baden-Württemberg on the basis of completed building projects. These cost-of-space values can be used to map precisely the room layout of the planned building and define use requirements.



BNB pilot certification for laboratory buildings (new construction), Experimental Research Center, Berlin

4.1.4 Inter-company vocational training facilities (BNB_ÜBS)

Inter-company vocational training facilities are a type of building that is typically a construction project as part of support measures involving various stakeholders (funding party, funding recipient, user or building administration). The special way in which these educational buildings are used for vocational training is reflected by the required room types. In addition to rooms for teaching theory, rooms for practical training (such as workshops, building halls, labs, kitchens), together with the related rooms (storage rooms, prep rooms), are needed for teaching and training. Depending on the vocational direction, the practical training rooms are completely different than the theory rooms in terms of cubage, design, equipment and use profile. In order to achieve the characteristics and requirements of this type of building, the sustainability requirements of the BNB were subjected to a series of adjustments in order to reflect the specific boundary conditions for this type of building and the procedures involved in funded building projects.

4.1.5 Outdoor facilities (BNB_AA)

In addition to the above-mentioned sustainability requirements for building construction measures by the federal government, sustainability aspects must also be addressed when it comes to outdoor facilities on federal properties. A distinction must be made here between general sustainability recommendations for complete federal properties (general analysis level) and concrete requirements for outdoor facilities of buildings which have to be considered as part of a specific construction project (specific analysis level). Two separate instruments have been developed for the two different applications with their different planning and design levels:

- Brochure: “Sustainably Designed Outdoor Facilities on Federal Properties”
- Assessment System for Sustainable Building for Outdoor Facilities

The “Sustainably Designed Outdoor Facilities on Federal Properties” brochure contains detailed explanations and information regarding the general principles of sustainable buildings on a property level. This includes information on how aspects of biodiversity can be specifically considered and implemented along with recommendations for the inclusion of sustainability aspects in property concepts. The “Sustainable properties” checklist in the appendix to the brochure addresses the characteristics and aspects of sustainable federal properties. This checklist is designed to support the process of identifying the contents and addressing the different sub-aspects which are necessary for an integrated overall concept. The recommendations of the brochure apply primarily to outdoor facilities of the “office and administration building” category. Furthermore, they can also be applied, albeit perhaps with certain restrictions, to other building categories and types of use, such as educational buildings, laboratory buildings or properties of the armed forces.

The “Assessment System for Sustainable Building for Outdoor Facilities” (BNB_AA) defines concrete requirements for the planning, design, construction and operation of outdoor facilities of buildings which must be considered within the scope of construction measures. Analogous to the Assessment System for building construction, the Assessment System for Outdoor Facilities is broken down into the six main criteria groups, ecological quality, economic quality, socio-cultural and functional quality, technical quality, process quality and location quality. In contrast to and thus strictly different from building construction, the assessment extends to location quality because an assessment of the outdoor facility cannot be separated from its location. The six main criteria groups include a total of 27 individual criteria. The Assessment System for Outdoor Facilities hence also serves as an orientation aid and communication tool for co-ordinating individual building qualities and additionally as a steering, control and assessment instrument for implementing the sustainability requirements which have been laid down for outdoor facilities.



Maintenance and development plan for the outdoor facility of the Federal Environment Agency's Haus 2019 building

4.1.6 Analogous application of the Assessment System for Sustainable Building (BNB)

In order to establish the principles of sustainable building also for federal building measures for which no corresponding BNB system variant is available, the BMI has issued detailed requirements for the analogous application of the BNB. More details regarding this can be found in a separated work guide³⁷.

The aim of this is to ensure that while considering project-specific and practice-related matters, a uniform quality standard can be pursued for aspects of sustainability in federal building projects.

POSSIBLE APPLICATIONS OF BNB MODULES AND ASSESSMENT TIMES

FIGURE A16



Possible assessment times:

- a Assessment of new construction project
- b Classification of new building stock as new construction (special solution for the transition phase)
- c Assessment of complete refurbishment
- d Classification of new building stock as complete refurbishment (special solution for the transition phase)
- e Assessment of the Use and Operation module (examples)
- f Special case of building diagnosis not linked to a measure (example)

Source: BBSR

4.2 Modules and their application

In addition to the three application cases of New Construction (I.1), Use and Operation (II.1) and Complete Refurbishment (III.1), there are four combined cases. The application of the different modules (figure A16) depends on the concrete decision situation and the assignment to the corresponding life cycle phase. The evaluation always refers to a relevant date or point in time. The Use and Operation BNB module has a special role to play in this context because this module can also be used as a supplementary module in conjunction with the two BNB modules New Construction and Complete Refurbishment.

I Development phase

I.1 New construction project

The New Construction BNB module is applied to new construction projects during the planning, design and construction phases. The criteria and assessment methods are considered during the planning, design and construction phases. Immediately after completion of the building, the New Construction BNB module is used to describe, assess and analyse the conformity of the new construction projects.

I.2 New building stock after new construction project

The New Construction BNB module can be combined with the Use and Operation BNB module and applied to existing buildings which can be classified as new building stock. These are existing buildings which were accepted under construction law and handed over to the agency using the building following the erection of a new building or complete refurbishment no more than five years previous, and were occupied and put into operation either fully or partially by the agency using the building (see Part C, section 4.4). Either the existing assessment can be updated, or the existing building can be described, assessed and its conformity analysed for the first time. Pursuant to section H of the RBBau Guidelines, the assessment work must commence no later than five years following the handover of the building. Section 4.4 of Part C of this Guideline contains further explanations, recommendations and procedures for new building stock.

II Regular operating phase (existing buildings)

II.1 Use and Operation module

The Use and Operation BNB module can be applied as a quality management instrument during building use in order to ensure sustainable process and asset qualities. This assessment module enables the assessment of use and operating processes. A description, assessment and conformity assessment can be carried out after the building quality has been assessed using the New Construction, New Building Stock or Complete Refurbishment BNB modules. It can also be applied repeatedly at regular intervals throughout the entire use phase.

Special case in II.1 Use and Operation module (without reference to a project)

This case is relevant for existing buildings which have not yet been assessed on the basis of a BNB module and for which no complex building project is currently planned. In this case, the structure of the Assessment System serves as a basis for describing and assessing an existing building. The purpose of such a diagnosis is to determine how far a building is from a positive assessment result. This also enables an assessment of total quality compared to a new building. Analogous to the “New Building Stock” application case (I.2), the assessment is based on the New Construction module

which integrates the criteria of the Use and Operation BNB module. In contrast to the “New Building Stock” application case, all the criteria of ecological, economic, socio-cultural and technical quality must be applied analogously. These must be transposed into real qualities on a case-to-case basis. The application is not tied to a particular time or phase, with the only exception being that it takes place during the use phase. It is hence not shown in the illustration here.

II.2 Building diagnosis for project preparation

The Use and Operation BNB module can be used as part of a comprehensive building diagnosis in order to identify the asset qualities which actually exist. This is especially important during preparation of a measure in order to satisfy an identified need (meeting requirements). Parts C and D of this Guideline contain further information, recommendations and procedures.

III Adaptation phase

III.1 Complete Refurbishment

The Complete Refurbishment BNB module is applied to complex refurbishment projects during the planning, design and construction phases. The criteria and assessment methods are considered during the planning, design and construction phases. Immediately after completion of the building measure, the Complete Refurbishment BNB module is used to describe, assess and analyse the conformity of the construction measure in the existing building.

III.2 New building stock after complete refurbishment

The Complete Refurbishment BNB module can be combined with the Use and Operation BNB module and applied to existing buildings which, following complete refurbishment, can be classified as new building stock. Either the existing assessment can be updated, or a first-time description, assessment and conformity analysis can be carried out. Pursuant to section H of the RBBau Guidelines, the assessment work must commence no later than five years following the handover of the building. Section 4.4 of Part C of this Guideline contains further explanations, recommendations and procedures.

Part B

Sustainable Building Projects



Part B – Sustainable Building Projects

1.	Integration of sustainability aspects into the planning process	57	4.	Final planning, contracting and construction	82
2.	Project preparation.....	60	4.1	Final planning.....	82
2.1	Requirements planning.....	60	4.2	Invitations to tender and contracting.....	82
2.2	Analysis of variants to meet requirements	61	4.2.1	Invitation to tender	83
2.3	Completion of project preparation	64	4.2.2	Contract awarding	84
2.3.1	Target agreement.....	65	4.3	Construction process	85
2.3.2	Pre-check	65	5.	Commissioning and as-built documentation.....	86
2.3.3	Sustainability report	65	6.	Optimising operations	88
2.3.4	Energy-related requirements	65	6.1	Controlled commissioning.....	88
2.4	Integration of sustainability aspects into the planning process.....	66	6.2	Management of energy and water consumption	88
2.4.1	Energy and metering/measuring concept	67			
2.4.2	Water management concept	69			
2.4.3	Cleaning and maintenance-friendliness.....	70			
2.4.4	Concept to avoid environmental and health risks from building products.....	71			
2.4.5	Extended ventilation concept.....	71			
2.4.6	Acoustic comfort concept.....	72			
2.4.7	Concept for barrier-free building	72			
2.4.8	Concept for accessibility and use qualities.....	72			
2.4.9	Waste and recycling concept.....	72			
2.5	Design competition	73			
3.	Design and approval planning.....	74			
3.1.	Updating the sustainability report	74			
3.2	Verifications	76			
3.2.1	Building services	76			
3.2.2	Heat insulation and protection against condensate	77			
3.2.3	Structural design, fire protection and sound insulation.....	77			
3.3	Cost calculation.....	78			
3.4	Other important design aspects	79			
3.4.1	Ecological aspects.....	79			
3.4.2	Economic efficiency and value stability	80			
3.4.3	Socio-cultural and functional aspects.....	80			

1. Integration of sustainability aspects into the planning process

As described in Part A of this Guideline, the way for the future sustainable quality of buildings is already paved in the early planning phase. It is therefore vital that the planning process be optimised with a view to sustainability. These aspects must be taken into account in all planning, construction and management processes in order to achieve (new buildings), maintain (building use and operation) and improve (refurbishment of buildings) the high quality of the building.

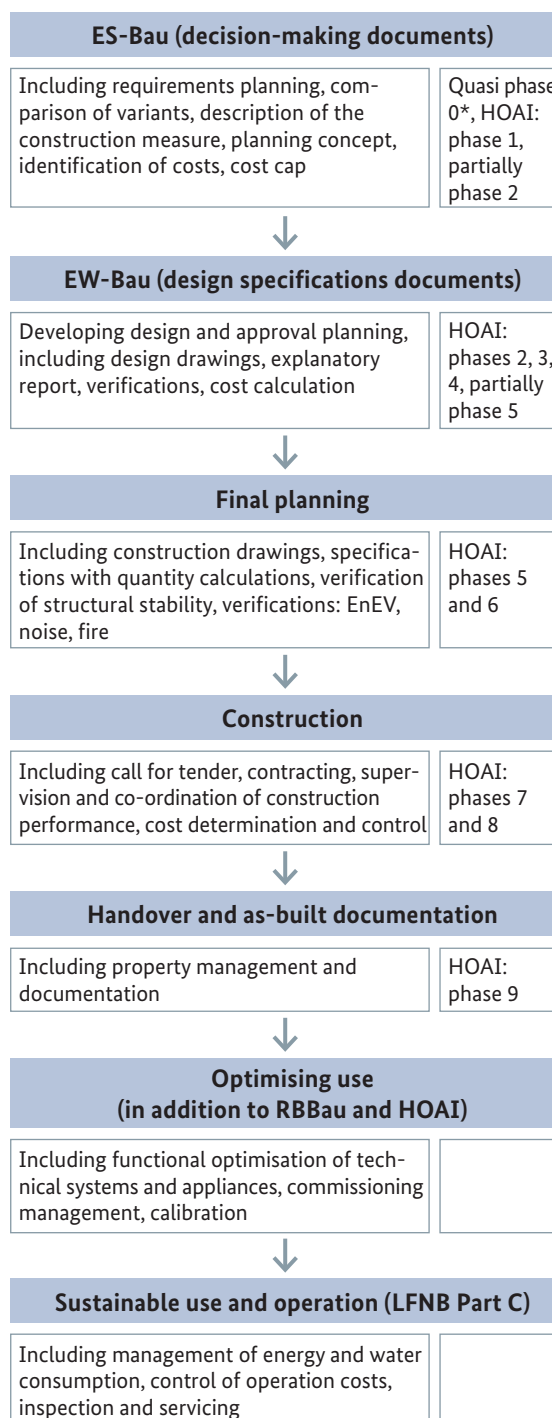
FEDERAL BUILDING Building projects by the federal government are subject to the Federal Construction Guidelines (RBBau Guidelines)¹. According to these Guidelines, the Guideline for Sustainable Building must be observed when preparing and executing building projects (see, for instance, Section K3 of the RBBau Guidelines). The implementation decrees of the appropriate supreme technical authorities contain more detailed rules regarding this matter such as the scope or responsibilities.

During the course of implementing this Guideline, the individual planning phases must be evaluated and documented as to how the respective sustainability aspects are addressed.

The following sections of this Guideline describe the general procedure for implementing sustainability goals in the planning process. The related application tools are also explained. The procedure is basically geared to the planning process according to the Official Scale of Fees for Services by Architects and Engineers (HOAI)². The implementation of federal-government building projects is presented using the example of a typical “large building project” (RBBau Guidelines, Section E) and by applying the Assessment System for Sustainable Building (BNB) (see also figure B1). Deviations can be expected here depending on the type of building project. That’s why the structure of the specific project workflow of a building project must be mapped in advance. In doing so, the information contained in the Guideline can be applied to other projects, such as municipal or federal-state projects, or to small new buildings, conversions or extensions.

PLANNING WORKFLOW ACCORDING TO RBBAU AND HOAI*

FIGURE B1



* Corresponding work phases (LP) according to HOAI as an indication for building planning and erection outside the scope of RBBau

** Within the meaning of “Utilisation concept” before LP 1

Source: BBSR

1 See BMUB (2016)

2 See HOAI (2013)

As a minimum requirement, the following documents must demonstrate that the aspects of sustainability have been implemented for the respective building project:

1. Project preparation³

- Preparation of a target agreement (Annex B1)
- Performance of the pre-check (Annexes B2/B3)
- Energy-related targets (**FEDERAL BUILDING Energy Target Specifications (Sample)**, Annex B4)
- Report on sustainability (Annex B5)
- In the case of a design competition, integration and documentation of the requirements of sustainability aspects (Annex B6)⁴

2. Design and approval planning⁵

- Performance of intermediate assessments (Annex B2/B3)
- Updating the reporting on sustainability (Annex B5)

3. Project completion

- Documentation
- BNB certification, in as far as foreseen or agreed

The tables in Annex B2 (see also an excerpt of the Annex on pages 59 and 75) can be helpful when preparing the necessary estimates for the documents listed above. These tables contain recommendations regarding the criteria which should ideally be observed or evaluated during the respective planning and construction phases in order to ensure that the goals set are reached. The required quantitative or qualitative evaluations must be drawn up for each project with the support of the BNB coordinator. Deviation from the recommendations is possible in justified cases.

Buildings without specific requirements are the standard and are referred to as standard buildings in this document. On the other hand, there are buildings with special requirements (so-called special buildings) which are planned specifically on the basis of specially agreed characteristics or properties.

When the project order is sent to the building administration, the buildings to be erected as part of building measures must be differentiated in terms of standard and special buildings. The supreme technical authority, together with the project sponsor (owner) and the user, decide which buildings are to be planned as special buildings, or whether exceptional approvals are to be issued.

This decision is based on the following “optional characteristics of special buildings”. Classification as a special building means that additional requirements are directly agreed to regarding the minimum degree of fulfilment of the main criteria of the BNB (see Annex B7).

Optional characteristics of special buildings for the purposes of this Guideline:

- Buildings where construction costs according to the cost calculation exceed (a gross sum of) euro 10 million
- Buildings which are erected in a prominent urban development situation
- Buildings which are subject to stricter quality requirements during the assessment of overall sustainability (greater than 80 percent fulfilment in at least two of the five main BNB criteria groups) or in major individual aspects (100 percent fulfilment in the individual criterion)

The application of this Guideline ensures that sustainability is taken into account in the planning process through the goals set and the preparation of the related concepts in the respective phases. Adequate documentation serves as evidence for the subsequent sustainability assessment.

3 In the case of federal-government building projects, this is provided by the supplementary documents according to the RBBau Guidelines, Section F 1.4.

4 See also: “System for Sustainability Requirements in Design Competitions” (SNAP) brochure (BMVBS 2013 b)

5 In the case of federal-government building projects, this is provided by the documents according to the RBBau Guidelines, Section F 2.

PHASES ACCORDING TO THE RBBAU GUIDELINES							
Criteria group	Description	Phases according to RBBau					Use optimisation
		ES-Bau	Competition	EW-Bau	Final planning	Construction	
ECOLOGICAL QUALITY							
Effects on the global and local environment	1.1.1 Global Warming Potential (GWP)		* See separate recommendation	★			○
	1.1.2 Ozone Depletion Potential (ODP)			★			○
	1.1.3 Photochemical Ozone Creation Potential (POCP)			★			○
	1.1.4 Acidification Potential (AP)			★			○
	1.1.5 Eutrophication Potential (EP)			★			○
	1.1.6 Risks to the Local Environment			×		×	○
	1.1.7 Sustainable Material Extraction/Biodiversity				×	×	○
Demand of resources	1.2.1 Primary Energy Demand	★★		★			○
	1.2.3 Drinking Water Demand and Quantity of Wastewater	★★		★★			○
	1.2.4 Land Consumption	×		×			○
ECONOMIC QUALITY							
Life cycle costs	2.1.1 Building-related Life Cycle Costs	★★		★★			○
Economic efficiency and value stability	2.2.1 Space Efficiency	×		×			○
	2.2.2 Adaptability	×		×			
SOCIO-CULTURAL AND FUNCTIONAL QUALITY							
Health, Comfort and user satisfaction	3.1.1 Thermal Comfort	×		★★			○
	3.1.3 Indoor Air Quality	★		★★	×		○
	3.1.4 Acoustic Comfort			×			○
	3.1.7 Use Qualities						○

Excerpt from Annex B2.1 “Overview of criteria to be observed in the individual phases of the RBBau Guidelines” (new construction, version 2015)

ES-BAU (DECISION-MAKING DOCUMENTS)							
Criteria group	Description	Mandatory verification for standard buildings	Qualitative	Quantitative	Additional verification in the case of special buildings (selected on the basis of the special features of the building)	Qualitative	Quantitative
ECOLOGICAL QUALITY							
Demand of resources	1.2.1 Primary Energy Demand	Estimation of primary energy demand without construction		×	Estimation of primary energy demand in the life cycle – construction and operation		×
	1.2.3 Drinking Water Demand and Quantity of Wastewater	Estimation of fresh water demand and wastewater volume according to Annex 1 to Sample 7		×	Estimation of the water consumption indicator on the basis of fresh water demand and wastewater quantity		×
	1.2.4 Land Consumption	Evaluation of the type, scope and direction of the actual use of the area beyond the requirement level	×			×	
ECONOMIC QUALITY							
Life cycle costs	2.1.1 Building-related Life Cycle Costs	Estimation of costs according to Sample 6, Annex 1 to Sample 7 and Sample 11		×	Estimation of building-related costs in the life cycle for cost categories 300, 400 and 500		×
Economic efficiency and value stability	2.2.1 Space Efficiency			×	Assessment on the basis of the space efficiency value	×	
	2.2.2 Adaptability	Partial assessment of different requirements (building geometry, layout, construction, technical equipment)	×		Detailed assessment of different requirements (modularity of the building, spatial structure, energy and media supply, heating and water)	×	
SOCIO-CULTURAL AND FUNCTIONAL QUALITY							
Health, comfort and user satisfaction	3.1.1 Thermal Comfort	Consideration of the minimum requirements of the criteria profile (detailed proof in the EW-Bau phase)	×				
	3.1.3 Indoor Air Quality				Assessment of the material concept and the concept of the indoor air hygiene	×	
	3.1.6 Influence of the User				Assessment of the requirements of the criteria profile	×	
	3.1.7 Use Qualities	Consideration of the requirements of					

Excerpt from Annex B2.2 “Verification requirements in the ES-Bau phase” (new construction, version 2015)

2. Project preparation

During project preparation, the foundation stone for the sustainability quality that can be achieved for the building is laid at an early point in time. Project Preparation covers the main areas listed below. The starting point is the presentation of the project organisation with a view to integrating aspects of sustainability into the planning and building process in co-operation with the project stakeholders.

Main areas in project preparation are:

- Requirements planning
- Variant analysis for requirements planning/procurement method
- Classification as a new construction or refurbishment project and assignment to a system variant/BNB module
- Definition as a “special building” or “standard building”
- Completion of project preparation⁶
 - Preparation of a target agreement
 - Pre-check (Annex B3)
 - Report on sustainability
 - Energy-related targets (**FEDERAL BUILDING Energy Target Specifications (Sample), Annex B4**)
- Integration of sustainability aspects into the planning process
 - Integrated planning approach
 - Concept to take planning complexity into account
 - Planning and design competition

FEDERAL BUILDING According to the applicable RBBau Guidelines, the procedure for establishing Decision-making Documents (ES-Bau) includes requirements planning (E 2.2.1), variant analysis for requirements planning with a cost calculation (E 2.2.2) as well as qualification of ES-Bau (E 2.2.3). The contents of the ES-Bau Documents can be found in Section F1 of the RBBau Guidelines. The cost cap for large new buildings, conversions or extensions according to Section E of the RBBau Guidelines is laid down in the ES-Bau.

Using the target agreement table as a basis, the necessary planning work, including the necessary verification procedure, must be identified by the building administration during the project preparation phase (see an excerpt of the Annex on page 59). Depending on project tasks and execution, the services to be performed by the BNB coordinator must be allocated. Generally speaking, the aim should be internal (building administration) BNB coordination.

The aspects of sustainability addressed in the following sections must be taken into account for each specific project as early as possible during the planning phase (at the latest when the related information becomes available) and must then be updated in all of the relevant phases of planning. The sustainability coordinator is responsible for coordination and deciding on the depth of verification.

2.1 Requirements planning

The purpose of describing requirements is to methodologically identify the functional requirements, to translate these functional requirements into qualitative and quantitative requirements and to implement these during the construction process. The building authority advises the user and the project sponsor (owner) during the preparation of the requirements description. This is where the user and the project sponsor (owner) can define their qualitative requirements. The criteria described in the Assessment System for Sustainable Building can be very useful here. The user and the project sponsor (owner) can jointly define minimum requirements for the individual sustainability qualities which are also reflected in user demands. These requirements have a direct impact on the investment and use costs of the building. Requirements planning forms the basis for execution. One of the aims is to specifically address and examine the space requirement requested by the user in terms of need and responsibility, especially with a view to over-supply, and to avoid the need for a new building by making better use of existing buildings. Requirements planning should also include the intended equipping standards. The special sustainability requirements of a building must be expressly laid down in requirements planning.

FEDERAL BUILDING Requirements planning is approved by the user's supreme authority.

⁶ With regard to federal government building projects, see RBBau Section F 1.4



Public-private partnership project with the BNB Gold standard, German Federal Ministry of Education and Research

2.2 Analysis of variants to meet requirements

The purpose of the analysis of variants to meet requirements is to identify the variant with which requirements planning can be implemented with maximum economic efficiency. The aim is to address all structural, planning and construction-law aspects in terms of quantity, quality and costs in such a manner that alternative options for meeting the requirements and for achieving the overall economic efficiency of the measure can be assessed. The following procurement variants should be examined with a view to their suitability based on qualitative criteria:

- Lease of property, including conversion or extension measures that may be necessary
- Purchase of existing buildings, including conversion or extension measures that may be necessary
- Lease or lease-purchase
- New construction, conversion or extension projects as internal building projects
- Public-private partnership (PPP)

When examining the variants, consideration must be given to the principles of life cycle-orientated cost optimisation, especially of future operating, other use and risk costs. In addition to the pure cost-based comparison of variants, a benefit analysis is recommended so that aspects of sustainable building which cannot be quantified are also sufficiently taken into account. In the case of a new building, a cubic capacity survey can be used to prove technical feasibility. The costs are calculated here using cost indicators. Furthermore, long-term property developments must also be included.

The procurement methods available for a specific project can lead to different levels of project detail in terms of how sustainability is addressed. The conditions for in-house planning without a competition differ significantly from those for a PPP project. The building administration must hence continuously consider this distinction as part of project development.

Aspects related to urban development and location

As part of the analysis of variants to meet requirements, urban development and location-specific issues must be specifically examined with a view to sustainability. This means that municipal urban development concepts must be taken into consideration when planning new buildings. The BNB can provide information regarding location issues.

The goals of sustainable neighbourhood/property policy include the following aspects:

- Thrifty and careful use of land for buildings and minimisation of surface use for development
- Conversion of existing buildings
- Compact structures combined with a reduction in the site occupancy index
- Urban integration of new buildings in the existing surroundings
- Consideration of the dimensions and orientation of the building structure, future traffic flows, shading situations, building-specific noise immission or wind flows typical for the area

Before a decision can be made in favour of a new building, the analysis of variants must clearly show that the need for space cannot be covered by existing buildings in an economically sensible manner – including options for optimising occupancy. In this case, options for a change in use, conversion or replacement of existing buildings must be considered. In order to protect natural areas, the goal is to minimise land consumption (BNB 1.2.4), to avoid settlement of open landscapes and to minimise additional sealing of the soil surface. The possibility of space recycling must also be considered. Preference should be given to utilising areas that are already sealed. The use of industrial wasteland, for instance, or areas formerly used for military or other purposes, as well as the possibility to close gaps between buildings must also be examined. Contaminated areas are not generally ruled out for future use and should

hence be included as an alternative option in planning. Please refer to the “Technical Guidelines for Soil and Groundwater Conservation”⁷ and the requirements of environmental and nature conservation.

The risks (BNB 6.1.1) and conditions (BNB 6.1.2) at the micro-location must also be included in the choice of location and in planning considerations, as must proximity to user-specific services (BNB 6.1.5) and access to utilities (BNB 6.1.6). It is often better to use an existing infrastructure rather than build a new one. Preference should generally be given to locations with good public transport connections (BNB 6.1.4) in order to minimise traffic flows. Since most journeys by car are on average shorter than five kilometres, using a bicycle instead, which does of course require a suitable bicycle infrastructure, can contribute significantly to eco-friendly, energy-efficient mobility (BNB 3.2.5).



User-friendly bicycle facilities provide an incentive to use bicycles

7 Baufachliche Richtlinien Boden- und Grundwasserschutz (BMI 2018c)

Identification of costs and profitability analysis

An important part of project preparation involves examining economic efficiency within the scope of analysing variants to meet with requirements. There are many guidelines and tools available that address the methodology of the life cycle-orientated profitability analysis. The “Guide – an Introduction to Profitability Analyses” from the Federal Ministry of Finance and the “Guide on Profitability Analyses during Preparation of the Civil Engineering Measures by the Federal Government” from the Federal Building Ministry are of particular relevance in this context.

The methods described in the two documents referred to above are primarily used as part of the analysis of variants to meet requirements and serve as tools for identifying the most economical procurement options in the early phase of planning based on the estimated costs of manufacture. The methodology described in the Guideline for Sustainable Building for identifying and calculating building-related life cycle costs is applied during or after a construction measure on the basis of the final costs. Not only the aim, but also the time of application and the data bases of the Guidelines referred to above thus differ from an evaluation that uses the “Building-related Life Cycle Costs” criterion (BNB 2.1.1). The purpose of this BNB criterion is to enable the comparison and optimisation of building projects on the basis of specified boundary conditions so that evaluation using a uniform evaluation standard is possible.

In order to ensure optimised life cycle costs in a building project, BNB criterion 2.1.1. should already be applied at an early stage during planning and execution. This requires estimating the result. During project preparation, the estimation according to this criterion converges with the profitability analysis according to the above-mentioned documents. Using altered boundary conditions, the profitability analysis can be based on the input values and results of the estimate according to BNB criterion 2.1.1 because the recording of costs required here is usually more detailed. Both methods are based on the identified costs of manufacture according to DIN 276-1.

Based on the calculation of costs (**FEDERAL BUILDING as shown in the “Cost calculation” template of the RBBau Guidelines**), the building-related life cycle costs can be estimated. Beginning with the cost groups calculated, the building authority and the project sponsor (owner)/operator must identify and evaluate the cash value [€/m² gross floor area] over the first 50 years of use according to the calculation rules of BNB criterion 2.1.1. The calculation tools available on the BNB platform or, alternatively, the LCC calculation method available in eBNB, can be used for verification.

The costs of manufacture must be calculated on the basis of either the results of the cost estimate according to DIN 276-1 or cost indicators from comparable building projects that have been completed. If no data is available, databases such as PLAKODA are recommended in order to identify costs.

The period of reference is as follows:

- Convention in the BNB LCC method: The observation period generally covers the first 50 years. In addition to this, other reference periods may be agreed upon depending on the type of building use.
- In the case of PPP projects, it is recommended that comparison calculations be carried out for a 30-year⁸ reference period.
- A reference period of 80 years should be used for building structures with a longer technical life cycle.

The expected utility costs are calculated according to the “Annual consumption and operation costs” template of the RBBau Guidelines.

8 See Leitfaden Public Private Partnership – Wirtschaftlichkeitsuntersuchungen bei PPP-Projekten, NRW (2007)

Since the calculation scenario projects future costs incurred, assumed annual price increase rates are the only way in which price developments can be taken into account. The general annual price increase and, in deviation from that, the annual increase in heating and electricity costs, as well as the discount rate in the case of the cash value method to be used in the profitability analysis, can be found in the publications by the Federal Ministry of Finance. For the purpose of evaluation according to the Assessment System for Sustainable Building, it is imperative that verification be based on the billed as-is costs of the building project and on the calculation parameters defined for the system variants.

The aim of the cost calculation is to minimise total costs, specifically building costs plus use/operation costs. Possible alternatives should be outlined and evaluated, especially with a view to the following priorities:

- Investment costs versus operating costs
- Investment and operating costs versus external costs and environmental impacts
- Use of innovations with a view to missing costs indicators and durability

Apart from calculating costs, no quantifying evaluations or verifications are carried out during this phase. Instead, the planning concept is described in terms of quality. This applies in particular also to sustainability.

FEDERAL BUILDING When it comes to federal building, additional verification (see Annex B2.2) may, however, already be necessary in the ES-Bau phase.

Other aspects of economic efficiency and the value stability of building structures must also be taken into account. For the purposes of the Assessment System for Sustainable Building, Space efficiency (BNB 2.2.1) (**FEDERAL BUILDING** verification according to the “Cost Calculation” template of the RBBau Guidelines) and capability of conversion (BNB 2.2.2) must be verified for the building.

2.3 Completion of project preparation

If a decision is made on the basis of the survey of demand and the variant analysis to erect a new building or, alternatively, to completely refurbish an existing building, the documents for project preparation must be completed in line with the specific issues of the project. Aspects of the existing building must be recorded, especially for refurbishment projects (see also Part D of this Guideline).

FEDERAL BUILDING If, based on the analysis of variants, the user's supreme authority opts to build the building itself, the ES-Bau documents are then qualified. The project sponsor (owner) commissions the building authority to complete documentation in order to include the costs in the federal budget pursuant to Section 24 of the Federal Budget Code (BHO). According to Section F1 of the RBBau Guidelines, these documents are:

- Correspondence
- Documents on requirements planning (quantitative and qualitative requirements planning)
- Documents on variant analysis, including a cost-to-benefit analysis, if applicable
- Supplementary documents for the self-built variant, including:
 - Description of the building project
 - Identification of costs
 - Rough estimate of the expected use costs
 - Extract from the land survey register
 - Drawings showing the planning concept
 - Space calculation according to DIN 277
 - Target/as-is comparison of space based on the space requirement

These documents can also be used either directly or indirectly in order to assess the sustainability of a building design in an early planning phase.

2.3.1 Target agreement

The drafting of a target agreement is basically geared towards the BNB criteria and is an essential part of high quality project preparation. A sustainability-orientated target agreement is used to define concrete site and project-specific design and planning goals. This establishes the prerequisites for targeted design and planning and for taking aspects of sustainability during competitions into account and ensures that all of the criteria that serve sustainability are considered. Close coordination with the appropriate BNB conformity testing office is recommended.

The target values agreed to by the building authority, the project sponsor (owner) and the user before design and planning begin (minimum degree of fulfilment, see Annex B7), the necessary services and measures, as well as deadlines and responsibilities must be laid down for each project in the target agreement table (refer to Annex B1) for each individual criterion. In this way, the building authority, the project sponsor (owner) and the user can continuously check that these values are being adhered to in the individual design and planning phases.

2.3.2 Pre-check

The achievement of the values agreed upon in the target agreement must be checked at least during the course of drafting the sustainability report. If the Assessment System for Sustainable Building is applied, the BNB criteria must be estimated in qualitative and quantitative terms and assessed on the basis of these results with a view to the overall quality target for the building. The pre-check sample can be used for orientation (see Annex B3). When it comes to estimating the overall degree of fulfilment of a building that is being planned, it is recommended that verification be carried out with a safety coefficient of at least 2.5 percent because deductions in the overall result often occur as part of the conformity examination.

2.3.3 Sustainability report

The “Sustainability assessment report” (see Annex B5) must be drawn up and updated in order to estimate at an early point in time the implementation of the individual sustainability criteria. This report is designed to ensure the consideration and anchoring of aspects of sustainability and basically picks up on the results of the pre-check. The report lists the measures that can be used to achieve the target values set. It serves as a basis for decisions regarding further planning. Decisions must be formulated in an easy-to-understand manner and laid down in writing. Generally speaking, the individual criteria and the main criteria groups must be assessed and an overall assessment carried out, along with a determination of the degree of overall fulfilment. These steps must be taken prior to the report so that the sustainability targets can be checked by the authorities in charge.

2.3.4 Energy-related requirements

The energy requirements must be developed specifically for the building analogous to Annex B4 “Energy Target Specifications (Sample)”. It should also be taken into account whether the building is part of a property, and if this is the case, the property-related energy boundary conditions must be included when developing the energy requirements and the energy concept. The following aspects must be considered both during erection and operation:

- High energy efficiency
- Low resource consumption
- Environmentally compatible solutions
- State of the art



Pilot project by the Federal Building Ministry to meet the Efficiency House Plus demands



The Federal Environment Agency's Haus 2019 building – pilot project to meet the energy demands of the EU's Energy Performance of Buildings Directive (EU 2010)

The main structural and technical requirements must be integrated into the energy-related requirements in order to optimise the primary goal, namely to minimise the overall primary energy demand of the building while ensuring the agreed comfort level and fulfilling the minimum regulatory requirements. Optimisation must be considered equally with a view to the choice of fuel and a reduction in final energy. At minimum, the following issues should be explored as part of identifying requirements:

- Consideration of existing centralised/decentralised energy supply
- Possibilities for property-specific synergies
- Utilisation degree of existing utilities
- Consideration of higher-level energy-related requirements (such as the Energy Saving Ordinance, decrees, programmes)
- Compensation options of existing buildings by outperforming the requirements for new buildings (energy supply for the purposes of a “productive building”)
- Questioning current supply methods (for instance, combined heat and power generation) with a view to improved building standards (heating and electricity demand) as well as boosting the use of regenerative resources
- Own energy supply

FEDERAL BUILDING With a view to the Renewable Energies Heat Act (EEWärmeG)⁹ and the federal government's special model role, it is expected that at least 15 percent of energy demand will be covered by renewable energy sources.

2.4 Integration of sustainability aspects into the planning process

Since buildings and properties are subject to very different boundary conditions, this Guideline serves primarily as a practical aid, however, it cannot deliver a complete checklist for taking all aspects of sustainability into account. Based on the findings of the previous sections, the following aspects must be examined in more detail as part of project preparation:

- Integrated planning of project-specific specialist disciplines
- Complexity of planning, taking into account the required concepts

Integrated planning and design

Optimising the planning workflow is the basis for implementing sustainable buildings. This calls for improved co-ordination between all stakeholders. Integrated planning (BNB 5.1.2) covers the entire life cycle of a building from project development right through to demolition. This means that architecture, structure and building systems all interact very closely. Integrated planning makes this interaction transparent and optimises it in iterative steps during planning. Early involvement of different specialist planners and designers (interdisciplinary planning team, refer to BNB 5.1.2), along with the user and the public, supports target-orientated development of a sustainability concept. In this way, high quality planning can help to reduce environmental impact while improving both comfort and economic efficiency. The building authority itself can manage the project or, when necessary, place this in the hands of external service providers.

9 See EEWärmeG (2015)

Complexity of planning

Planning a sustainable building calls for a holistic approach. Each planning decision has various impacts on the individual aspects of sustainability. By drawing up concepts that take into account ecological, economic, socio-cultural/functional and technical aspects, these aspects can then become a permanent and systematic part of creating and operating a building. Planning can be largely optimised by comparing variants, weighing up different solution options within the interdisciplinary planning team and checks carried out by independent third parties.

Customary concepts include:

- Safety and health protection plan
- Fire protection concept
- Sound protection concept
- Energy concept
- Management concept (cleaning and maintenance)
- Concepts for special structural solutions

Special concepts address some of the following issues:

- Measurement and monitoring concept
- Optimisation of daylight and artificial light
- Water management
- Avoiding environmental and health risks from building products
- Sealing and re-exposing surfaces
- Extended ventilation concept
- Acoustic comfort
- Conversion capability and dismantling
- Waste and recycling
- Other aspects to save resources
- Avoiding and managing project risks
- Waste management during use
- Barrier-free building
- Colour scheme

2.4.1 Energy and metering/measuring concept

Minimising energy demand is largely influenced by preparing, updating and implementing an energy concept. The development of a metering/measuring and monitoring concept and its implementation form the basis for checking and optimising energy demand during building operations. The concept-based examination expressly includes the planning of energy supply and the use of renewable energy (see Annex B4). From a life cycle perspective, the primary energy demand, as well as the final energy demand, of a building must be minimised (BNB 1.2.1). Special attention must be paid to passive and renewable energy. The type of building, the building shape and its location must already be defined during project preparation as preconditions for low primary energy demand during the use phase.

Energy concept

The level of a building's future consumption of fossil and regenerative fuels is strongly influenced by its architectural design, location and geographical orientation. This influences passive solar energy and annual demands for heating, cooling and electricity for lighting depending on the share of window surfaces and, if applicable, mechanically assisted ventilation.

As part of project preparation, initial decisions must be made regarding the energy quality of the building, building envelope and technical equipment (see Annex B4 Energy Target Specifications (Sample)). These decisions will then have to be implemented as binding requirements in subsequent final planning. The energy quality of the building envelope and the technical equipment (lighting, heating, if applicable, hot water, air handling systems) must be selected in such a manner that the requirements of the Energy Saving Ordinance for primary energy demand are fulfilled.

FEDERAL BUILDING When it comes to federal buildings, there are additional requirements that are regulated by a separate decree.

In this case, final energy and primary energy demand must be calculated for the use phase. Internal or external energy consultants can be involved in energy planning. In addition to energy-related aspects, the choice of heating systems must also consider limiting the local environmental impact caused by emissions of particulate matter because not every heating system is equally suitable.

The building's grey energy and its technical equipment are taken into account as part of the eco-balancing calculations in the BNB and are not part of the assessments here.

In order to achieve the federal government's climate policy goals, the economical use of renewable energy should surpass the requirements of the Renewable Energies Heat Act. Taking into account the geographical orientation or angle of the exterior surface of the building, the option to use solar energy must be examined and a yield estimate calculated. Instead of solar energy, small, local wind turbines and wastewater heat recovery systems are also being used for the first time. Aspects of urban development and existing requirements must be integrated into considerations at an early point in time.

The decisions made must be sufficiently considered in the calculation of costs. If the life cycle cost analysis shows that a specific measure is not economically effective compare to other variants, the inclusion of external costs (Part A, section 2.2.2) has proved to be useful.

External costs

External costs must initially only be identified for the environmental impact of the "greenhouse gas potential" in relation to the primary energy demand of the building during the use phase and its monetisation for possible execution variants. In order to calculate external costs and final energy demand, including upstream energy sources, the corresponding CO₂ equivalents (for example, according ÖKOBAUDAT) as well as the external cost factor for greenhouse gases must be identified on the basis of the latest publications by the Federal Environment Agency.

FEDERAL BUILDING According to Annex B4, currently it is calculated at 80 euro per tonne of CO₂.

External costs must be calculated in absolute terms according to the calculation steps shown below (table B1) and in relation to the reference areas used to identify costs (see also online publication 17/2010¹⁰ by the Federal Building Ministry).

IDENTIFICATION OF EXTERNAL COSTS

TABLE B1

Calculation steps	
CO₂ equivalent = $\sum (\text{EndE}_{\text{Use}} * \text{CO}_2 \text{ equivalent factor})_i$	
	[t]
External costs = CO ₂ equivalent * EX-CO ₂	
	[euro]
EndE	Final energy demand according to sources
i	1 to n
n	Number of energy sources
EX-CO ₂	External cost factor in [euro/t]

Source: BBSR

As part of comparing the costs of the different variants, the calculated external costs can also be generally included in the evaluation. The requirements for the energy quality of the building can be found in the Energy Target Specifications (Sample), (Annex B4).

10 BMVBS (2010)

As the depth of planning increases (execution planning), the aforementioned cost calculations must be updated in more detail until a decision is made.

Measurement and monitoring concept

The measuring and monitoring concept must include monitoring of energy resource consumption and operating costs during the use phase. The prerequisites for efficient building management must already be established in the design and planning phase. This means that stakeholders, in other words users/project sponsors (owners/operators)/building authorities/planners, must work together during requirements planning. The necessary measuring and metering equipment must be planned and the costs calculated must be taken into account (see Annex B4 Energy Target Specifications (Sample)).

Suitably organised measures should ensure the continuity of expert support throughout the life cycle. With permanent, software-based stock-taking and consumption data (EMIS/PLAKODA), buildings and properties can be systematically recorded and can also be put into relation to each other. The aim is to improve building characteristics on a long-term basis, namely to reduce costs, protect resources and the environment and to maintain or improve user comfort.



Implementation of the monitoring concept on the basis of differentiated data collection

2.4.2 Water management concept

The aim of a drinking water and wastewater concept for the purposes of a water management concept is to save water as a natural resource (drinking water) and to minimise intervention in local site conditions (for instance, temporary lowering of groundwater levels). Moreover, water as a resource can also be viewed in terms of energy (for instance, heat recovery and evaporative cooling).

Solutions must be developed and proposed in the drinking water and wastewater concept in order to reduce drinking water consumption, to reduce expenditure on the provision of drinking water and wastewater treatment and hence to largely avoid disrupting the natural circulation of water. During planning, prerequisites that influence water consumption independent of user behaviour are established. These prerequisites can be checked and analysed with a view to defined assumptions regarding user behaviour and the planned water management concept (BNB 1.2.3).

In order to protect water as a natural resource, drinking water demand in administration buildings that goes beyond user consumption can be replaced partially or fully, for instance, by using grey water (including rainwater), depending on the required water quality, or consumption can be reduced significantly through water-saving installations.

Sewage (wastewater)

An Estate Sewage Disposal Concept (Liegenschaftsbezogenes Abwasserentsorgungskonzept LAK) must be drawn up that then serves as a basis for deciding upon the necessary construction measures. In this case, an overall drainage system concept will be developed for the entire property – also taking into account future structural changes. In this context, reference is made to the “Technical Wastewater Guide”¹¹ which contains the fundamental, technical and procedural regulations for planning, executing, operating and documenting wastewater systems of the federal government.

11 See BMI (2018a)

FEDERAL BUILDING The remedial concept of the LAK, Part B, forms the basis for the budget documents which must be drawn up when needed for federal building.

The use of wastewater for energy purposes is currently a special matter. If hot water is to be supplied in the building, the concept should be expanded with a view to thermal use (for instance, using heat exchangers). First steps are also underway to make use of the kinetic energy of wastewater.

Rainwater

As an alternative to conventional forms of discharge via the sewage system, natural rainwater management is becoming increasingly popular because this combines many water management and economic advantages. The major processes of drainage, retention, purification and also the possible use of rainwater are increasingly shifting the focus towards managing rather than disposing of water as a resource.

The positive effects are as follows:

- Draining and retention measures lessen the hydraulic burden on sewers and natural outlet channels so that high-water peaks can be reduced.
- Draining through the vitalised soil zone ensures effective removal of dirt particles from surface water.
- The cost of maintaining wastewater systems is reduced.
- Groundwater volumes are increased on a permanent basis.

Furthermore, the use of rainwater can form part of a wastewater concept. In this case, rainwater is temporarily stored in cisterns and can be used, for instance, for irrigation or in a separate pipe system for toilet flushing. Special hygiene requirements apply to the two latter forms of use. Since the technical measures needed to use rainwater must usually be considered to be complicated and hence expensive, their economic efficiency should be examined on a case-to-case basis.

Greywater

The water collected from sinks and showers is usually only very slightly contaminated. If treated properly, it can be reused, for instance, to water outdoor areas. This method calls for a separate wastewater system, along with technical components to store and treat the water collected. The economic efficiency of this method must be examined on a case-to-case basis.

In addition to the options which are theoretically available, the examination depth of the water management concept should also consider life cycle costs according to the BNB because the choice of decentralised supply and disposal systems is largely determined by system maintenance requirements. On the other hand, the costs of municipal supply and disposal can be easily calculated at a very early point in time.

2.4.3 Cleaning and maintenance-friendliness

The building design should generally be such that the building and equipment parts selected require as low a level of cleaning and maintenance as possible during the use phase (BNB 4.1.3). With a view to low cleaning requirements, preference must be given to smooth surfaces and mostly uniform materials (same method of cleaning). Glass components require considerable cleaning work depending on the installation situation. Moreover, attention must be given to the possibility of cleaning surfaces on both sides or accessing larger intermediate spaces.

Depending on the dimensions of the building and its large cleaning areas, the possibility of using machines for cleaning must be examined and enabled. Inaccessible corners, recesses, dead angles, intermediate spaces, columns in hallways and rooms, as well as structures that require the use of large lifting equipment should be avoided. Furthermore, maintenance work and maintenance-friendliness must be considered when selecting individual building components and technical systems. Technical systems should be as simple as possible. They should be safe and easy to maintain and operate.



Measuring carbon levels to verify ventilation concepts

2.4.4. Concept to avoid environmental and health risks from building products

When building products are used, care must be taken to avoid pollutants that could pose a risk to the environment and health. This applies both to working with the products at the construction site and to the use phase of the building.

This aim is supported by a concept that contains information regarding potential environmental and health risks with building products and is used in the early phase of planning as a basis for planning execution and tendering. Ideally, this concept contains recommendations for avoiding potential pollutants according to the “Risks to the Local Environment” criterion (BNB 1.1.6) and includes all building product groups that come into direct or indirect contact with soil, groundwater and air (processing at the construction site).

The concept should also include information regarding the avoidance of risks to health from building products. Choosing low-emission building products for indoor areas is a precondition for compliance with the values specified in the “Indoor Air Quality” criterion (BNB 3.1.3) for indoor air measurements after completion of the building. The relevant pollutants are volatile organic compounds (VOCs) and formaldehyde, both in surface-near floorings and coatings and also in underlying primers, undercoats, fillers and adhesives in common areas.

2.4.5 Extended ventilation concept

The primary goal of the extended ventilation concept is to limit the increase in carbon levels in indoor air caused by users to a maximum of 1000 ppm. The air exchange required to achieve this can be generated by natural ventilation and/or mechanically assisted ventilation systems. Both cases can impact the quality of indoor air (see BNB 3.1.3) and thermal comfort (see BNB 3.1.1) as well as the building’s energy demand. This is why the ventilation concept should not only ensure the necessary air exchange (taking into account the dimensions and occupancy rates of the rooms as well as the hours of use), but should ideally also contain information about other conditions related to room climate. This applies irrespective of the type of ventilation chosen.

Detailed solutions are included in the concept as planning progresses. In the case of natural ventilation, information regarding the openable window surfaces needed with a view to actual and realistic ventilation times and cycles helps to achieve the required air exchange. In the case of mechanically assisted ventilation, hygiene requirements for the system selected avoid higher microbiological levels in indoor air. When both types of ventilation are combined, all aspects of the respective form of ventilation are applicable.

The concept may also include measures to counteract singular peak burdens, for instance, the installation of sensor-controlled ventilation indicators (carbon indicators) in the case of window or hybrid ventilation or the fitting of hygrometers and thermometers to measure and visualise humidity and temperature in rooms.

2.4.6 Acoustic comfort concept

The planning concept for acoustic comfort begins with the identification of the relevant room groups and the corresponding reverberation time. All relevant influences, such as work processes, types of communication, room layout, room size, proportions and equipping are taken into account here.

2.4.7 Concept for barrier-free building

The concept for barrier-free building is prepared in close co-operation with the user and covers both public and dedicated workplace areas. Various aspects are interrelated here:

- The barrier-free accessibility of public areas is a minimum requirement, not just for outdoor areas but also for inside the building.
- In addition to this, the recommendations of the Federal Building Ministry's Guideline Accessibility in Building Design (LFBB) can be used in different stages (requirements planning, concept preparation and verification of the individual requirements laid down in the concept). According to the LFBB, all issues of barrier-free accessibility in building design must be examined for the different types and degrees of disability keeping in mind the principle of "design for all". Corresponding requirements must also be defined.
- Additional precise requirements for barrier-free accessibility of designated workplace areas must also be taken into account (for example, share of accessible areas and provision of barrier-free toilet facilities).

FEDERAL BUILDING Implementation of the LFBB is mandatory for federal building projects.

2.4.8 Concept for accessibility and use qualities

The basis for the spatial structuring in design planning is the definition of public accessibility (BNB 3.2.4) of the inside of the building and the related outdoor areas with the following points being taken into account:

- General or partial public accessibility (unless restricted for security reasons)
- Opening the outdoor and internal building facilities (such as libraries or cafeterias) to the public
- Creating options for third parties to rent rooms within the building

In direct relation to accessibility, use qualities (BNB 3.1.7) must also be taken into account. Outdoor qualities should not only benefit building users, but ideally they should be available to the public.

2.4.9 Waste and recycling concept

A building must comply with the provisions of the Closed Substance Cycle and Waste Management Act (KrWG)¹² and not just when it is demolished. Instead the following aspects must also be taken into account during all phases of the building's life cycle:

- Save natural resources
- Avoid waste
- Correctly and safely recycle unavoidable waste
- Eliminate waste that cannot be recycled commensurate with the public good

The federal government's "Guidelines for Recycling"¹³ describe the planning and execution of the measures necessary for handling building materials to be recycled as well as construction and demolition waste. In addition, the recycling of waste is described in more detail here. Reducing landfill space, raw materials and production energy can help to achieve the principles

¹² See KrWG (2013)

¹³ See BMI (2018b), also available at: www.arbeitshilfen-recycling.de



Winning design: Anderhalten architects, new building for the Federal Environment Agency in Dessau that meets the BNB Gold requirements in the planning competition



of sustainable planning over the entire life cycle of a building. The following building-related resource-saving aspects must be examined with a view to their implementation:

- Reuse of building parts or elements installed
- Examination of the use of recycled building materials
- Examination of the use of building materials/parts that can be recycled
- Preference for low-waste structures thanks to the possibility of selective dismantling of materials
- Waste avoidance during construction work

As part of project preparation, the following project-specific issues must be examined with a view to demolition, separation and recycling, and solutions must be identified in a concept study:

- Will the new building be used temporarily or how long will it be used?
- Is the building to be designed for dismantling or rebuilding?
- Does the type of use imply regular conversion of the building, which calls for conversion measures during operation?
- Are there any rules, regulations or ordinances that require the use of recycling materials?
- Do these requirements result in specifications for the recycling rates to be achieved?
- Do these requirements result in higher target requirements in the target agreement table? (BNB 4.1.4 “Dismantling, Waste Separation and Utilisation”)
- Do special planning considerations with a view to saving resources and avoiding waste have to be explained in the pending design competition?

2.5 Design competition

Design competitions held according to RPW 2013 (Design Competition Guidelines) with independent consultancy by an expert jury are the ideal way to assess the architectural quality of a design and its integration into urban planning (BNB 3.3.1). The aims and requirements of sustainable building must also be effectively implemented for each phase during the course of customary competitions. When hosting design competitions¹⁴, aspects of sustainability must be addressed in all of the competition phases – from preparation to completion. The task description must identify the main requirements concerning sustainable building – based on this Guideline and/or the criteria of the BNB. Proven compliance with these requirements must be demanded in the competition. In order to be able to respond in a flexible manner to the respective tasks and goals of the competition, specific procedures have been developed. The “System for Sustainability Requirements in Design Competitions” (SNAP) brochure provides recommendations for implementation. However, it was not possible to include all conceivable procedures in this brochure so that the recommendations must be adapted to the respective tasks and supplemented where needed. The scope of integrating sustainability should be in reasonable relationship to the building and total of the awards and recognition for the competition. It is also recommended that at least one expert adjudicator be involved in the competition procedure who is able to judge sustainability with a focus on operation, energy and ecology.

14 See BMVBS (2013 a)

3. Design and approval planning

B3

The quantitative and qualitative requirements from requirements planning are implemented in design and approval planning in a specific building design – normally at a scale of 1:100. This phase of planning offers the greatest room for influence on the future development of costs for the construction project. Existing concepts must be updated or new concepts developed. Preferred solutions must be derived here which incorporate aspects of sustainable building into design planning. The special sustainability requirements of the construction project as laid down in requirements planning can be implemented here. If the aspects of sustainable building are not (sufficiently) taken into account in design planning during this phase, their inclusion in planning at a later point in time will mean a considerable amount of additional work and hence lead to a significant increase in costs.

FEDERAL BUILDING As required by the Federal Construction Guidelines and following approval of the ES-Bau by the supreme technical authority and recognition under budget law by the Federal Ministry of Finance, the Design Specification Documents (EW-Bau) are then drawn up by the building authority according to Section E of the RBBau Guidelines (RBBau). The EW-Bau phase largely address the work phases 2 (pre-planning), 3 (design planning) and 4 (approval planning) according to the Official Scale of Fees for Services by Architects and Engineers (HOAI) and ends with complete design and approval planning. In as far as necessary, parts of final planning can be included in the EW-Bau. When preparing the EW-Bau, the contents of the ES-Bau are binding. The ES-Bau documents continue to provide the cost framework. If the building authority finds that the EW-Bau documents comply with the cost framework laid down in the ES-Bau, it can then proceed with final planning.

Pursuant to the RBBau Guidelines, Section F 2,¹⁵ the EW-Bau must include, among other things, the design documents described below:

- Drawings (such as an overview drawing, land register map, site plan, design and approval drawings)
- Explanatory report
- Verifications (structural design, fire protection, Energy Saving Ordinance, sound insulation)
- Cost calculation

3.1. Updating the sustainability report

The “Sustainability assessment report” (see Annex B5) based on the current building design must be updated in order to examine and estimate in more depth the implementation of the individual aspects of sustainability in the planning phase.

Some of these aspects will have already been taken into account in project preparation and will be ready for final evaluation according to the BNB system, while numerous requirements will only become relevant in the subsequent phases of planning. During the design and approval planning phase, the BNB assessment table in Annex B2.3 (see adjoining excerpt of the Annex) can be useful for verifying whether aspects of sustainability have been taken into account or for assessing sustainability. This must be developed on a project-specific basis and adapted for each individual case in terms of the type and depth of verification. The individual sustainability qualities of the building design must be mapped with the aid of the assessment criteria, if possible, in the BNB assessment table in order to obtain a general view of the overall quality addressed. This planning document in table form must be supplemented by a report explaining the background information and assumptions to the project stakeholders.

15 See BMUB (2016)

EW-BAU (DESIGN SPECIFICATION DOCUMENTS)							
Criteria group	Description	Mandatory verification for standard buildings	Qualitative	Quantitative	Additional verification in the case of special buildings (selected on the basis of the special features of the building)	Qualitative	Quantitative
ECOLOGICAL QUALITY							
Effects on the global and local environment	1.1.1 Global Warming Potential (GWP)				Calculation of the criterion acc. to BNB 1.1.1		×
	1.1.2 Ozone Depletion Potential (ODP)				Calculation of the criterion acc. to BNB 1.1.2		×
	1.1.3 Photochemical Ozone Creation Potential (POCP)				Calculation of the criterion acc. to BNB 1.1.3		×
	1.1.4 Acidification Potential (AP)				Calculation of the criterion acc. to BNB 1.1.4		×
	1.1.5 Eutrophication Potential (EP)				Calculation of the criterion acc. to BNB 1.1.5		×
	1.1.6 Risks to the Local Environment	Verification of the criterion acc. to BNB 1.1.6	×				
Demand of resources	1.2.1 Primary Energy Demand				Calculation of the criterion acc. to BNB 1.2.1		×
	1.2.3 Drinking Water Demand and Quantity of Wastewater	Estimation of the water consumption indicator on the basis fresh water demand and wastewater quantity		×	Calculation of the criterion acc. to BNB 1.2.3		×
	1.2.4 Land Consumption	Verification of the criterion acc. to BNB 1.2.4	×				
ECONOMIC QUALITY							
Life cycle costs	2.1.1 Building-related Life Cycle Costs	Estimation of building-related costs in the life cycle for cost categories 300, 400 and 500		×	Calculation of building-related costs in the life cycle according to 2.1.1		×
Economic efficiency and value stability	2.2.1 Space Efficiency	Verification according to BNB 2.2.1		×			
	2.2.2 Adaptability	Detailed assessment of different requirements (building geometry, layout, construction, technical equipment) according to BNB 2.2.2	×				
SOCIO-CULTURAL AND FUNCTIONAL QUALITY							
	3.1.1 Thermal Comfort	Assessment of the requirements of the criteria profile	×		Calculation of the criterion acc. to BNB 3.1.1		×
	3.1.3 Indoor Air Quality	Assessment of the material concept and the concept of the indoor air hygiene	×		Assessment of the material concept and the concept of the indoor air hygiene	×	

Excerpt from Annex B2.3 "Verification requirements in the EW-Bau phase" (new construction, version 2015)

In the case of special buildings as contemplated in this Guideline (see section 1, page 58), it is recommended that the criteria already highlighted in the project preparation phase undergo more in-depth evaluation in order to ensure compliance with the stricter requirements for such buildings.

FEDERAL BUILDING In the case of federal building projects, updating the report on sustainability (sample report in Annex B5) supplements the explanatory report, which, according to RBBau Guidelines, contains the description of the design along with details regarding production and utilisation costs as well as energy-related data for the building. The design description includes the following information:

- Design idea, design requirement and exterior design
- Technical building systems and installation layout
- Energy concept
- Conversion capability and expansion options

Moreover, the description also includes information regarding special exterior conditions, which have a special impact on the design and hence on manufacture and utilisation costs. With a view to the cost groups which must be listed in the explanatory report, information regarding the structure, including material and properties, must also be provided. Due to the detailed planning stage, the breakdown of costs in the EW-Bau (refer to DIN 276-1¹⁶) must be adapted accordingly. The building utilisation costs must be broken down according to DIN 18960¹⁷. The depth of detail in the explanatory report determines the precision with which the first specific evaluation according to the BNB can be carried out. Within the scope of the BNB projects carried out, the difference between the overall degree of fulfilment forecast at the time of the EW-Bau and the final assessment at the time of completion is less than five percent of the overall degree of fulfilment, demonstrating the limited scope for improvement in the subsequent project phases.

16 DIN 276-1: 2008-12

17 DIN 18960: 2008-02

3.2 Verifications

3.2.1 Building services

Parallel to design and approval planning, other specifications must be drawn up for the energy-related quality of the building which result from the requirements already mentioned in section 2.4.3 (see Annex B4 Energy Target Specifications (Sample)). The way for this was already paved during project preparation so that the requirements and verifications can be addressed in more detail during design and approval planning. In order to implement an exemplary and future-enabled concept, a reduction in primary energy demand of the planned building and, more importantly, in the final energy demand, must be a top priority.

Design and approval planning must contain the verifications required under the applicable Energy Saving Ordinance. According to the specifications of project preparation and subject to the Energy Target Specifications (Sample), the requirements laid down in this ordinance must be outperformed. Energy demand for hot water supply, demands for electrical energy and cooling are also subject to the requirements laid down in the Energy Target Specifications (Sample).

While heating energy consumption is continuously declining, consumption of electrical energy is rising significantly due to the number of electric loads and the ancillary electrical energy needed. In order to also achieve a reduction in carbon emissions in conjunction with electricity supply and hence help achieve the goals for climate protection, demand for electrical energy must be reduced dramatically, for example, by using more efficient systems, such as:

- daylight and presence-controlled lighting systems and adapted intensity levels for lighting,
- more efficient drives,
- highly efficient lift systems,
- highly efficient IT systems (new and replacement systems),

as well as the use of control systems to monitor the functionality of electric loads.

If systems are equivalent, preference should be given to electric devices which use very little electricity when in operation or in standby mode. More information on today's standards for reducing energy consumption can be found in the test criteria of the German Blue Angel eco-label, for instance, and the GED energy saving label (German Energy Label Group). The use of electricity from renewable energy is another measure. At the time of requirements planning, it is particularly important that the user be informed of the schedule for operating hours and workplace design and trained in energy-saving behaviour.

User influence

When planning the technical preconditions for a comfortable room climate, user influence must always be taken into account (BNB 3.1.6) with a view to the operation and control of ventilation, sun protection, glare protection, room temperature as well as natural and artificial light in as far as this is compatible with central control of the technical systems. Surveys have shown that user satisfaction, and hence indirectly user performance, is closely related to the comfort implemented at the workplace and the user's ability to influence these factors.

Security

Another important aspect of building services is the equipment that enhances the user's subjective sense of safety and security. These include, for instance, additional safety and security systems and services, the presence of contact persons outside regular working hours or the illumination of the building and the property.

3.2.2 Heat insulation and protection against condensate

With a view to structural heat insulation in winter, the applicable requirements of the Energy Saving Ordinance for heat transfer coefficients should still outperform those of the reference building. The aim is to reduce heat demand for air conditioning in buildings while at the same time ensuring a high degree of thermal comfort and avoiding damage to the building. Furthermore, the quality of heat insulation and protection against condensate for the building envelope (BNB 4.1.2) must be reflected by requirements for the following properties:

- Component-based average heat transfer coefficient U [$\text{W}/(\text{m}^2 \cdot \text{K})$]
- Thermal heat bridge correction ΔU_{WB} [$\text{W}/(\text{m}^2 \cdot \text{K})$]
- Air permeance class (joint permeability)
- Condensate volume within the structure [kg/m^2]
- Air exchange n_{50} [h^{-1}] and, if applicable q_{50} [m/h]
- Solar radiation index S [-]

When it comes to determining the average heat transfer coefficient U , reference is made to the requirements in the Energy Target Specifications (Sample) regarding the energy quality of the building envelope (see Annex B4).

Effective sun protection primarily means the prevention of summer heat entering the building. Temperature balancing should preferably be ensured by night cooling without neglecting weather protection and security issues.

FEDERAL BUILDING The “Guideline on Construction and Planning Requirements for Building Measures by the Federal Government to Warrant Thermal Comfort in Summer” (“Climate Directive”, BMVBS 2008 a) must be considered. The building classification process should be given special consideration here.

3.2.3 Structural design, fire protection and sound insulation

Structural stability must be demonstrated at the time of the EW-Bau. Whenever possible, the load-bearing structure chosen should ensure maximum resource savings and durability and should include economically reasonable load-bearing reserves in order to enable

future conversion (BNB 2.2.2). Moreover, it should also reflect structural conditions, such as required heat storage capacity, acoustic insulation or fire behaviour. It must be possible to easily add, relocate or dismantle non-load bearing partition elements so that any conversion measures will have little or no effect on the operation of the building.

Depending on the type of building, the minimum requirements for the fire protection concept to be presented are laid down in the applicable state building regulations. The Fire Safety Guide¹⁸ from the Federal Building Ministry is another useful tool. It may be necessary to plan a fire protection level that goes beyond that of the statutory requirements, for instance, due to individual use requirements for certain rooms, components or building sections (higher property protection), because the minimum requirements for fire protection normally focus on safe evacuation of a building. More extensive fire protection concepts may be needed not only to protect human life, but also for stored documents, IT equipment and fixtures. These concept variants must be examined and compared from both an economic and ecological perspective. Examples of measures that go beyond the minimum requirements stipulated by the building authorities include:

- Avoiding the installation of substances/products that in a fire could lead to the development of toxic gases and heavy smoke or could cause the fire to spread quickly (due to burning drops of molten material, for example)
- Installation of automatic fire/smoke detectors or other alarm systems
- Installation of an automatic fire extinguishing system, such as an sprinkler system, in as far as this is not mandatory
- Creation of smaller fire and smoke zones
- Creation of enlarged cross-sections for smoke discharge
- Implementation of higher fire ratings

18 See BMVBS (2006)

Sound insulation

During the design phase, the calculated sound insulation is verified according to DIN 4109 and DIN 4109, supplement 2. This means that critical areas must be identified so that following completion, their sound insulation quality can be measured and checked. Furthermore, areas should be defined according to own use and external use while taking into account rooms that require special security and, if applicable, partial areas to be leased to third parties.

It must be noted that the most unfavourable points of a building (such as walls, ceilings, floors) are decisive for verification of sound insulation. The required sound insulation values must always be achieved by all the building parts so that the respective requirement level can be reached.

The assessment must include all exterior walls, partition walls and ceilings in common rooms designed for use for one hour or more, as well as in-room and nearby building services. Rooms with the same structural elements or building parts must be combined to form room types.

The following aspects must be verified:

- Insulation against outdoor airborne noise
- Insulation against airborne noise from other workrooms and within work areas (partition walls, partition ceilings, stairwell walls)
- Insulation against impact noise from other workrooms and within work areas (partition walls, partition ceilings, stairwell walls)
- Sound insulation of technical building services systems (water installation, other building services)

It must be noted that sound insulation verification must also be continued beyond the design phase. Checks of the verification documents as part of BNB conformity testing have shown that temporary changes in execution are not always immediately included in verification procedures.

3.3 Cost calculation

The aim of the cost calculation as contemplated in the Guideline for Sustainable Building is to minimise building-related costs in the life cycle (BNB 2.1.1). The building costs according to DIN 276-1¹⁹ for cost groups 300 (Building – structure), 400 (Building – services) and 500 (External facilities) can already be presented in detail in the design phase. Furthermore, all other cost groups according to DIN 276-1 must be listed and documented so that it is possible to check completeness and classification. When designing technical equipment for the building (heating, ventilation and air-cooling systems, sanitary installations, electrical systems and lighting), the recommendations by the Mechanical and Electrical Engineering Working Party of National, Regional and Local Authorities (AMEV – Arbeitskreis Maschinen- und Elektrotechnik staatlicher und kommunaler Verwaltungen) in particular must be adhered to with a view to maintenance costs and service life.

If the advantages or disadvantages of different, competing technical services cannot be identified without detailed investigation, the technical solutions are compared as follows:

- Economic variant comparison: investment, annual costs according to the annuity method, full-cost method, complete financial plan, net present value method (only if savings are to be expected)
- Energy and annual balance

Based on the comparison, the building authority recommends a preferred solution.

19 DIN 276-1: 2008-12

334 Außenkern und -fenster AUSSENWÄNDE
Nische [22861] BAUTEILKOMPONENTE

Fensterassistent Allgemein

Name *

Nische

Abmessungen

Fenstermaß Breite* m Höhe* m Fläche m²
3 1,25 3,75

Abschlussfuge mm Abzugsfläche m²
20 3,0216

Rahmenbreite Blendrahmen* cm Flügelrahmen cm
5 5

Anzahl Pfosten Riegel

3 0 Details

Breiten von links nach rechts 1. Breite % 2. Breite % 3. Breite %
20,0 50,0 20,0

Höhen von oben nach unten 1. Höhe % 2. Höhe % 3. Höhe %
20,0 50,0 20,0

Oberlicht vorhanden Höhe cm
Rahmenanteil % Glasanteil %
41,1 58,9

1 Anschlussfuge: Fugendichtungsbänder Butyl
2 Blendrahmen: Aluminium-Rahmenprofil, pulverbeschichtet
3 Flügelrahmen: Aluminium-Flügelrahmenprofil, pulverbeschichtet
4 Verglasung: Isolierglas 2-Scheiben



Users can rely on an integrated wizard when modelling more complex building components in eLCA

Verification of energy demand and the estimates for water demand allow the expected operating costs to be presented in greater detail. According to DIN 18960²⁰ (BNB 2.1.1), calculations must be made for the following types of use costs:

SELECTED TYPES OF USE COSTS

TABLE B2

Use costs to be calculated according to DIN 18960

Cost Category 300 Operating costs	KG 310	Utility costs (power/electricity, water)
	KG 320	Waste disposal
	KG 330	Cleaning and care of buildings
	KG 350	Operation, inspection and servicing
Cost Category 400 Repair costs	KG 410	Structural repair work
	KG 420	Repair of technical building services

Source: BBSR

Using the cash value method, the building costs and use costs (BNB 2.1.1) are put into relation according to a uniform calculation method and implied interest rates so that buildings costs can be put into relation with use costs and can also be allocated to BNB benchmarks. This approach provides building administrations with additional information regarding economic planning decisions.

3.4 Other important design aspects

3.4.1 Ecological aspects

Eco-balancing assessment

As soon as costs have been calculated, an ecological evaluation (LCA) is also possible in the design and approval planning phase because the IT-based evaluation programs are based on the corresponding principle of element catalogues.

The following global environmental impacts can be currently quantified:

- Global Warming Potential (BNB 1.1.1)
- Ozone Depletion Potential (BNB 1.1.2)
- Photochemical Ozone Creation Potential (BNB 1.1.3)
- Acidification Potential (BNB 1.1.4)
- Eutrophication Potential (BNB 1.1.5)

The following criterion serves as the standard for the energy-related consumption of resources:

- Primary Energy Demand (BNB 1.2.1)

In order to ensure standard-compliant mapping of the substances used within the scope of an eco-balance inspection, the consumption of abiotic resources must be calculated and shown as part of the BNB assessment.

Due to the heavy weighting of global environmental impacts and resource consumption in the BNB system as well as the criteria that are still difficult for the building administration to assess, a detailed (if possible) calculation is recommended with an examination of maintenance and replacement intervals. Incorrect assumptions can lead to serious deviations in the overall degree of fulfilment.

Risks to the local environment

It is already possible during the design phase to estimate risks to the local environment (BNB 1.1.6) by specifically selecting building materials and products. Based on the quality level defined during project preparation, different requirements must be considered for different building product groups, depending on which pollutants may be contained due to their different characteristics or constituent parts.

In order to assess which building products are capable of fulfilling the specific requirements of the project, the WECOBIS database with information on building materials can be used during the design phase. This database provides manufacturer-independent information on product groups within the context of BNB 1.1.6, also with reference, for instance, to the environmental labels that are accepted as verification.

Irrespective of the intended assessment result, it must be ensured at any rate that low-emission building products are used so that appropriate results can be achieved in indoor air measurements (see BNB 3.1.3) when the building is completed.

3.4.2 Economic efficiency and value stability

In addition to the economic procurement of a building, the economic efficiency of its operation is one of the most important factors for assessing its economic quality due to the long periods of observation. With a view to the future-orientated assessment, the stability of the value of a property is the second most important factor. These two factors are mapped by assessing the space efficiency as a standard for economic efficiency and the ability to adapt as a standard for value stability.

Space efficiency

Space efficiency is assessed within the scope of the BNB (BNB 2.2.1) and using the ratio between useable floor space and gross floor space and is hence a measure for calculating the utilisation of space within buildings. Space efficiency can be boosted through cost-related optimisation (such as reducing building and operating costs through efficient space distribution or the avoidance of areas that are difficult to use) and through environmental optimisation (such as reducing the environmental impacts of a property in operation or reducing sealing).

Adaptability

In order to secure the value stability of buildings, their economic use period should be fully utilised or sensibly extended. There may be a need to adapt a building during its life cycle in an effort to maintain its usability or to ensure that it can be rented out or marketed at a later point in time. The adaptability of a building is assessed within the scope of the BNB (BNB 2.2.2) on the basis of the building's adaptability to changing use needs and use conditions within one type of use (flexibility) and with a view to aspects that address the ability to adapt to alternative types of use due to a change in user, for instance. This means examining building geometry, layout, design and building services.

3.4.3 Socio-cultural and functional aspects

Comfort is evaluated on the basis of thermal comfort (BNB 3.1.1), indoor air quality (BNB 3.1.3), acoustic comfort (BNB 3.1.4) and visual comfort (BNB 3.1.5). User influence (BNB 3.1.6) is directly linked to performance and satisfaction as well as energy consumption that results from the user's actions.



Natural light creates a high level of visual comfort in the reading room of the German Federal Constitutional Court in Karlsruhe

Thermal comfort

In order to warrant thermal comfort in winter and summer (BNB 3.1.1), a first simulation for rooms identified as being critical should be carried out in the design phase on the basis of the current status of planning. If necessary, consideration should be given to mechanical heating or cooling in certain rooms, while taking into account the energy demand required for this.

FEDERAL BUILDING The Climate Directive is applicable to federal buildings (BMVBS 2008 a).

Acoustic comfort

The concept for acoustic comfort (BNB 3.1.4) is updated during the design phase. DIN 18041 is the basis for the acoustic room design. Permanently installed sound absorbers and their place of installation are selected, if necessary, during the further course of design. The result is a presentation of the calculated reverberation time cycles in the different octave bands for room types with longer (speaking) distances and offices. In the case of rooms with shorter distances, the A to V ratios between the sound absorption area A of the room and the room volume V are included in the assessment.

In view of the increasing number of thermally activated components in buildings, such as heating or cooling ceilings and walls, it is extremely important that acoustic measures be adapted to structural conditions. Simple retrofitting of sound absorbers in operation while taking ceiling heights, lighting solutions, air flows into account are now a considerable challenge for planners.

Visual comfort

Integrated planning of natural and artificial light at an early point in time using a simulation can already ensure in the design phase visual comfort (BNB 3.1.5) with high quality lighting combined with low energy demand for lighting. It has been demonstrated that a high level of natural lighting boosts performance and the ability to concentrate at the workplace. The following requirements must be taken into account when assessing sustainability:

- Availability of natural light at the workplace and throughout the building
- Visual contact with outdoors
- No-glare natural and artificial light
- Distribution of light
- Colour rendering

Different areas of activity are subject to different rules regarding required light intensity (AMEV "Lighting 2011" guideline²¹, Technical Rules for Workplaces, ASR).

FEDERAL BUILDING In the case of federal buildings, indoor lighting is also designed on the basis of the requirements laid down in the Energy Target Specifications (Sample), Annex B4. The BMUB decree "Energetic exemplary function of federal buildings – guidelines for the implementation of a modern and energy-efficient lighting" of 25 July 2013 also applies.

Barrier-free building

The barrier-free building concept drawn up as part of project preparation must be developed in more detail in the design phase, described using specific measures and outlined for planning. Information related to this can be found in the Guideline Accessibility in Building Design, which shows fields of action along with specific solutions and the corresponding standards and principles of labour protection law.

21 See Mechanical and Electrical Engineering Working Party of National, Regional and Local Authorities (AMEV 2011)

4. Final planning, contracting and construction

4.1 Final planning

As part of final planning, construction drawings and specifications with quantity calculations are drawn up in preparation of the invitation to tender and contract awarding. These are the parts of work phases 5 and 6 or comparable work phases of the specialist areas of the Official Scale of Fees for Services by Architects and Engineers (HOAI) which are required for the complete presentation of final planning. During this phase, audited structural stability calculations with structural analyses must be presented, along with the verifications required by the Energy Saving Ordinance, as well as sound insulation and fire protection verification documents. The most important definitions regarding the sustainability criteria were already laid down during project preparation and in the design and approval planning phase. The specifications made there must now be implemented in detail planning. This means that as part of final planning, the sustainability goals defined in the project preparation and in the design and approval planning phases must be once again be examined and adapted in the interest of ongoing quality assurance. In the event of changes in planning compared to the design and approval planning phase, the economic and ecological life cycle analyses must be urgently updated due to their importance in the BNB assessment.

FEDERAL BUILDING The cost framework laid down in the ES-Bau and the EW-Bau as approved and recognised under budget law is binding for final planning of federal building construction. If this cost framework is exceeded during the preparation of final planning, such increase must be approved and recognised under budget law in the procedure prescribed for the ES-Bau.

During the final planning phase, the targeted sustainability qualities must be described in as much detail as possible so that quality losses during tendering are kept to a minimum. There is only a limited possibility to exert influence in this phase.

4.2 Invitations to tender and contracting

The integration of aspects of sustainability in the execution of construction work must be warranted by integrating the aspects of sustainability into the invitation to tender and contracting of construction work (BNB 5.1.4). In this case, the sustainability criteria considered in design and planning are used as a basis for high quality performance of the works. Furthermore, it must be ensured during the invitation to tender and contracting phase that final planning is rigorously implemented. Depending on the type of tendering, the building administration must decide on how strongly aspects of sustainable building are to be taken into account in the tenders. Public invitations to tender primarily provide for the use of the common arrangement of work sections for building works. Neither the general preliminary remarks nor the individual items of the common arrangement of work sections address the special issues of sustainable building so that the individual items will have to be adapted. With a view to the awarding audit that must be carried out after the tender process, the current controversial debate regarding the correct time for the building product declaration must be included in the specifications. In particular, in the case of the strictest requirements in criterion 1.1.6, the bidder's declaration obligations must be at a point in time that is prior to installation of the products so that the release check by the sustainability co-ordinator or project management can take place at any time. Depending on the requirements, the declaration obligations can be brought forward to as early as contract awarding. This applies especially when, as part of further processing, the bidder has to procure building products at an early point in time on the market, and short-term replacement prior to installation is not possible.

4.2.1 Invitation to tender

Sustainable planning means that tender documents must be drawn up with a view to an environmentally responsible procurement policy and must include specific sustainability requirements (BNB 5.1.4). These requirements for principles of sustainability, such as

- durability,
- easy cleaning and maintenance-friendliness,
- requirements for health and eco-friendliness,
- environmental standards,
- use of tropical wood from certified sources,
- use of recycling materials,

must be described in the tender documents, specifications or in the technical specifications without reference to a specific product. If products with certain classifications are desired, this is only possible by adding “or an equivalent type”.

Environmental and health-related requirements

During the tender phase, suitable requirements in the specifications should especially ensure that the installation of materials or products with a potential toxic risk for the environment or humans can be avoided in as far as possible. The potential pollutants that must be addressed are as follows:

- Dangerous substances (CLP Regulation²²) and in particular substances of concern (REACH Regulation²³)
- Hazardous substances that can be leached
- Heavy metals
- Volatile organic compounds (VOCs) including organic solvents
- Halocarbon cooling and blowing agents
- Biocidal products (European Biocidal Products Ordinance²⁴)

Eco-labels can be used to specify requirements.²⁵ It must be possible for the bidder to prove that his product is equivalent to the environmental criteria in the tender documents using other means, such as test reports or information provided by the manufacturer. When drawing up the specifications, the construction products must hence be specified with a view to their use – based on the requirements from the standardised or approved ratings and classes – and in detail with a view to their environmental and health-related properties.

The test criteria of the following eco-labels among others can provide assistance when describing and selecting products:

- Blue Angel (German eco-label for eco-friendly products and services)
- EU Ecolabel (European eco-label for eco-friendly products and services)
- IBO test mark (Austrian building biology and building ecology test mark for building materials and interior furnishings)

Additional information is also available in the Planning and Tendering Tools section in the WECOBIS Information System on Ecological Building Materials (www.wecobis.de). Examples of text modules for creating work items can be found here which describe the requirements for building products as specified by the BNB (for instance, BNB 1.1.6 “Risks to the Local Environment”).

In order to ensure good room air, suitable verification of the emission behaviour of the building products to be installed must be submitted together with the bid. In this case, building products are evaluated according to the conditions for measuring room air applicable at the time of installation as stipulated in the Assessment System for Sustainable Building (BNB 3.1.3). Final planning must also pay particular attention to the description of the interior work materials and the impact of ancillary building materials on health and

22 CLP Regulation (Regulation on Classification, Labelling and Packaging of Substances and Mixtures, 2009)

23 REACH Regulation (Registration, Evaluation, Authorisation and Restriction of Chemicals, 2018)

24 See Biocidal Products Ordinance (2013): on 31 August 2013 this Ordinance replaced the Biocidal Products Directive

25 See EU (2001)

safety. Annex B8 lists indoor air pollutants and their sources, which may be caused by building products and building systems. The scope of confirmation testing, such as chamber measurements or room air measurements, must also be listed in a suitable manner in the tender documents. In some cases, setting up a sample room must be taken into account in the tender documents in order to ensure that the quality level target is reached. This makes it possible to obtain initial basic indoor room measurements during the construction phase so that any measures that may be necessary can be initiated.

If the targeted use of recycling materials is to be supported by the project goals or by higher-level specifications, this must be marked accordingly in the tender documents or honoured in contract awarding. Depending on the place of installation and the material to be substituted, specific requirements must be stipulated for each specific item. These requirements must also take into account the requirements contained in the standards and approvals, as well as in pollutant law.

When materials or products are to be reused, it is particularly necessary to ensure their properties. This can be of a structural, structure-physical or hygienic nature. When using recycled wood, for instance, one issue that must be examined is the use of chemical wood preservatives. When old parquet flooring is used, the matter of PAHs²⁶ in parquet glue must be identified, or when pre-cast concrete parts from existing buildings are used, the degree of carbonation must be determined.

4.2.2 Contract awarding

The purpose of giving additional consideration to higher-level aspects of sustainability in contract awarding is to make it possible to evaluate the expected quality of the building that goes beyond the planned minimum standards on the basis of clear-cut assessment criteria. Clear-cut, applicable assessment criteria can be an incentive for the bidder to submit a corresponding bid. The permissibility of assessment criteria in relation to the estimated contract sums is decided in close co-operation with the contract awarding departments in charge. The assessment of product-related environmental properties in conjunction with the avoidance of environmental impacts during building operation as well as life cycle-orientated contract awarding rules are listed as examples.

One prerequisite for correct and hence high quality construction is the awarding of contracts exclusively to companies that have demonstrated their suitability in terms of reliability, expertise and performance pursuant to the “General Provisions Relating to the Award of Construction Contracts”, Part A (VOB/A). Contract awarding offices must examine the suitability of construction companies in each case. Pre-qualified companies do not have to be checked because they have already been checked within the scope of the pre-qualification procedure (PQ VOB/PQ list).

26 PAHs: polycyclic aromatic hydrocarbons

4.3 Construction process

The construction or building processes (BNB 5.2.1) must also be defined in order to protect resources and the environment by selecting the processes (for instance, digging the construction pit) and building machines available. At the same time, the health of all stakeholders must be protected.

According to the Federal Immission Control Act²⁷, each construction site should be planned, set up and operated in such a manner so as to avoid noise that can be avoided according to the latest state of the art. Precautions must be taken in order to minimise unavoidable noise from the construction site. The avoidance of dust on the construction site can significantly help to protect workers on site and other persons. Furthermore, the environment must be protected against damage caused by substances. Soil, vegetation and groundwater must be protected against harmful contamination and mechanical damage.

Construction planning and execution must meet the requirements of the Closed Substance Cycle Act. The aim is to protect natural resources, avoid waste, and achieve the high quality, correct and safe reuse of unavoidable waste in as far as possible, as well as to dispose of non-reusable waste in a manner that serves the public good. In addition to the quality of production site planning, the interest of sustainable planning requires that the planned sustainability criteria also be implemented and checked (for instance, by a safety co-ordinator) during the construction process.

In order to avoid defects or damage to the building, comprehensive quality checks must be carried out during the building process and following completion of the building (BNB 5.2.2). The materials and building products used must be precisely documented using safety data sheets and product descriptions.

27 See BImSchG (2015)

5. Commissioning and as-built documentation

At the time of handover, responsibility for the building passes to the project sponsor (owner). After this, the building is handed over to the user/tenant. Comprehensive documentation of the measures carried out is one of the key tasks of the planning process. Extensive documentation of the property (BNB 5.1.5) helps to simplify the future processes in the life cycle of a building.

B 5 **FEDERAL BUILDING** Commissioning and as-built documentation are described in detail in the RBBau Guidelines, Section H. The “Building-related Guidelines for Documentation of Existing Buildings”²⁸ and the “Building-related Guidelines for Surveying”²⁹ contain supplementary rules.

Once a building measure has been completed, digital documentation of existing buildings (**FEDERAL BUILDING** according to the RBBau Guidelines, Section H) describes the condition actually built and forms the basis for the digital updating of the building stock. It contains the CAD documentation with the digital structural and technical as-built drawings along with alphanumerical structural and technical description data of the schedule of rooms and buildings (**FEDERAL BUILDING** commissioning at least according to the standard scope of data stipulated in the “Building-related Guidelines for Documentation of Existing Buildings” (BFR GBestand)). A schedule for existing rooms and buildings provides the user/project sponsor (owner)/operator of the building with information regarding the building which is relevant for his area. This is designed to ensure that both users and operators use the building and its features made available to them in a correct manner.

FEDERAL BUILDING In the case of federal buildings, projects with BNB assessment must be managed basically with a view to the verifications to be provided and the documentation requirements in the eBNB because future conformity checks will be carried out within the eBNB.

With a view to sustainability, the project sponsor (owner), operator, user and building authority can also agree to other documents (outside the scope of HOAI basic services) in terms of scope and form. Costs that exceed the basic services must be taken into account as part of project organisation. This includes, for instance, additional overviews of the materials and building products to be used as well as submission of safety data sheets and product descriptions (BNB 5.2.2). The documentation of the materials used or installed during construction, which at times is already part of the documents and verifications to be furnished by contractors according to the “General Technical Terms and Conditions for Construction Work” (Allgemeine Technische Vertragsbedingungen für Bauleitungen), is of paramount importance for the future phases of the life cycle. Especially in the case of conversion or demolition projects, detailed information is vital regarding the materials and ancillary materials used in construction. The safety data sheets contain important information regarding the identity of a product, risks, safe handling and prevention measures, as well as incidents. The definition of safety data sheets is as stipulated in the relevant EU directive³⁰. These data sheets must be collected by a previously named institution (firm, service provider). The basic material information and, in particular, the documentation of the quantities installed will also provide a good basis for the future handling of the related resources integrated into the buildings. This information and documentation can serve as a basis for future urban mining concepts.

Complete documentation of the building-related maintenance, service and operating manuals is an important precondition for efficient operation of the building and can hence have a positive impact on building-related costs in the life cycle. Furthermore, updated calculations regarding the execution process can be used to confirm a desirable target state in design and planning. These documents form an important basis for any future modernisation or renovation work in a later phase of the life cycle.

²⁸ See BFR GBestand (2012)

²⁹ See BFR Verm (2018)

³⁰ REACH-Regulation (2018), Art. 31

As part of this Guideline, the guidelines referred to above for documentation of existing buildings are supplemented by the BNB “Examination Document” or the digital verification obligations in the eBNB. In addition to providing documentation of purely structural and technical properties according to the RBBau Guidelines, they also compile the verifications and calculations (such as LCC and LCA calculations, user manual, results from indoor acoustic and air measurements) that result from the individual criteria of the BNB.

Measurements as verification of quantitative evaluation according to the BNB

Quality assurance of building construction (BNB 5.2.2) can be demonstrated using various measurement methods and should be included in the as-built documentation at the time of commissioning. The aim of these measurement and analysis methods is to check and document whether target values have been reached. The following measures are recommended as part of general structural quality assurance:

- Methods for controlling the energy-related quality of a building (such as an air-tightness test, thermography)
- Building and room acoustic measurements (such as testing airborne sound, footfall sound, reverberation time)
- Other measurements (such as measuring room air, natural light and artificial light)

In order to ensure and document indoor air quality, indoor air must always be measured at least one day before furnishing begins. The results of these measurements must at least comply with the Indoor Air Quality criterion (BNB 3.1.3). If the results of measurements cast doubt on the permanent use of the building for reasons of hygiene, measures must be taken to improve the quality of indoor air.



Measuring the airtightness of the Federal Environment Agency's Haus 2019 building with the differential pressure measurement method

If ventilation systems are used, the exterior air volume flows must be measured in the respective room types before commissioning. The systems must generally undergo microbiological testing; purely visual inspection of the ventilation systems is not sufficient. During acceptance testing, the requirements of VDI 4300, Sheet 10, must be taken into account.

In order to assess acoustic comfort (BNB 3.1.4) after completion of the building, the reverberation time can be measured instead of verifying calculations according to the criteria profile.

6. Optimising operations

Part C (Recommendations for Sustainable Use and Operation of Buildings) contains detailed information regarding optimisation of building operations. The Use and Operation BNB module is a useful tool for optimising use and operation processes. With this module, sustainability assessments can be performed during the use phase and then used to specifically record, influence and steer the quality of processes and the building.

Controlled commissioning is essential in order to achieve the best-possible operation of the building as soon as use begins and can help to ensure long-term and efficient functioning of building services. Another precondition for environment-friendly and economical building operations is the possibility to record and analyse measurements of energy and media flows, so that weaknesses can be identified and eliminated. For this purpose, a measuring/metering and monitoring concept is required in order to enable comprehensive and, if possible, differentiated energy management during the use phase. The monitoring services must be awarded in due time in order to enable an early co-ordination process and smooth monitoring at the time the building is commissioned.

6.1 Controlled commissioning

Controlled commissioning (BNB 5.2.3) is essential for optimising the functionality of building equipment. The individual components of building services are co-ordinated and adjusted to operate together following acceptance. A concept for adjustment and re-adjustment is required for controlled commissioning. After this, the system can be re-adjusted once again after around one year as part of optimising operations. Since this work is not a standard service, it must be contractually specified and performed and documented by specially qualified staff or contractors. In addition to verification of adjustment, this documentation must also include the main settings for the system so that any incorrect changes, for example, by the user, can be reversed.

6.2 Management of energy and water consumption

The basic goal of energy and water consumption management (see also Part C, section 3.2.3.1 or BNB_BB 5.3.2) is to monitor and minimise energy and water consumption during the use phase. This requires systematic recording of all consumption values and their analysis in order to identify excessive consumption and other irregularities. The purpose of this is to detect malfunctions, identify potential for savings and to develop possible solutions in order to lower energy and water consumption. As part of monitoring, energy and water consumption is hence periodically recorded and analysed. The analysis particularly focuses on comparing the results with consumption from previous periods.

The quality of energy and water consumption management is determined by the following sub-aspects:

- Recording (monitoring) and analysis of energy and water consumption
- Initiating measures in response to demand and circumstances

Through ongoing monitoring of performance and consumption accompanied by repeated analyses of use and operation data by the owner/operator and user, consumption and therefore both costs and environmental impacts can be optimised and at best reduced during the use phase. Informing users of the effect of certain measures on sustainability is also very important here. The preconditions for measurements and metering must already be included in the design (see section 2.4.1).

The technical concepts for technical building systems required in this context are laid down in the Energy Target Specifications (Sample), section 2, "Requirements for Technical Concepts" (see Annex B4) and must be observed in the design.

FEDERAL BUILDING The consumption values and operating costs must be reported to Landesbetrieb Vermögen und Bau Baden-Württemberg pursuant to the provisions of Section K6 of the RBBau Guidelines. The RBBau Guidelines template must be used for reporting. This ensures that the data can be reused in PLAKODA.



Part C

Recommendations for the Sustainable Use and Operation of Buildings

Part C – Recommendations for the Sustainable Use and Operation of Buildings

1.	Sustainable use and operation91	4.	Consideration of sustainability criteria during the use phase 121
2.	Stakeholders during the use phase.....92	4.1	Databases and DP tools..... 121
3.	Criteria for sustainable use and operation.....94	4.2	Sustainability assessment in the use phase 121
3.1	Overview of process and property qualities during the use phase.....94	4.3	Assessment of existing buildings with the Use and Operation BNB module 122
3.2	Description and assessment of the property and process qualities during the use phase.....95	4.3.1	System rules and methodology..... 124
3.2.1	Operating concept.....95	4.3.2	Assessment motives 125
3.2.2	Operation costs controlling.....97	4.3.3	Overall assessment and partial assessment 125
3.2.3	Energy and water consumption99	4.3.4	Quality management to secure sustainable process and building qualities..... 125
3.2.3.1	Management of energy and water consumption 100	4.3.4.1	Cases of application 126
3.2.3.2	Energy consumption 102	4.3.4.2	Application of the BNB module..... 127
3.2.3.3	Drinking water consumption..... 103	4.4	Assessment of new building stock as a special case..... 128
3.2.3.4	Greenhouse gas emissions due to heating and electric energy consumption 104	4.4.1	Continuation of the conformity-tested assessment of the planning and construction phase 128
3.2.4	Building documentation throughout the life cycle..... 107	4.4.2	First-time assessment of new building stock 129
3.2.5	Inspection, servicing and safety precaution 108	4.5	Preparation of a measure to cover an identified demand..... 129
3.2.5.1	Inspection and servicing..... 108	4.6	BNB sustainability coordination in the use phase 130
3.2.5.2	Safety precautions 110		
3.2.5.3	Building maintenance 111		
3.2.6	Eco-friendly and health-safe cleaning 112		
3.2.7	Technical operations management and qualification of technical staff..... 112		
3.2.8	Building users – information, motivation and satisfaction 113		
3.2.8.1	Influencing user behaviour 114		
3.2.8.2	User satisfaction management and user satisfaction 116		
3.2.9	Actual air climate quality..... 118		
3.2.10	Reporting obligations..... 120		
3.2.10.1	Operator's sustainability report 120		
3.2.10.2	Reporting in preparation of a BNB assessment..... 120		

1. Sustainable use and operation

The principles, protected assets and protection goals which were laid down during the design and planning phase for new buildings or complete refurbishment and conversion measures (see Part A, section 3) also apply in principle to the use phase. During the use phase, however, the focus is on the building's actual properties and characteristics as well as the quality of the management processes; the description, assessment and targeted influencing of planned features are of secondary importance in this phase.

The parameters that influence the actual features and properties are diverse in nature. These include the actual structural and technical condition achieved as well as the type and scope of its preservation and its ongoing improvement. Contrary to the planning and construction phase, which is characterised by target values, assumptions and goals, the actual climate and other real external factors are what influence the building during the use phase. Building operations are also characterised by the actual type of operation and use and hence by real operator and user behaviour. These are the most influential factors during the use phase. User behaviour not only includes the direct behaviour of users and visitors, but also the use processes of the institution using the building. Operator behaviour refers to the behaviour of all those involved either directly or indirectly in the operation of the building. However, the quality of the management and decision processes of the owner or of third parties appointed by the owner (for example, operator) is particularly important.

Extensive data can be collected during the use phase. These data provide an insight into the actual features and properties of the building. For this purpose, data must be collected regarding the actual use of resources, the specific impacts on the global and local environment, operation costs, actual user satisfaction and the resultant conditions in the building (like air quality). By collecting and analysing these data, it is possible to describe, assess and document to a large extent how much a building and its use actually contribute to sustainable development.

However, the sustainability assessment is much more than just an assessment of building quality during the use phase. Another important part of this assessment involves analysing and assessing the type, scope and quality of the management processes that accompany use and operation. Sustainability assessments performed during the use phase make it possible to specifically record, influence and steer the quality of processes and the building.

A sustainability assessment can be carried out at any particular point in time. This can be used either for permanent controlling or for first-time or follow-up assessment of a building, or in preparation of refurbishment or conversion planning. The assessment can also be used as a quality control tool following completion of new construction, refurbishment or conversion measures (also in order to enforce warranty claims) and following changes to the type of operation. In the case of public-private partnership (PPP) projects, as with all other projects, the sustainability assessment can be used to actively report on building behaviour and the quality of processes and hence to check compliance with the agreed features, properties and parameters.

The specific evaluation of both the building qualities, as well as the use and management processes, can help to provide recommendations, characteristics and benchmarks for future planning and use phases. There is a direct correlation between the sustainability assessment of the use and operation of a single building and the portfolio analysis and preparation of various reports, such as sustainability reports, energy, greenhouse gas or environmental reports as well as reports on corporate social responsibility.

2. Stakeholders during the use phase

The extent to which buildings can contribute to sustainable development during the use phase is determined both by the features and properties that result from planning and implementation as well as the given climatic and other boundary conditions. In particular, the behaviour, of those stakeholders involved in use and operation influences the building's contribution. The type and scope of this influence results, among other things, from the respective area of responsibility and the options available to the relevant stakeholders to act and exert influence, as explained in greater detail below.

Operator

The operator is the public authority or body which is responsible for the operation and maintenance of the building (building management). The operator can also be the owner of the building. The operator is responsible for all building management processes and hence also for compliance with the recommendations of Part C of the Guideline for Sustainable Building.

FEDERAL BUILDING For pursuant to the provisions of Sections C (building maintenance) and K15 (operations management) of the RBBau Guidelines, this is the task of the office managing the building. The operator is supported by the building authority and the operational monitoring service according to the RBBau Guidelines. The building authority is responsible for proper repair if an order has been placed to implement consumptive measures pursuant to Section C of the RBBau Guidelines. This includes measures to maintain buildings, including technical building equipment and outdoor facilities. Scheduled servicing and inspection do not form part of building maintenance nor does preparation work which becomes necessary due to a new function (see Section C of the RBBau Guidelines).

Commissioned third parties

The operator can fully or partially assign the tasks of building management to third parties. However, this does not release the operator from its obligation to implement the requirements of the Guideline for Sustainable Building. The operator is required at all times to employ suitable means to ensure that these requirements are met. Third parties who have been commissioned with building management must also implement the requirements of the Guideline for Sustainable Building while advising and supporting the operator with regard to compliance with requirements.

Using authority (body or public authority using the building)

The using authority is the body or public authority using the building. Both the building and its management processes must meet the user's needs and must be aligned to its activities and services. Environmental management is increasingly shifting into the line of focus at public and private institutions according to their responsibility and the growing public interest in environmental protection issues. In addition to sustainable building, the sustainable use and operation of buildings is a key component of successful environmental management.

The using authority can hence demand sustainable building management from the operator because this is the only way in which this authority can meet with its own requirements in terms of environmental management. Operators or third parties commissioned by them are required to report to the institution or agency using the building or its central representation. With environmental management, the respective institution can ensure the environmental compatibility of its services, products and operation processes as a contribution to sustainable development. Moreover, environmental management also enables the transparent demonstration of efforts in the field of sustainable environmental protection.

Users

Within the scope of this Guideline, the direct users of the building are the authority staff working in the building. In the case of buildings that are open to the public and which are heavily frequented, visitors are also considered to be users who avail themselves of the services provided by the authority using the building. Both groups are jointly referred to as users in this Guideline. In case of educational buildings, the term “users” includes the pupils, students, trainees or seminar participants as well as teaching staff (such as teachers, professors, lecturers) and any office staff, for example, in the administrative departments.

Operational monitoring service

The operational monitoring service examines operations management by the operator with a view to its application and compliance with the principles of operations management. Furthermore, the service assists the operator with expert advice. The purpose here is to ensure efficient building operations.

BNB sustainability coordinator

It is the task of the operator to check the building management processes for compliance with the Guideline for Sustainable Building, to coordinate sustainability in the use phase and to perform sustainability assessments. The operator assigns these tasks normally to a BNB sustainability coordinator.

FEDERAL BUILDING For federal buildings, the sustainability coordinator is supported by the authority using the building, the building realisation level and the operational monitoring service within the scope of their tasks pursuant to the RBBau Guidelines.

Responsibilities, tasks and areas of responsibility on the part of stakeholders in the use and operation of the building (operator, facility management company, users or administration) are laid down in numerous regulations and specifications and are also partially defined by the RBBau Guidelines. Part C of the Guideline for Sustainable Building contains recommendations that supplement the existing regulations and specifications with a view to securing sustainable use and management processes. Irrespective of the recommendations laid down in this Guideline, the provisions of



Perennial monitoring of the new building of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

the RBBau Guidelines and other binding regulations and specifications that apply to the use phase remain in effect, especially with a view to responsibilities and workflows.

FEDERAL BUILDING When applying this Guideline to the use and operation of federal government buildings, compliance with the rules of the RBBau is automatically a precondition for compliance with the requirements of the Guideline for Sustainable Building. One example is reporting of consumption rates pursuant to Section K6 of the RBBau Guidelines. Their relevance for sustainability is explained in section 3.2.10 “Reporting obligations”. The provisions of the RBBau Guidelines must be adhered to in order to ensure the necessary process quality for sustainable building management. The following guidelines, guides and tools must be mentioned here:

- Building-related Guidelines for Documentation of Existing Buildings (BFR GBestand – Baufachliche Richtlinien Gebäudebestandsdokumentation)
- Guideline for Monitoring the Safety Precaution of Federal Government Buildings and Structures (RÜV – Richtlinien für die Überwachung der Verkehrssicherheit von baulichen Anlagen des Bundes)
- Fire Safety Guide for Federal Government Buildings
- Guidelines for Recycling

3. Criteria for sustainable use and operation

C3

The use and operation of a building are normally the longest phase in the life cycle of a building. The use and operation phase (collectively referred to here as the use phase) is typically also the phase with the strongest economic and ecological impacts. This is the phase during which socio-cultural and functional aspects come to bear. That's why the assessment of sustainability is so important during the use phase. When the operating and use parameters of a building are regularly checked, the use and management processes can then be optimised in order to operate the building in a more efficient and environmentally friendly manner and perhaps even at less cost. At the same time, it is possible to improve functional quality and maintain or continuously improve user satisfaction.

Furthermore, use and management parameters that have been identified and documented can, when needed, be used for a comprehensive diagnosis of the building. This diagnosis can then be used as a basis for refurbishment, conversion or remodelling decisions and planning.

3.1 Overview of process and property qualities during the use phase

The most important tasks of the operator include defining the goals to be achieved in the management process as well as the regular examination of the potential for optimisation possible within the scope of the services to be provided.

These services are generally covered by the term "building management" and, pursuant to DIN 32736:2000-08 "Building Management - Definitions and scope of services", include technical, infrastructural and commercial building management. The information needed to exploit the possibilities for improvement along with reporting to the owner can be primarily generated using a Computer Aided Facility Management system (CAFM system).¹

Process and property qualities must be examined, assessed and recorded during the use phase. The use phase contains a host of complex processes that involve numerous stakeholders. In order to ensure that the economic, ecological and socio-cultural factors are sufficiently addressed, a comprehensive quality management system is required to manage the building. This is the reason why the Use and Operation BNB module of the federal government's Assessment System for Sustainable Building must be used during the use phase. Using this BNB module, the following process qualities are examined, assessed and documented during the use phase in order to achieve sustainable use and operation in as far as possible.

Criteria group: "Process quality of use and operation"

- User Satisfaction Management (BNB_BB 5.3.1)
- Management of Energy and Water Consumption (BNB_BB 5.3.2)
- Operation Costs Controlling (BNB_BB 5.3.3)
- Inspection, Servicing and Safety Precaution (BNB_BB 5.3.4)
- Eco-friendly and Health-safe Cleaning (BNB_BB 5.3.5)
- Technical Operations Management and Qualification of Technical Staff (BNB_BB 5.3.6)
- Property Documentation during the Life Cycle (BNB_BB 5.3.7)
- User Information and Motivation (BNB_BB 5.3.8)

The actual property qualities must also undergo regular examination and assessment. In this case, it is necessary to analyse and assess how the building actually behaves in day-to-day operations under real use conditions. Requirements for checking property qualities have been integrated into the Use and Operation BNB module in order to enable a uniform and comparable assessment.

¹ See Eser (2009), p. 36

In this case, the actual property quality of the building is examined which results from sustainability-oriented design and planning, erection, use and operation. However, the examination of property quality can also be carried out as part of a comprehensive diagnosis of an existing building.

The Use and Operation BNB module must be regularly used in order to examine and document an exemplary selection of actual property qualities. This is carried out as part of the “real qualities” criteria group.

Criteria group: “Real qualities”

- Greenhouse Gas Emissions due to Heating/ Electric Energy Consumption (BNB_BB 1.1.1)
- Energy Consumption (final energy) due to Heating/ Electric Energy Consumption (BNB_BB 1.2.1)
- Drinking Water Consumption (BNB_BB 1.2.3)
- Actual Thermal Comfort in Winter (BNB_BB 3.1.1)
- Actual Thermal Comfort in Summer (BNB_BB 3.1.2)
- Actual Indoor Air Quality (BNB_BB 3.1.3)
- Actual User Satisfaction (BNB_BB 3.1.9)

In the case of a new construction, or a complete refurbishment, conversion or conversion measure, an assessment must be carried out for the first time three years after commissioning.

Annex C1 provides an overview of the minimum requirements for achieving sustainable building operations. Furthermore, recommendations in view of sensible improvements in quality are also provided.

3.2 Description and assessment of the property and process qualities during the use phase

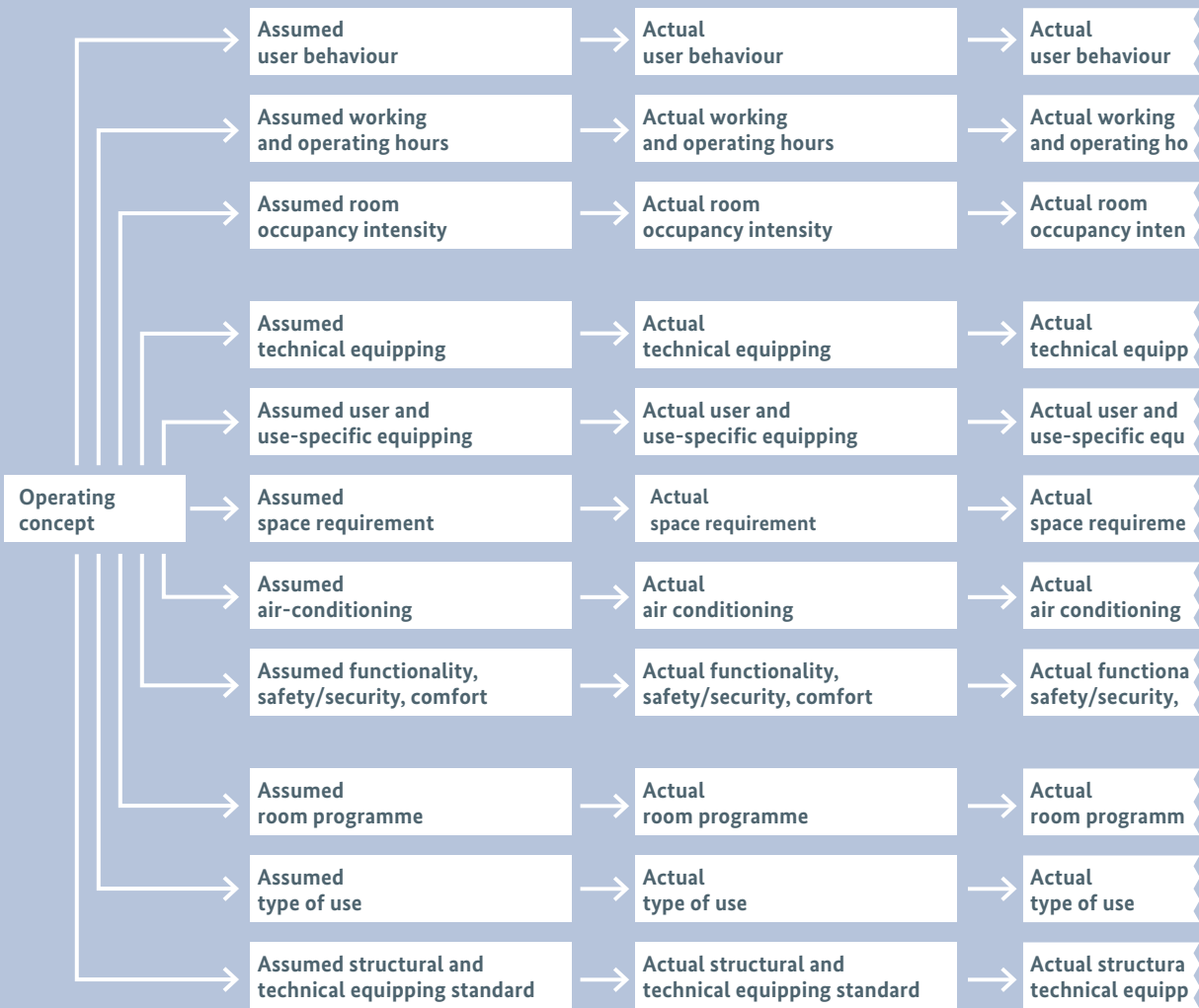
3.2.1 Operating concept

At the beginning of the planning and construction process, in other words, during the requirements planning phase, a comprehensive operating concept must already be drawn up for all of the individual activities to be carried out in a building. The operating concept must be continuously updated and adapted during the use phase. If no operating concept is available, this must be drawn up for the first time. The operating concept must define both the measures to be performed in order to achieve the required service levels as well as the requirements for reporting. In order to ensure good process and property quality, it is vital that an operating concept be drawn up. An operating concept shows the actual condition of the building and its management in relation to the user or owner requirements.

The operating concept must be geared to the type and scope of building use, although this can develop or change during the use phase of a building. In some cases, the forecast or planned building use, which served as a basis for design and planning during requirements planning or in the planning phase of a building, can differ from the actual resultant building use at the beginning of the use phase. As part of sustainable building management, the actual building use must hence be regularly examined and the operating concept adapted accordingly. The following factors of building use are relevant:

- Actual type of use
- Current space programme
- Actual room occupancy
- Actual working and operating hours
- Current user demand for functionality, security/ safety, comfort
- Current structural and technical equipping standard
- Current user behaviour
- Current user and use-specific equipping

ASPECTS OF THE USE AND MANAGEMENT ANALYSIS
FIGURE C1



Source: BBSR

Use and management analysis

Actual building use must be regularly examined as part of a comprehensive analysis (use and management analysis, see figure C1), and the operating concept must be adapted accordingly. The use and management analysis is an important task for the authority using the building because it can be used to exploit possible optimisation potential. The use and management analysis is a precondition for both successful operation costs controlling (see section 3.2.2) and energy management (see section 3.2.3.1). Minimum requirements and recommendations can be found in Annex C1.

The operator is required to support the authority using the building during its use and management analysis. The results of the use and management analysis, along with all relevant information regarding actual building use, must be made available to the operator. This information includes immediate notification of changed factors and boundary conditions related to building use as shown in the list contained in Annex C1.

3.2.2 Operation costs controlling

Operation costs as used in this Guideline refer to operating and repair costs. Operating and repair costs (cost categories 300 and 400 according to DIN 18960) and their share in operation costs have a key role to play in life cycle costs and hence in the economic quality of buildings. Planning, recording and analysing operating and repair costs on the basis of a uniform method makes it possible to identify potential cost savings and provides an indication of improvement possibilities. As part of operating and repair cost controlling (Operation Costs Controlling, BNB_BB 5.3.3), the costs actually incurred must be compared to the cost targets set by the operator for the specific building. If the cost targets are exceeded, the reasons for this development must be identified and analysed so that either potential for optimisation can be found or the cost targets can be adjusted as required. Following this, suitable measures to control costs must be introduced. The aim of operation costs controlling is to reduce the operation costs, in other words, to identify and exploit potential savings. In addition to a suitable organisation and workflow to record and analyse actual costs according to type of costs and cost centres, functional cost control calls for the creation and analysis of time series and the comparison of benchmarks.

The quality of cost controlling is determined by the following sub-aspects:

- **Planning operation costs:**
Frequency and degree of detail
- **Recording and analysing operating and repair costs:** Frequency, scope and degree of detail
- **Operation costs analysis and measures programme:** Availability, quality and implementation

Operating and repair must be recorded and broken down according to DIN 18960. The controlling of operating and repair costs must at least include cost categories 310 to 350 and 410 to 440 according to DIN 18960. As a minimum, the breakdown must comply with the level of breakdown shown in Annex C2. Costs in conjunction with replacement investments (complete exchange and replacement of building parts/components) must be separately recorded in cost controlling. Target values or budget planning for building realisation level and repair costs can be drawn up with a reference to information from maintenance and full service contracts. It is recommended that bids already be requested for these contracts during the design and planning phase.

FEDERAL BUILDING According to the RBBau Guidelines, other stakeholders are also involved in sub-tasks of cost controlling. With a view to this, the advisory services of the building authority (building realisation level) can be named when identifying the costs for building repair. The tasks of the building authority are laid down in Section C of the RBBau Guidelines. The tasks of the operational monitoring service are laid down in Section K 15 of the RBBau Guidelines. The operator is responsible for cost controlling.

Planning operation costs

Operation costs planning includes planning operating and repair costs as well as reporting. As part of operation costs planning, cost targets must be set for the budget year ahead. These are then used later to assess the operating and repair costs actually incurred. Operation costs planning must be carried out periodically (every twelve months) and must be broken down to the minimum degree of detail shown in Annex C2. Ideally, the costs should be broken down throughout to the 3rd level in accordance with DIN 18960.

When deciding on the target values for the property-specific and location-specific operating costs, the current and the foreseeable boundary conditions must be taken into account, such as:

- Type and scope of use
- Definitions and standards regarding user comfort (for example, operative temperature in summer)
- Results from the analysis of previous cost records
- Calculations based on the operation concept that forms the basis for building management (for example, identification of energy costs after optimisation measures have been implemented)
- Orientation and best values which were achieved with the management of exemplary, comparable buildings (best practice)
- Local rates for energy and services

In order to determine repair costs according to cost category 400 of DIN 18960, all the necessary work must be carefully identified. Repair costs are planned on the basis of the construction requirement determined as a result of the current condition of the building. In order to identify the condition of the building and the necessary repair work, the building must be periodically inspected (**FEDERAL BUILDING** see Section C of the RBBau).

Operating costs planning must include target values for utility costs. The procedure to be used here is described in section 3.2.3.1 “Management of energy and water consumption”. Target values for other operating cost categories (cost category 300 according to DIN 18960) can be identified, for instance, on the basis of the contract awarding results or existing contracts with service providers (for example, building cleaning or servicing and inspection work).

The operator is responsible for compiling the complete operation costs planning according to the above rules. The operator is required to document operation costs planning in a report. Section 3.2.10 “Reporting obligations” contains information concerning the distribution and minimum contents of the report.

Recording and analysing actual operating and repair costs

Actual operating and repair costs must be periodically recorded, analysed and documented as part of reporting. Cost recording requires a cost recording concept that contains the costs to be recorded, as well as responsibilities, information flow and the infrastructure required to identify and document operating and repair costs. This also includes the applicable rules for compiling at a central point the cost information that is often supplied by various stakeholders. The operator is responsible for drawing up the cost recording concept.

As part of cost controlling, operating and repair costs according to cost categories 310 to 350 and 410 to 440 of DIN 18960 must be recorded and analysed periodically. Recording and analysis must be carried out regularly, at least once a year, and should have the minimum degree of detail as shown in Annex C2. Regular recording and analysis every three months is recommended. The core element of the cost analysis is the comparison of actual and planned costs. Irregularities and deviations from benchmarks must be identified on the basis of examinations of absolute amounts and cost structure (shares of fixed and variable costs, identification of main cost drivers, and so on). When necessary, costs must be adjusted with a view to impacts which were not foreseeable when operation costs were planned, such as price developments, weather or special conditions resulting from use/operation.

The operator is responsible for recording and analysing actual operating and repair costs. The operator is required to document the results in a report. Section 3.2.10 “Reporting obligations” contains information concerning the distribution and minimum contents of the report.

Operation costs analysis and the measures programme

The operating and repair costs identified must undergo an operation costs analysis which involves a root-cause analysis and a general analysis of the operation costs.

Root-cause analysis in the case of benchmark violations

If target values in operation costs planning are violated or in the case of other irregularities identified during recording, the operator is required to find the underlying cause. The causes identified must be considered in a measures programme which should eliminate the reasons for the higher operation costs.

Operation costs analysis

A operation costs analysis must be carried out periodically for the operating and repair costs, and the parameters that must be reported must be identified. This must be carried out even if there are no signs of deviations from the planned figures or of potential savings. The analysis must be basically carried out every three years and following major structural or organisational changes.

The operation costs analysis generally examines the aspects below.

- Whether structural or technical potential exists to reduce operating costs (with a distinction between investment measures and low-investment improvement measures)
- Whether the operating concept is being implemented correctly
- Whether differences exist between the operating concept and actual building use (see section 3.2.1)

Measures programme

The measures programme involves the planning, assessment and monitoring of the success of measures which aim to reduce operating and repair costs. Measures must be generally implemented if a measure offers apparent economic benefits or if the economic benefits can be demonstrated in a profitability analysis that takes qualitative assessment methods into consideration (such as a benefit analysis).

The operator is responsible for identifying the reasons behind why target values have not been reached or other irregularities found, as well as for the operation costs analysis and the measures programme supported by the building authority and the operational monitoring service. When it comes to identifying actual building use as part of the use and management analysis, the operator is supported by the authority using the building.

Each year, the operator drafts a report documenting the results of the operation costs analysis and, if applicable, the root-cause analysis and the measures programme. Section 3.2.10 “Reporting obligations” contains information concerning the distribution and minimum contents of the report.

3.2.3 Energy and water consumption

Energy and water consumption is extremely important because it has a considerable impact on the economic and ecological quality of the use phase. The operator must hence focus on monitoring and optimising energy and water consumption. The quality of this monitoring is determined by much more than just the consumption rates. The only way to ensure that the best possible consumption rates can be or have been reached is by gearing the use and management processes to a sufficient degree to monitoring and optimising energy and water consumption. This means that during the use phase the actual building qualities must be examined on the basis of consumption rates while management of energy and water consumption must be established in the management process.

3.2.3.1 Management of energy and water consumption

The basic goal of energy and water consumption management (BNB_BB 5.3.2) is to monitor and minimise energy and water consumption during the use phase. This requires systematic recording of all consumption rates and their analysis with a view to higher consumption and other irregularities. The purpose of this is to identify potential for savings and to develop possible solutions in order to lower energy and water consumption. As part of monitoring, energy and water consumption is hence periodically recorded and analysed. The analysis is carried out primarily by comparing consumption in previous periods after consumption rates have been adjusted – in as far as necessary. It must be examined whether the use conditions can be compared. It only makes sense to compare calculated target values if the system boundaries are identical. Monitoring energy and water consumption allows malfunctions and defects in operations management to be identified and the management processes for the building to be continuously improved.

The quality of energy and water consumption management is determined by the following sub-aspects:

- Recording (monitoring) and analysis of energy and water consumption
- Initiating measures in response to demand and circumstances

The operator is responsible for energy and water consumption management.

Recording and analysing energy and water consumption

Energy and water consumption must be periodically recorded, analysed and documented as part of reporting. In order to ensure that the relevant consumption rates are directly recorded, a measuring/metering concept is needed which not only determines the consumption rates to be recorded, but also the responsibilities, information flow and the infrastructure required to identify and document energy and water consumption. The measuring/metering concept must already be drawn up during the design and planning phase of a building (see Part B, section 2.4.1 “Energy and metering/measuring concept” and BNB 5.1.3), achieved in the construction

DEVELOPMENT OF THE ELECTRIC ENERGY CONSUMPTION OF THE MAIN BUILDING OF THE FEDERAL ENVIRONMENT AGENCY DESSAU
FIGURE C2



Source: BBSR

phase and implemented in the use phase. With a view to the degree of detail with which consumption is to be recorded, the Energy Target Specifications (Sample) (Annex B4) must be observed. At the very least, the minimum requirements of the Energy Target Specifications must be met. It is recommended that all of the recommendations outlined in the Energy Target Specifications be implemented.

During the commissioning phase, consumption rates must be identified and documented on a monthly basis. Once steady – albeit perhaps not optimum – operation has been reached, this monthly basis should still be maintained. Only when steady and optimum operation has been reached can the identification and documentation of consumption rates be carried out less frequently depending on effort and expense. In order to ensure sustainable operation of the building, seasonal differences must be recorded, and it must be possible to detect disruptions on time. This means that identification and documentation of consumption rates should not be carried out at intervals of more than three months. Depending on the technical equipping of the building, there may be justification for longer intervals if a short response time to disruptions or defects is ensured.

As part of the analysis, the consumption rates recorded must be compared to the building-specific benchmarks (total consumption and partial consumption rates or partial energy parameters). Benchmarks must be identified using the consumption rates identified in previous periods and calculations made on the basis of the operating concept. If planning figures from the planning and construction phase of the building are available, these must also be used as benchmarks in as far as they have the same system boundaries and are otherwise suitable. The aim of the analysis is to identify benchmark violations and other irregularities, such as a sudden increase in consumption for a technical system compared to the previous period. Recording and analysing energy and water consumption must enable timely countermeasures (elimination of defects or disruptions). Before the analysis is carried out, consumption rates must be adjusted in as far as possible with a view to weather and any other special circumstances in conjunction with the use and operation of the building.

The operator is responsible for the recording, adjustment, documentation and analysis of energy and water consumption as well as the elimination of any defects or disruptions. The operator is required to document in a report the results of consumption recording and analysis. Section 3.2.10 “Reporting obligations” contains information concerning the distribution and minimum contents of the report.

Initiating measures

Measures must be taken in the cases listed below:

Initiating measures when benchmarks are violated

If benchmarks are violated or in the case of other irregularities identified during consumption recording and analysis, a search must be carried out to find the reason for the violation. Once the reason has been found, the defect or disruption must be immediately eliminated (short response time).

Initiating optimisation measures

An examination must be carried out periodically² in order to determine whether there is a structural or technical potential to reduce energy and water consumption (energy and water consumption analysis). In addition to referring to the concept for and assessment of organisational and/or investment measures which are to lead to a reduction in energy and water consumption, the energy and water consumption analysis should also examine whether possibilities exist for short-term, low-investment optimisation measures to reduce energy and water consumption. These measures could be carried out during inspection and servicing work on heating, ventilation, cooling and lighting systems. Organisational measures should always be implemented immediately. The results of the use and management analysis (see section 3.2.1, paragraph on “Use and management analysis”) must be taken into consideration in the analysis of energy and water consumption.

2 Basic interval: every twelve months and depending on structural and organisational conversion

Measures programme

The deviations, weak points and potential for optimisation identified in the energy and water consumption analysis and in the root-cause analysis, if any, must be included in the measures programme. The measures programme includes the planning, assessment and implementation of structural, technical and organisational measures which aim to reduce energy and water consumption. Measures should only be implemented if they have been assessed and found to be both economically and ecologically beneficial. The assessment of a measure must document the reasons why measures were abandoned which would lead to reduced energy and water consumption rates (for example, when the costs for implementing a measure are disproportionate to the savings in water and energy). Success must still be monitored as part of implementing the measure. After the measure has been implemented, actual energy and water consumption must then be compared with the consumption rates forecast.

Initiating measures when neither a measuring/metering concept nor recording are available

If no measuring/metering concept is available for existing buildings or if the concept available and its technical implementation are not up to date, such shortcomings must be eliminated. Detailed information regarding the preparation of measuring/metering concepts can be found in the in the Energy Target Specifications (Sample) (Annex B4).

Energy and water consumption management supports cost controlling. As part of cost controlling, the costs in conjunction with the management of the building are planned, recorded and analysed. The potential for costs savings is also examined. The potential to save costs in conjunction with the management of energy and water consumption is also part of cost controlling. The viewpoint, however, is different because the management of energy and water consumption focuses

exclusively on making use of physical potential for savings but ignores tariff optimisation. However, this potential for savings cannot always be achieved with economic measures. The “Management of Energy and Water Consumption” criterion (BNB_BB 5.3.2) hence permits the rejection of measures to reduce energy and water consumption if justified. One possible reason for this is the lacking economic efficiency of a measure.

The operator is responsible for the root-cause analysis, the energy and water consumption examination and the measures programmes.

3.2.3.2 Energy consumption

Actual (measured) heat and electric energy consumption (BNB_BB 1.2.1) is an important indicator both for the real use of resources and environmental pollution, in other words, ecological quality, as well as for the operation costs and hence the economic quality of a building. Identifying and assessing energy consumption in the use phase provides important information regarding the energy-related quality of a building and its management processes. The energy quality of a building impacts both the identification and development of a building's value and is hence another economic quality that affects the stability of a building's value.

Energy consumption is recorded and analysed analogous to the provisions for issuing energy demand certificates according to the EnEV. Wherever possible, information from the energy consumption certificate can be used. The focus is on the building's real (measured) heating and electric energy consumption. The energy consumption measured is adjusted to standard boundary conditions and referred to a suitable variable. It can then be assessed by comparing it with benchmarks for heating and electric energy consumption. If no consumption-orientated energy certificate is available for the building, consumption rates must be identified and compiled according to the rules for consumption-orientated energy certificates in line with the EnEV.



Thermographic testing of the street-side facade of the old and new BMU building in Berlin in order to check the quality of construction

The assessment must be made on the basis of the parameters shown or calculated in the energy consumption certificate for heating and electric energy consumption (final energy). If and to what extent reference values have been exceeded or not reached has to be examined. In the event that the parameters shown or calculated in the energy consumption certificate contain special loads, the parameters must be adjusted accordingly. Special loads include computer centres, commercial kitchens, canteens (not tea kitchens) and other forms of use where energy consumption differs significantly from office use. The reference values can be determined on the basis of the reference values in the “Bulletin – rules for energy consumption parameters and comparative values in non-residential buildings” from the Federal Building Ministry (see table C1) which are referred to in the EnEV. The comparative values are statistical values and are hence average values that do not reflect specific building parameters.

COMPARATIVE VALUES

TABLE C1

Use	Comparative values in [kWh/(m²NGF a)]	
	Heating/ hot water	Electricity
Office building, heated only	105	35
Office building, heated and ventilated	110	85
Office building with full air-conditioning, conditioning independent of outdoor temperatures	135	105

Source: “Bulletin – rules for energy consumption parameters and comparative values in non-residential buildings”, Federal Building Ministry dated 7 April 2015

The greenhouse gas emissions identified on this basis correspond to a carbon footprint in the use phase as part of the carbon footprint for the building.

The operator is required to document in a report the recorded and adjusted actual energy consumption which forms the basis for an assessment. Section 3.2.10 “Reporting obligations” contains information concerning the distribution and minimum contents of the report.

3.2.3.3 Drinking water consumption

Although per-capita water consumption in Germany is relatively low on an international scale and even though there is generally no shortage of water in Germany, minimising water consumption is still a management goal, for instance, for cost reasons and in conjunction with the energy consumption and environmental pollution that result from water treatment and supply.

Actual consumption of resources and the resultant environmental pollution are always the result of actual consumption. It is hence necessary to identify actual drinking water consumption (BNB_BB 1.2.3), to adjust it with a view to special loads, if any, and to arrive at conclusive consumption parameters. By comparing values for similar types of buildings and using best values achieved through the management of exemplary, comparable buildings (best practice), weak points can be identified in installation systems and in building operations, or user behaviour can be identified that deviates from the assumed behaviour. Mean water consumption must be determined based on the rule shown below. Annual building consumption for the past three years must be identified on the basis of consumption bills from the water company or meter readings. If no data are available for precisely one year, but only for 50 or 54 weeks, for instance, these data must be extrapolated or interpolated to 365 days. The consumption parts of special loads, if any, must be deducted (adjustment) for the assessment of annual consumption rates.

The following special loads must be deducted:

- Watering of outdoor facilities
- Types of use where water consumption differs considerably from office use, such as kitchens/canteens (not tea kitchens), building supervisor apartments, gyms, and so on.

Mean annual consumption (arithmetical mean) is derived from the adjusted annual consumption rates for the past three years. The water consumption parameter is calculated on the basis of the usable floor area of offices.³ In order to calculate an annual consumption parameter, mean annual consumption must be referred to the usable floor area of offices. It is not possible to include the space share of special loads, if any. Water consumption can also be referred to the number of users (normally staff) and compared to benchmarks on this basis.

The operator is required to document in a report the recorded and adjusted actual water consumption which forms the basis for an assessment. Section 3.2.10 “Reporting obligations” contains information concerning the distribution and minimum contents of the report.

3.2.3.4 Greenhouse gas emissions due to heating and electric energy consumption

It is a central goal of the Federal Republic of Germany to persistently reduce energy consumption in existing buildings until they have almost reached a climate-neutral level. Climate-neutral means a very low level of energy consumption in buildings where the remaining energy demand is largely covered by renewable energy. That's why actual greenhouse gas emissions (GHG emissions, BNB_BB 1.1.1) caused during the use phase are of paramount importance. These emissions are largely the result of energy consumption and should be recorded and analysed in addition to energy consumption. The choice of fuel and energy supply systems has a more differentiated impact in the identification and assessment of greenhouse gas emissions (environmental impacts) than in a primary energy assessment (demand of resources).

Identification of greenhouse gas emissions

Actual greenhouse gas emissions can be used to assess the energy quality of a building, operation and user behaviour, as well as the energy supply concept and its quality. Greenhouse gas emissions are not normally directly measured. They must be derived from the energy consumption rates and using emission factors. Greenhouse gas emissions must be identified in two different ways:

- Greenhouse gas emissions based on adjusted energy consumption
- Greenhouse gas emissions based on non-adjusted energy consumption in the year under review

Both calculations are based on actual energy consumption rates for heating and electric energy (see section 3.2.3.2 “Energy consumption”).

GHG emissions based on adjusted consumption

The aim of this calculation is to assess greenhouse gas emissions on the basis of comparable data. For this purpose, the energy consumption rates measured must be adjusted to reflect weather and location. This adjustment must be carried out using the method for energy consumption certificates contemplated in the EnEV.

GHG emissions based on non-adjusted consumption

This calculation of greenhouse gas emissions is to be carried out on the basis of the actual energy consumption rates measured without any adjustment. The purpose of this method is to record actual GHG emissions in a report.

³ Total floor area with use according to DIN 277-1:2016-01

The emission factors to be used can be found in the current “Energy and CO₂ Report on Federal Properties” by the BBSR. The greenhouse gas emissions used in the report include the greenhouse gas emissions that are generated on site during energy conversion along with the necessary upstream process chain (extraction, transport, conversion). Greenhouse gas emissions are recorded and expressed in kilogramme CO₂ equivalents. In addition to CO₂ emissions, other climate gas emissions are recorded, converted to CO₂ equivalents and included in the emission factor.

**EMISSION FACTORS FOR ENERGY SOURCES
OVER TIME**
TABLE C2

Energy sources	Total GHG equivalent emissions (incl. upstream chain) in kg/MWh				
	1990	1995	2000	2005	2010
Thermal energy source					
Lignite briquette	408	408	408	408	408
Natural gas	254	254	254	254	254
District heating (Germany mix)	263	263	263	249	249
Liquefied gas	278	278	278	278	278
Heating oil	317	317	317	317	317
Wood chips	22	22	22	22	22
Wood pellets	29	29	29	29	29
Coke	405	405	405	405	405
Crude lignite	394	394	394	394	394
Hard coal	446	446	446	446	446
Mains gas	158	158	158	158	158
Electric energy					
Electric energy electricity mix Germany	768	697	633	626	620
Electricity from solid biomass (CHP 50%)			24	24	24

Source: “Energy and CO₂ Report on Federal Properties 2012”,
BBSR 2012

If emission factors which cannot be found in the current report are needed to determine actual GHG emissions, factors can be used that are available via the “ProBas” web portal of the Federal Environment Agency (www.probas.umweltbundesamt.de). If the building is heated using district heating, the GHG emission factors of the respective utility can be used. If the utility company is unable to supply greenhouse gas emission factors, the table above can be used instead. If power is supplied via a private electricity grid/property grid with its own share of supply (for example, from a combined heat and power plant), the GHG emission factors of the respective plant operator can be used. A private electricity grid/property grid is a system which is connected to the public grid but which is largely operated independent of the rest of the grid.



Solar energy generated on the roof of the main building of the
Federal Environment Agency in Dessau

Since the procurement of green electricity does not automatically lead to the more widespread generation of renewable energy, the GHG emission factor for the German electricity grid (electricity mix Germany) must be generally used. It is not generally possible to include so-called green rates/green electricity. If the awarding of contracts for the supply of green electricity ensures a lasting reduction in electricity from non-renewable energy sources and an increase in the number of plants producing electricity from renewable energy sources, the GHG emission factor of the green electricity procured can be used in justified cases in order to calculate actual greenhouse gas emissions. This is considered to be the case when the “Procurement of Green Electricity – Tool for Pan-European Public Tendering” by the Federal Environment Agency has been applied.⁴

The GHG emissions calculated must be compared to reference values. The reference values are calculated using the emission factors from the comparative values for the EnEV in the latest version of the “Regulatory Guidelines for Energy Consumption Rates and Comparative Values in Existing Non-residential Buildings”. The greenhouse gas emissions calculated correspond to the carbon footprint during the use phase as a result of heating and electric energy consumption and are hence part of the building’s carbon footprint. If these emissions are to be published as the carbon footprint, they must be published together with details of system boundaries, information regarding the type and scope of adjustment and details explaining the reference parameters. Please refer to the latest carbon footprint standards.

The operator is required to document in a report the actual greenhouse gas emissions identified as a result of heating and electric energy consumption. Section 3.2.10 “Reporting obligations” contains information concerning the distribution and minimum contents of the report.

The following details must be noted here:

GHG emissions resulting from heating energy consumption

Buildings which use only one type of energy source to heat rooms and for hot water are assessed on the basis of the heating energy consumption shown in the energy consumption certificate or calculated according to the rules of the energy consumption certificate. Using the GHG emission factor specified for the final energy source (see table C2), the energy consumption rate is converted to the GHG rate as a result of heating energy consumption.

If more than one source of energy is used for heating energy, separate rates [kWh/(m²NGF x a)] must first be calculated for each of the energy sources. These must be adjusted to reflect weather and location using the method used for the energy consumption certificate. The greenhouse gas rates of the respective energy source are calculated using the GHG emission factors that correspond to the respective energy sources. These are added to form the GHG rate that results from heating energy consumption.

GHG emissions resulting from electric energy consumption

This is assessed on the basis of the electric energy consumption rate stated in the energy consumption certificate or calculated according to the rules of the energy consumption certificate. Taking the GHG emission factor for the reference year for the electric energy electricity mix in Germany, the GHG rate is formed as a result of electricity consumption.

Total GHG rate

The rates for greenhouse gas emissions resulting from heating energy and electricity consumption are added together in order to obtain a rate for total greenhouse gas emissions [kg GHG/(m²NGF x a)].

⁴ www.umweltbundesamt.de/publikationen/beschaffung-von-oekostrom-arbeitshilfe-fuer-eine

Evaluation

The evaluation is performed only for the total GHG rate which was calculated on the basis of weather-adjusted and location-adjusted energy consumption. The total GHG rate must be evaluated on the basis of a scale. The comparative values must be identified using the comparative values of “Regulatory Guidelines for Energy Consumption Rates and Comparative Values in Existing Non-residential Buildings” (7 April 2015) of the Federal Building Ministry which refer to the Energy Saving Ordinance. An average energy mix of 50 percent natural gas and 50 percent extra light heating oil is taken to calculate the emission factor of heating energy supply. The greenhouse gas emission factor to be used for heating energy supply hence totals 286 kilogramme of CO₂ equivalents per megawatt hour (refer to the criterion in BNB_BB 1.1.1). The greenhouse gas emission factor used for electric energy is that of Germany’s electric energy electricity mix.

The target value is at least 30 percent lower than the comparative value, while the reference value adheres to the comparative value and the limit value is no more than 40 percent higher than the comparative value. If comparative values are exceeded or if other irregularities are found, a root-cause analysis is necessary (see section 3.2.3.1 “Management of energy and water consumption”).

3.2.4 Building documentation throughout the life cycle

Building documentation throughout the life cycle (BNB_BB 5.3.7) is a basic requirement for sustainable management. During the use phase, this documentation helps to avoid any loss of information and serves as a basis for maintenance measures for the building and its technical equipment. Building documentation throughout the life cycle, as the starting point for planning future refurbishment and conversion measures, is also important for identifying value, for portfolio analyses and for verifying maintenance and repair.

A vast range of data is recorded in building documentation. It describes, for instance, use qualities and documents technical features, planning characteristics, execution details, equipment, materials, operating costs and consumption rates. The quality of building documentation throughout the life cycle is largely measured by the scope and systematic recording of the relevant information.

The main elements of building documentation throughout the life cycle are as follows:

1. Construction documentation: documentation of the building measures which resulted in the existing building
2. Documentation of the existing building from geometric inventory data and alphanumeric description data (condition actually built at the end of a building measure)
3. Primary verification: as original, permanently updated documentation of existing buildings
4. Collection of servicing, inspection and user manuals
5. Continuously updated documentation of building management from:
 - Documentation of energy and water consumption
 - Documentation of operating and repair costs
 - Documentation of existing supply and disposal contracts as well as servicing and maintenance agreements
 - Documentation of inspections, servicing and testing (inspection reports, inspection records etc.)
6. Continuously updated building parts catalogue: documentation of materials and ancillary materials installed

Building documentation throughout the life cycle is hence equal to a building passport or building file and forms the basis for a Building Information System⁵.

⁵ See OBJEKTinfo research project (KIT/ÖÖW), 2011

The operator is responsible for building documentation throughout the life cycle. In order to ensure sustainable building management, the operator must maintain building documentation throughout the life cycle that meets the requirements of at least items numbers one to five.

Up-to-date building documentation is vital for sustainable building management. The definition of responsibility for keeping primary verification ensures that building documentation is up to date. Furthermore, the definition of responsibilities ensures access to building documentation throughout the life cycle. Those involved in building management are ensured access to the building documentation data through copies of and excerpts (secondary verification) from the original building documentation throughout the life cycle (primary verification). Depending on the size of the building, this responsibility can be assigned to a single person or to an organisational unit.

FEDERAL BUILDING The content, scope and responsibilities of Section H of the RBBau Guidelines and the Building-related guidelines for documentation of existing buildings (BRF GBestand)⁶ must be observed for federal government buildings and structures. The latter guidelines have been partially laid down in greater detail and supplemented by more far-reaching documentation guidelines, such as the documentation guideline of the BBR⁷. When it comes to the collection of servicing, inspection and user manuals and the continuously updated documentation of building management, Section K 15 of the RBBau Guidelines must be additionally observed.

3.2.5 Inspection, servicing and safety precaution

Inspection and servicing of building parts and technical equipment are part of maintaining the building (BNB_BB 5.3.4). Their purpose is to reduce the risk of failure and susceptibility to disruptions. The requirements for safety precaution are based on the obligation to secure sources of danger.

3.2.5.1 Inspection and servicing

Systematic inspection and servicing based on an inspection and servicing schedule that has been tailored to the building and its technical equipment reduces repair costs and protects against follow-up costs on a long-term basis. Many technical systems have (manufacturer-) recommended or statutory servicing intervals. Empirical values and manufacturer instructions can be used for building parts. According to DIN 31051, inspection means “all measures for determining and assessing the actual condition of the object being examined, including the determination of the cause of wear and tear and the identification of the necessary consequences for future use”, and servicing refers to “measures to delay the reduction of the existing wear reserve”, which must be distinguished from repair and improvement measures.

Thanks to early recognition of weak points, regular inspections can help to preserve value and prevent damage. Systematic servicing additionally reduces the work and costs involved in maintaining the building. This means that early replacement of used or defective components can improve value and reduce operating costs. Systematic inspection also reduces the duration and probability of failure and is hence an important precondition for operating safety and user satisfaction. In order to warrant safe operation of the building, requirements under public law regarding technical safety tests, visual inspections and function testing of safety systems and components also apply. With a view to climate protection, the requirements of the EnEV must be observed. According to this ordinance, systems and technical equipment for heating, cooling and ventilation purposes must be maintained, and air-conditioning/ventilation systems with a nominal power for cold demand of more than twelve kilowatts must undergo regular energy efficiency tests.

⁶ See BFR GBestand (2012)

⁷ See Dokumentationsrichtlinie (DLR), BBR (2008)

The basis for systematic inspection and servicing is a corresponding schedule that has been tailored to the building and its technical equipment which can be mapped in the inventory lists.

The inspection and servicing schedule must contain at least the following information for each system or component:

- Dedicated identification number (also on-site)
- Description
- Type of system or part
- Location
- Year built and planned service life
- Warranty dates
- Servicing and testing cycles
- Date of last service or test as well as dates or deadlines
- Safety and environmentally relevant requirements
- Technical specifications, including performance and supply range
- If applicable, length, width, diameter
- Servicing, inspection and user manuals
- Necessary servicing and inspection work according to manufacturer recommendations
- Necessary servicing and inspection work according to generally accepted rules of technology (for example, hygiene inspection of ventilation systems, damage identification and removal of mould)
- Necessary servicing and inspection work according to public law regulations (for example, energy inspection according to section 12 of the Energy Saving Ordinance)
- Necessary safety tests as well as visual inspections and function testing (for example, for technical fire protection)
- Information regarding the necessary qualifications or expertise of the companies/employees commissioned to perform the individual inspection and servicing work, for example, for the hygiene inspection of ventilation systems
- Preparation of the necessary documentation of the results/performance of inspections, servicing and testing (such as inspection reports, inspection records)

Energy-related inspections must be carried out pursuant to section 12, “Energy-related inspections of air-conditioning systems”, of the Energy Saving Ordinance. Hygiene inspections must be carried out on ventilation systems pursuant to VDI 6022. If water damage occurs, or if humid spots are found or the user reports suspected mould in the form of a musty or mouldy odour or dark spots on walls, ceilings or furniture, the damage must be recorded as laid down in the “Mould Guide” from the Federal Environment Agency’s Indoor Air Hygiene Commission.⁸

In order to ensure sustainable building management, inventory lists must be kept during the use phase of all of the technical systems and components which must be inspected, serviced and/or tested according to the manufacturer’s recommendations or public-law requirements. It is possible to deviate from these recommendations and requirements in justified cases. The inventory lists must be kept and continuously updated. The operator is responsible for drawing up and updating the inventory lists. The operator receives the support of the building authority and the operational monitoring service within the scope of their tasks according to the RBBau Guidelines.

The operator must perform the energy inspections according to the details and requirements of DIN SPEC 15240. A host of documents, such as sample contracts, inventory lists or service catalogues, are available from the Mechanical and Electrical Engineering Working Party of National, Regional and Local Authorities. Using these documents ensures correct inspection and servicing. The operator is required to document inspection and servicing in a report. Section 3.2.10 “Reporting obligations” contains information concerning the distribution and minimum contents of the report.

8 See www.umweltbundesamt.de/publikationen

3.2.5.2 Safety precautions

Anyone who creates or maintains a source of danger must ensure that third parties are protected against damage. Buildings, as a possible source of danger, must be secured, and users and any third parties must be protected against harm. This responsibility of the owner is referred to as a safety precaution obligation (BNB_BB 5.3.4). The safety precaution obligation results from different requirements. Under public law, this obligation is rooted in the accident prevention regulations or the “Occupational health and safety rules of the occupational accident insurance fund” and in the building regulations of the federal states (refer, for instance, to section 16 of the Berlin Construction Rules). This obligation, however, is also required under civil law. It was under civil law, in particular, that the safety precaution obligation was developed, primarily through court decisions, so that it is difficult for the party obligated to ensure safety precautions to identify the precise scope of this obligation. What is decisive is that this party is not obligated to protect against every source of danger. However, precautionary measures must be taken on all accounts in order to protect against recognisable hazards in the case of correct and even slightly incorrect use.

Under construction law, protection must be provided against hazards posed by buildings or structures.

FEDERAL BUILDING With a view to this, the “Guideline for monitoring the safety precautions of federal government buildings and structures” (RÜV – Richtlinien für die Überwachung der Verkehrssicherheit von baulichen Anlagen des Bundes) is applicable to federal government buildings. This guideline describes responsibilities for monitoring stability and safety precautions in terms of the safe preservation of buildings and structures and determines the interaction between the building authority and the operator.

In addition to the provisions of the RÜV-guideline, other protection measures are often also needed in order to meet the safety precaution obligation. The applicable rules of the occupational accident insurance fund must be mentioned here. If these rules are not observed, a violation of the safety precaution obligation can be assumed. Furthermore, other protection measures are usually required due to safety precaution obligations under civil law.

The measures listed below, for instance, may be required:

- Clearing access routes and paths of snow and ice
- Protecting paths and common areas against roof avalanches and falling icicles
- Lighting access routes and ensuring level floor surfaces
- Keeping access routes free of dangerous objects (nails, broken glass, and so on)
- Putting up signs to warn of possible dangers which cannot be ruled out in the building (for example, ponds and other water areas or slippery surfaces on wet floors)
- Visual assessment of trees on the property to check stability, falling trees and broken branches, twice a year, leafed and leafless

Therefore, in addition to the safety precaution obligation measures required under public law (for example, procedures according to the RÜV-guideline), the entire hazard potential of the respective property must be recorded, analysed and assessed in the interest of sustainable building management. If measures are considered to be necessary, they must be implemented, and responsibilities must be defined along with the type and scope of measures monitoring.

The safety precaution obligation regarding the hazards posed by the respective property (premises, including the main components and accessories) falls to the owner⁹. He will be supported by the operator and the building authority and by the authority using the building.

FEDERAL BUILDING In some cases, special rules have been made between the parties involved in building management for individual federal government buildings and structures.

The authority using the building must inform of hazards recognised by it and is also responsible for all other safety precaution obligations. It is supported by the building authority as part of its tasks according to the RBBau Guidelines and by the operator in as far as protection measures are to be implemented using structural means.

The operator is required to document adherence to the safety precaution obligations in a report. Section 3.2.10 “Reporting obligations” contains information concerning the distribution and minimum contents of the report.

3.2.5.3 Building maintenance

As already explained in section 2 “Stakeholders during the use phase”, the consumptive measures of building maintenance (**FEDERAL BUILDING** according to **Section C of the RBBau Guidelines**) are maintenance measures. Small, non-essential structural modifications or extensions can be carried out as part of building maintenance. Within the meaning of this Guideline, these non-essential investment measures are considered to be equivalent to consumptive measures.

It is neither reasonable nor often possible in the case of consumptive measures to quantify sustainability aspects and determine an overall degree of fulfilment according to a BNB module for the planning and construction phase (new construction or complete refurbishment). The requirements for the sustainable procurement of services are applicable here. The “Sustainability Compass”¹⁰ by the Deutsche Gesellschaft für internationale Zusammenarbeit (GIZ) is available as

a useful tool here. In the interest of sustainable building management, it must be ensured with a view to consumptive measures that the qualities found in existing buildings are maintained. Therefore, consumptive measures should in no way lower (deterioration ban), but instead should at best raise the qualities of existing buildings. In addition to the qualities found during an inspection, the qualities documented (see section 3.2.4 “Building documentation throughout the life cycle”) should also provide the starting point for a sustainably consumptive measure. If the planning and construction phase of an existing building was already assessed using a BNB module, extensive documented qualities will usually then be available. These qualities must be basically preserved.

First of all, the criteria of the BNB module (New Construction or Complete Refurbishment) must be identified, which can be influenced by the respective measure (influenced criteria). After this, the achieved qualities of the influenced criteria must be identified (existing qualities). The existing qualities can be found in the documentation of the BNB assessment of the planning and construction phase or in the building documentation throughout the life cycle. The qualities of the consumptive measure (planned qualities) must be defined on the basis of the existing qualities. The planned qualities must at least match the existing qualities.

When determining the planned qualities, the assessment standards of the influenced criteria of the BNB must be used as a basis for orientation. If these cannot be directly applied to the case in question, analogous application should be carried out. In the case of analogous application, the goals of the criterion must be identified and applied to the specific case.

⁹ The owner may also be the operator.

¹⁰ See www.oeffentlichebeschaffung.kompass-nachhaltigkeit.de/en

Depending on the respective consumptive measure, one or more criteria may be influenced. Annex C3 contains a useful tool: “Criteria table for building maintenance measures”. This table makes it easier to identify influenced criteria and helps to secure quality. The existing qualities and quantities must be compared in the criteria table with the planned qualities and quantities. The table must be drawn up by the building authority and handed over to the authority and the operator for their approval. The criteria table is part of the building requirements record according to the RBBau Guidelines.

3.2.6 Eco-friendly and health-safe cleaning

The purpose of cleaning a building (BNB_BB 5.3.5) is not only to take care of the building parts and inventory, but also to ensure the comfort and health of its users. The goals of cleaning a building include maintaining hygiene, maintaining visible surface qualities, maintaining functionalities and protecting against harmful influences. In order to avoid burdens on the environment and health, compatibility with the environment and health must be observed, especially during the production, use and disposal of the products used and when the corresponding technologies are used. Furthermore, it must be assessed whether cleaning meets with the selected and required service level.

In order to ensure eco-friendly and health-safe cleaning, the Federal Environment Agency has drawn up the “Guideline for sustainable public procurement of cleaning services and cleaning agents”¹¹. The operator is responsible for ensuring eco-friendly and health-safe cleaning.

FEDERAL BUILDING This guide must be applied to cleaning services in federal government buildings.

3.2.7 Technical operations management and qualification of technical staff

Technical operations management (BNB_BB 5.3.6) is part of technical building management.

As part of technical operations management, the following activities are performed with a view to the building and its systems:

- Operation
- Monitoring
- Troubleshooting
- Optimisation
- Maintenance
- Repair

These activities are primarily geared towards maintaining building operations and correct use. Efficient building management depends heavily on the skills of the staff employed here. When it comes to large office and administration buildings or special properties, extensive and complex technical systems and equipment are in place which not only have to be correctly set at the time of commissioning, but which must also be permanently monitored, correctly operated and, when necessary, adjusted. Depending on the type of system and technical equipment, this calls for special skills, and the staff working here must be sufficiently trained and educated.

Operating staff include staff who are familiar with technical operations management. This staff includes individuals who operate and monitor technical systems and are responsible for safety/security equipment. Operating staff can be either permanently posted on site for the most part or can permanently monitor the building services systems per remote control. The greater the complexity and the bigger the building, the more qualified staff should be. That's why in addition to qualifications, further training of operating staff is so important.

11 UBA (2012), “Leitfaden zur nachhaltigen öffentlichen Beschaffung von Reinigungsdienstleistungen und Reinigungsmitteln”

Generally speaking, it is irrelevant from the perspective of sustainable management whether operations management tasks are performed by internal staff (staff employed by the operator, the building authority or the authority using the building) or by external staff (for example, firms specialising in building management). In both cases, it must be ensured that operating staff are sufficiently qualified. This can be seen to be the case if the operating staff employed are skilled personnel who have been sufficiently trained for the tasks to be performed. Furthermore, operating staff should attend regular training in the respective tasks in which the focus is preferably on one of the following topics: sustainability, energy management, energy savings or optimising operations.

In both cases, the aim is to achieve equally high performance for technical operations management. When commissioning a specialist firm with a service level agreement, for instance, the response time, scope, reporting and trouble-shooting speed must be guaranteed to such an extent that response times to malfunctions are short and high system availability is guaranteed. If technical operations management is carried out by internal operating staff, this must also be guaranteed with the same level of quality. The operator must draw up a structural and functional organisation for trouble-shooting. The aim here must also be short response times to malfunctions and high system availability.

3.2.8 Building users – information, motivation and satisfaction

User behaviour influences resource consumption, effects on the environment, operating and repair costs as well the quality of use. The potential to cut costs can only be exploited if the building and its systems are also used in a suitable manner. Behaviour-related measures at the workplace alone can lead to significant energy savings or losses compared to the planned and target figures. Incorrect use of components and technical systems can reduce service life. For this reason, comprehensive information and motivation of users (employees working in the building) are needed as part of sustainable building management.

Furthermore, user satisfaction can be regarded as an indicator for the building quality actually achieved. With this in mind, information regarding potential for optimisation and weak points must be collected. The primary goal is to achieve a high degree of user satisfaction with workplace and building conditions. Conditions that help to create user satisfaction promote creativity and productivity among employees. Regular user satisfaction analyses provide an insight into the potential for optimisation. Users know the property from everyday situations and can provide valuable information. The possibility to express opinions contributes towards user participation. For this reason, information from users concerning the potential for optimisation and weak points must be collected and analysed (communication management).

3.2.8.1 Influencing user behaviour

When it comes to sustainable operation of a building, both users and operators can bear equal responsibility. Through co-operation and mutual exchange, both stakeholder groups can warrant the sub-goals of saving and protecting resources, minimising operation costs and maintaining health, comfort and safety. In addition to qualified operating staff, this also calls for the provision of information and adequate passing on of knowledge to users who do not normally have detailed expertise (BNB_BB 5.3.8). It is vital here that information be prepared specifically for the respective target groups and attractively designed and that users be informed of their responsibility and options to act in their own areas of work. Measures to create awareness among users and suitable recommendations for action can directly promote sustainable behaviour at the workplace.

Means in this respect are, for example:

- Information for users concerning current consumption rates
- Motivation of users through suitable incentive schemes
- Training offers for users
- Target agreements between the operator and users (for example, for energy saving goals)
- A permanently updated user manual

The process of influencing users is made up of three phases: creating awareness, informing and motivating as well as monitoring success and reporting (see figure C3).

Phase 1: Creating awareness

Sufficient information regarding the situation, goals and measures forms the basis for motivating users. Transparency and knowledge create acceptance, awareness and the willingness to act in a sustainable manner.

Phase 2: Informing and motivating

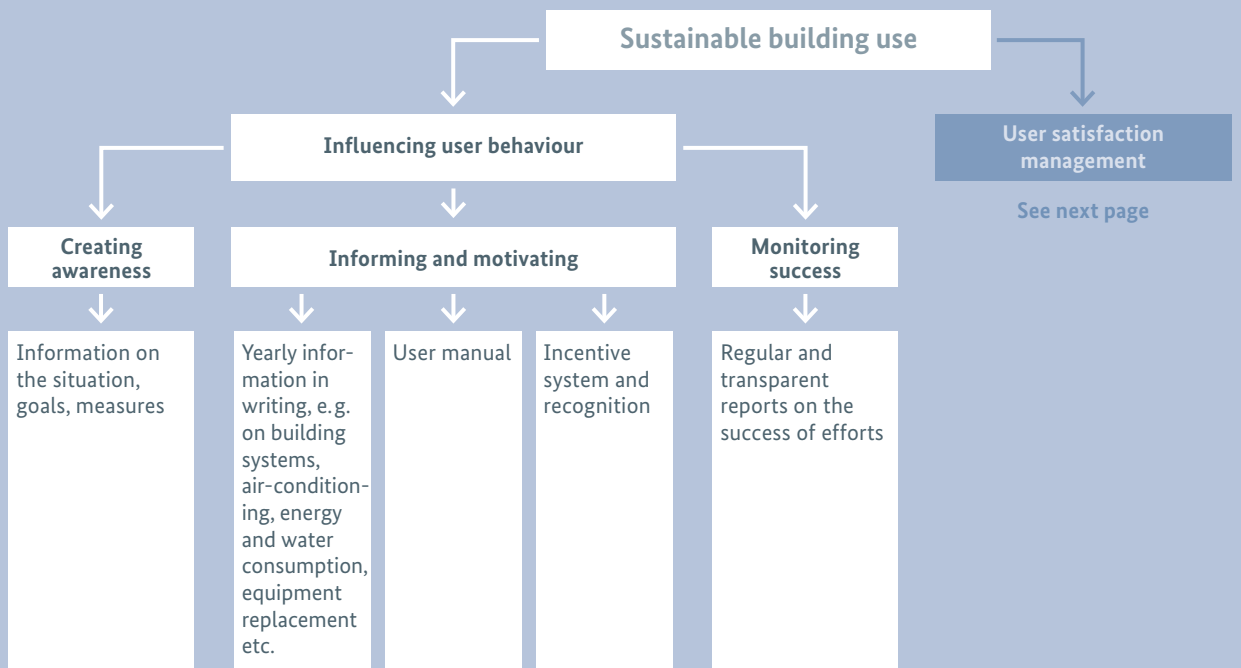
The information and motivation process must be designed as a continuous exercise. In no way should it demand too much of the user. What is important here is to provide building users with recommendations for action that have been adapted to their respective possibilities for exerting influence and to motivate them to act. In order to ensure sustainable building management, the operator must provide users at least once a year with up-to-date, target-group specific information in writing (digital or analogue). This information contains at least details of the following areas:

- Operation of building services in the user's range of influence
- Healthy room climate
- Low energy and water consumption
- Avoidance, separation and disposal of waste
- Modification or revision of the building energy concept
- Modification or revision of user-relevant equipment
- Recommendations for actions related to the seasons (including suitable ventilation in summer or winter, and so on)
- Mapping of energy and water consumption rates over the past three years

Part of preparing target-group specific information must take place in a continuously updated user manual which contains, at a minimum, generally understandable explanations of the technical situations and the special features of individual parts and components. In order to ensure that the user manual receives the necessary attention, it should be attractively designed.

INFLUENCING USER BEHAVIOUR

FIGURE C3



Source: BBSR

People can be motivated by offering incentives for individual behaviour. An incentive system must be developed that motivates users to address aspects of sustainability and encourages them to make personal efforts to contribute towards the sustainable management of buildings. Recognition is one vital element of a successful incentive system. This can be expressed through very different measures.

Possibilities here include competitions (energy-saving and ideas competitions) with award ceremonies or a theme office party with suitable contributions and awards for committed users. Measures like these can have a decisive impact on joint motivation, and this can boost the quality of sustainable operation of the building.

Phase 3: Monitoring success and reporting

Other essential components of the information and motivation process are monitoring success and reporting, which should be both regular and transparent for users so that they can be informed of the success of their efforts in due time.

Participants in the information and motivation process

The operator is responsible for the process of informing and motivating users. He must take the necessary measures in order to prepare the information for the specific target groups and to explain about responsibilities and options to act in the respective work area. The authority using the building must support the operator here. This is particularly true with regard to motivation. The authority using the building should also propose to the operator an incentive system, including recognition, that can motivate users to address topics of sustainability. The operator is responsible for monitoring success and reporting.

3.2.8.2 User satisfaction management and user satisfaction

User satisfaction is not only decisive for the acceptance of the building, it also serves as an indicator for the quality actually achieved with the building and its management processes. A high level of user satisfaction has a positive impact on productivity among employees and is an important part of a sustainably managed building.

In order to boost user satisfaction and improve the quality of a building and its management processes, user satisfaction management (BN_BB 5.3.1) must be established. User satisfaction management is made up of two elements:

- Recording information (user satisfaction analysis and communication management)
- Measures programme

The “recording information” element can be used to identify the strengths and weaknesses of a building. The operator is required to document the results of user satisfaction management in a report. Section 3.2.10 “Reporting obligations” contains information concerning the distribution and minimum contents of the report.

The operator is responsible for both recording information and for the measures programmes. The authority using the building must support the operator when user satisfaction analyses are being carried out and when suitable structures are being set up for communication management. The building authority supports the operator in establishing the measures programme and during the evaluation, planning, implementation and monitoring of the success of measures.

Information can be recorded either through a user satisfaction analysis or communication management.

User satisfaction analysis

The user satisfaction analysis is the component of recording information in which the operator actively approaches users (proactive component). The user satisfaction analysis indicates the extent to which conditions at the immediate workplace or in the building as a whole meet the requirements and ideas of the individual users. Regular user surveys are an important quality feature of good management.

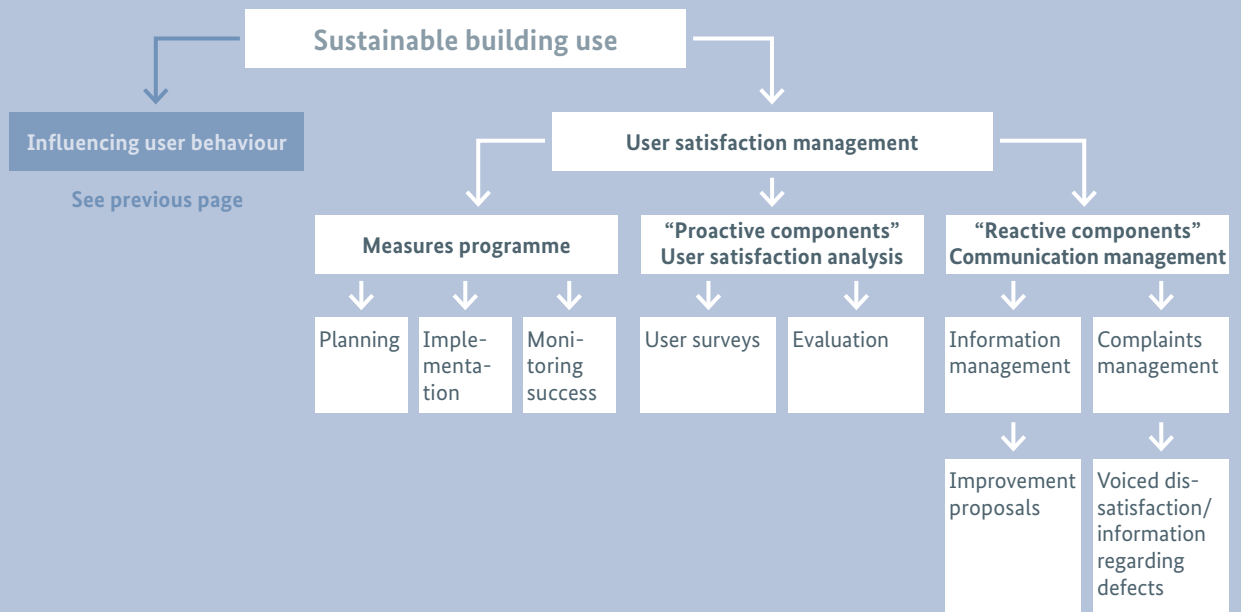
The quality of the user satisfaction analysis is determined by the following aspects:

- Scope of user satisfaction analyses (qualitative)
- Frequency of user surveys (quantitative)
- Handling of results (qualitative)

The user satisfaction analysis must be conducted in a standardised form. The “Tool for user surveys on comfort at the workplace (INKA)” is available for this purpose. This tool comprises standardised questionnaires and supplementary documents that are available via the information portal: www.nachhaltigesbauen.de. The questionnaires cover individual user satisfaction with air room quality, acoustic, visual and thermal comfort, as well as the type and scope of options for the individual design of conditions at the workplace. User satisfaction with the building and surrounding areas is additionally included in the survey.

The user satisfaction analysis must be conducted at regular intervals of no more than four years, and two separate surveys must be carried out in summer and winter in order to record seasonal differences. There are two different versions of the INKA questionnaire (the long and short version). The long version of the questionnaire (total index) must be generally used for first-time surveys or following extensive organisational or structural changes. Any approach that deviates from this must be explained.

USER SATISFACTION MANAGEMENT
FIGURE C4



Source: BBSR

Based on the results of the user surveys, building quality can be evaluated with a view to the social sustainability dimension, and the potential for improvement can be drawn up. One result of the user satisfaction analysis is the user satisfaction index which can be used as a scale for presenting actual user satisfaction (BNB_BB 3.1.9). The result of the identification of actual user satisfaction is important as an absolute value, especially when surveys are repeated regularly. This allows the development of user satisfaction to be recorded and the effects of measures can be identified and documented in order to monitor success. It is also possible to conduct comparisons with the user satisfaction index of similar buildings with similar use.

Communication management

Communication management refers to the systematic recording and processing of information (for example, improvement proposals) and notification of dissatisfaction (for example, complaints or information regarding defects) which were initiated by the user. The operator acts in response to such information and notifications.

Communication management is the reactive component of recording information. It is used to record defects and complaints as well as improvement proposals. The implementation of communication management is a basic requirement for sustainable building management. Communication management must ensure that:

- Easy-to-reach contacts are available to motivate users to make contact
- The information brought forward is systematically accepted and documented, and is treated as confidential
- The information accepted is promptly processed, and the sender receives feedback regarding his information
- The information received is analysed, for instance, with a view to the number of complaints, the extent to which the information creates a representative picture of user opinion, frequency of similar cases, and so on

Measures programme

In addition to recording information, user satisfaction management has a second element: the measures programme. This is where the findings of the information recorded are gathered which aim to optimise building and operating quality, to eliminate weak points found or to boost user satisfaction. In addition to planning, the measures programme must also include the implementation of the measures and monitoring success (for example, through follow-up surveys). In justified cases, individual measures do not have to be implemented. It must be explained, for instance, why the measure violates the principles of economic efficiency and good housekeeping, why the measure is not necessary and why it cannot be implemented.

3.2.9 Actual air climate quality

The goal of actual air climate quality is to maintain and promote the health of room users. A good air climate is also an important precondition for user satisfaction and performance. Actual air climate quality is part of the socio-cultural and functional quality of a building.

The main quality parameters for a good room climate, which are strongly influenced by the type of use and building operation, are as follows:

- Thermal and hygienic room conditions (temperature, absence of drafts, air humidity)
- Odour quality of room air (room air quality)
- Absence or sufficient removal of harmful substances from room air

Other criteria for a good room climate are good room acoustics, a sufficiently low sound pressure level, sufficient daylight in the room as well as glare-free, adequate lighting for workplaces. These criteria, however, are largely a function of the building structure. They are already defined in the building design, however, at the latest when the building is erected, and are essential for assessing the sustainability of new buildings. These

parameters can be influenced to little or no extent during building operations so that they are of no use as quality characteristics of sustainability-orientated building use and are not included at this point in the evaluation.

The room climate quality parameters can be directly influenced by building operations and building use through the following aspects:

- Operation of heating and air-conditioning systems with a focus on achieving optimum thermal comfort, however, at least within the scope of the agreed limits
- Operation of air handling systems with external air flow rates orientated towards good indoor air quality
- Regular servicing of all technical building systems, including control systems and, if necessary, prompt adjustment to changes in room occupation or room use
- Regular, high-quality servicing, repair and checking of air handling systems, with a special emphasis on hygiene
- Prompt removal of microbial infestation (mould), including the defects causing infestation, for instance, in the building structure
- Hygiene-orientated cleaning, especially with a view to the cleaning agents used
- Low-emission room fixtures and use (furniture, selection and arrangement of laser printers)

The decisive processes for a good room climate are considered in the profile of the criterion: BNB_BB 5.3.4 “Inspection, Servicing and Safety Precaution” which focuses on process quality. The success of these processes is documented on the basis of the quality level of the following criteria profile actually achieved: “Actual Thermal Comfort in Winter” (BNB_BB 3.1.1), “Actual Thermal Comfort in Summer” (BNB_BB 3.1.2) and “Actual Indoor Air Quality” (BNB_BB 3.1.3).



Determining and verifying interior comfort parameters during the operating phase

A very limited number of measured variables is sufficient for a comprehensive evaluation of thermal comfort. Depending on the heating and ventilation concept selected, it is often sufficient to record the room temperature. At best, measured values will be recorded anyway by the central building control systems or as part of energy monitoring (BNB_BB 1.2.1) so that reliable evaluation of thermal comfort is often easily possible. If the situation, for instance, in the occurrence of drafts, calls for additional measurements, these can be carried out with reasonable effort.

A comprehensive evaluation of indoor air quality is much more complicated because a vast number of substances can be verified in the room air depending on the sources of substances inside and outside the building. As part of assessing sustainability, indoor air quality is evaluated on the basis of concentrations of selected substances.

The substances or substance groups to be measured have been selected so that:

- They have a good correlation with the odour quality of the indoor air (“indicator effect”)
- They typically reflect pollution in offices with modern equipment, although it is also assumed that the building structure only releases substances into the room air which do not rule out the use of the building material or building structure
- They can be compared with the criterion for new office buildings (BNB_BN 3.1.3 “Indoor Air Quality”)
- The measuring equipment is suitable for the purpose

With a view to this, the following substances/ substance groups were selected for measuring:

- Carbon dioxide content of room air as an indicator of odours caused by human activities or the outside air exchange per user
- Volatile Organic Compounds (VOCs) and formaldehyde as indicators of levels of odorous and/or health-relevant substances released by the building structure and fittings
- Radon, particulate matter and fibres to rule out any special danger to user health

Microbial examination of room air is not foreseen as part of criterion 3.1.3. It is assumed that the buildings meet the requirements described in the criteria for new buildings so that grave structural defects that promote mould are unlikely. If these defects do in fact occur, they must be identified and eliminated as part of the required inspection and servicing (BNB_BB 5.3.4 “Inspection, Servicing and Safety Precaution”). Furthermore, targeted microbial testing with a high-quality process, such as the hygiene inspection of the air handling system, must be carried out as required.

3.2.10 Reporting obligations

As part of sustainable building management, the operator must make cost and consumption data from ongoing management processes available on a regular basis. These data are then available as comparative values for management processes for the operator's own property and for other properties, and serve as a basis for designing future construction projects. For this purpose, the energy and water consumption data as well as the operating and repair costs must be sent at least once a year to a central data recording unit.

FEDERAL BUILDING During the use phase of federal buildings, the provisions of Section K6 of the RBBau Guidelines must be observed in this context. Sample 3 must be used for reporting annual consumption rates and operating costs according to the RBBau Guidelines.

3.2.10.1 Operator's sustainability report

There are many people involved in the use and operation of a building. To ensure sustainable building management, the various participants must contribute to the necessary extent. The transparency of management processes and actual building quality are hence also an indication of sustainable building management. For this purpose, the main services and results of building management must be communicated in a sustainability report to the participants of building management. This report should also sufficiently honour the efforts of all participants in the field of sustainable building management. The sustainability report should be drawn up by the operator and handed over in digital and analogue form to the authority using the building, the building realisation level and the operational monitoring service. During preparation of the report, the operator receives the support of the building authority and the operational monitoring service.

The sustainability report must be drawn up each year and must be distributed by the fourth quarter of each year at the latest. The report essentially contains a review of the past budget year. In some areas, it presents an outlook for the coming budget year. The report must be drawn up on the basis of the checklist in Annex C4. A template to be filled in is available from the information portal: www.nachhaltigesbauen.de

3.2.10.2 Reporting in preparation of a BNB assessment

If an assessment is foreseen with the Use and Operation BNB module, the "Operator's sustainability report" must be additionally sent in digital form to the Conformity Testing Office and the Office for Sustainable Building at the BBSR.

FEDERAL BUILDING Proof of compliance with the reporting obligation according to Section K6 of the RBBau Guidelines is a basic precondition for the performance of a conformity test and hence a condition for recognition of the assessment with the Use and Operation BNB module.

4. Consideration of sustainability criteria during the use phase

The criteria of sustainable use were explained in the previous section. Tools are now available so that these criteria can be considered in use and management processes. These include, for instance:

- Databases and electronic data processing applications (DP tools)
- The “Tool for user surveys on comfort at the workplace (INKA)”
- The “Sustainability Compass” from the Deutsche Gesellschaft für internationale Zusammenarbeit¹²

4.1 Databases and DP tools

The comparative values needed for cost controlling and energy management are available from building databases. The databases of numerous private suppliers can be used for this purpose. Generally speaking, operators should build up their own databases on the basis of past consumption and cost data. This is particularly important for operators of extensive building stocks.

When it comes to planning and managing public sector buildings, the “Planning and cost-data module of the federal states and federal government” tool (PLAKODA – Planungs- und Kostendatenmodule der Länder und des Bundes) has become established. This tool was developed and is updated by Staatliche Vermögens- und Hochbauverwaltung Baden-Württemberg. Based on a comparison of properties, the PLAKODA provides in modules comparative values for operation costs and energy consumption. In order to ensure that PLAKODA has a sufficient and up-to-date data basis and can provide the required values for sustainable planning and management, actual costs and consumption rates must be reported regularly. The compliance with the reporting obligations creates an important basis for sustainable building operations.

FEDERAL BUILDING With a view to the management of federal government buildings, the provisions of Section K6 of the RBBau Guidelines must be observed in this context.

Systematic and standardised recording and analysis of costs and consumption rates are important preconditions for setting up a database and for reporting. The DP tools of numerous private suppliers can be used for this purpose. The “Energy and media information system of the federal government and federal states” (EMIS), which is being developed further via the EMIS working group, was drawn up for the recording and analysis of cost and consumption data of public sector buildings.

FEDERAL BUILDING The operator and the operational monitoring service must use this tool or an DP tool with similar functionalities in conjunction with the management of federal government buildings.

4.2 Sustainability assessment in the use phase

As already explained in the preface, a sustainability assessment can be carried out several times during the life cycle of a building. The BNB has a modular structure for this purpose.

As shown in the following figure C5, the following three application cases take place during the use phase:

- I.2/III.2: New building stock with assessment times b and d (see section 4.4)
- II.1: Regular operation with assessment times e and f (see section 4.3)
- II.2: Project preparation with assessment time e (see section 4.5)

The Use and Operation BNB module is the central assessment module of the use phase and is hence applied in all three phases. However, in cases I.2/III.2 and II.2, it is used as a supplementary module in conjunction with the New Construction and Complete Refurbishment modules.

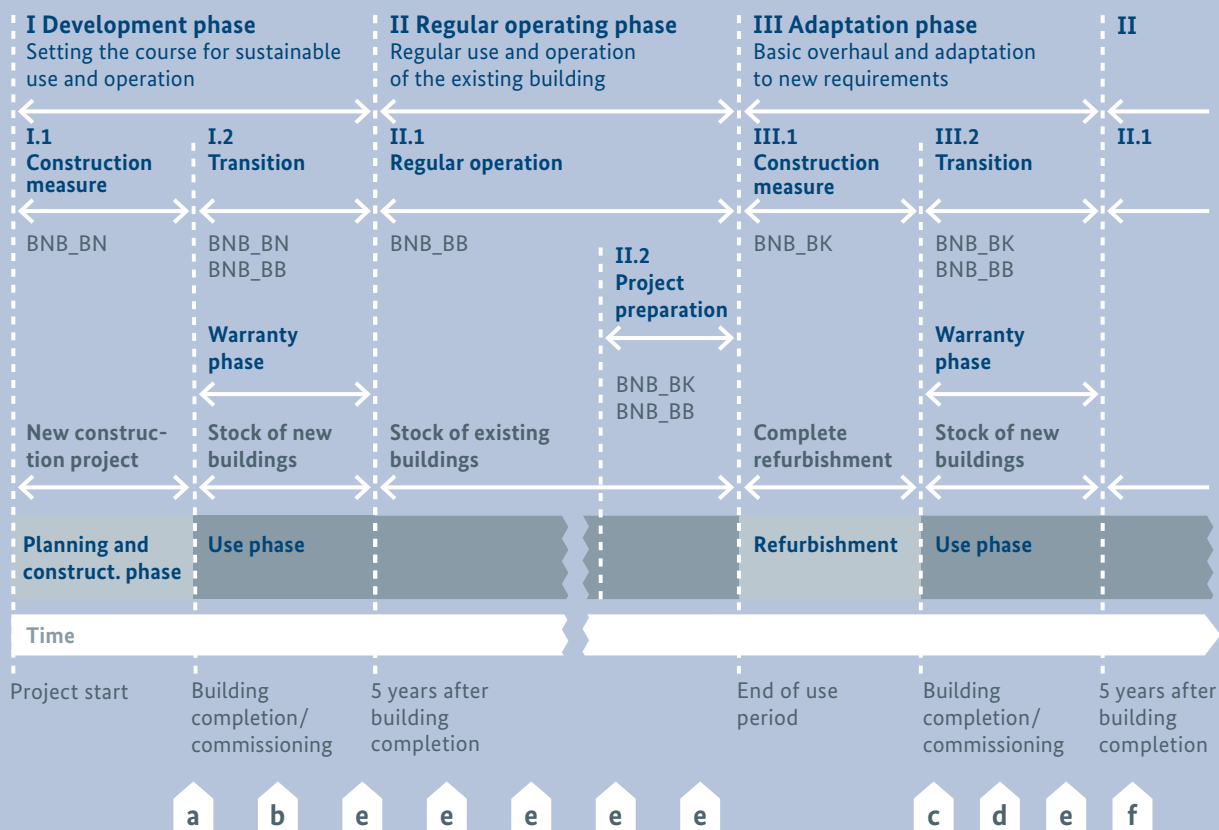
In addition to the GEFMA 160 “Sustainability in Facilities Management”,¹³ a directive is available for users outside BNB complete applications which could be a basis for the development of sustainability concepts and allows their systematic review.

12 See www.oeffentlichebeschaffung.kompass-nachhaltigkeit.de/en

13 “Nachhaltigkeit im Facility Management”, GEFMA 160, German Facility Management Association, 2014

ASSESSMENT TIMES IN THE USE PHASE

FIGURE C5



Possible assessment times:

- a Assessment of new construction project
- b Classification of new building stock as new construction (special solution for the transition phase)
- c Assessment of complete refurbishment
- d Classification of new building stock as complete refurbishment (special solution for the transition phase)
- e Assessment of the Use and Operation module (examples)
- f Special case of building diagnosis not linked to a measure (example)

Source: BBSR

4.3 Assessment of existing buildings with the Use and Operation BNB module

The application of Parts A and B of this Guideline and the related New Construction BNB module ensured that the principles, protective goods and targets of sustainable building were implemented in the planning and construction phase. The building quality achieved forms the basis for sustainable use and operation of the building. It is now therefore the task of all users and operators to guarantee and continuously improve during the use phase the quality of the building that was achieved in planning and execution.

This does not apply any less to existing buildings which were not yet planned and built according to the principles, protective assets and protection goals of sustainable building. With a view to these buildings too, it is the responsibility of all users and operators to achieve a sustainable use phase in as far as possible.

The Use and Operation BNB module is used to implement and quantify the general requirements for sustainable building, use and operation described in Parts A and C. With the assessment of individual aspects which are orientated towards the protection goals of

SUSTAINABILITY CRITERIA OF THE BNB MODULE USE AND OPERATION

TABLE C3

Sustainability criteria			Target value Score maximum	Factor of relevance	Percentage share of overall result	Target value
REAL QUALITIES (CRITERIA GROUP 1)					0.000 %	1400
Effects on Global and Local Environment						
BB	1.1.1	Greenhouse Gas Emissions due to Heating and Electric Energy Consumption	100	2	0.000 %	200
Demand of Resources						
BB	1.2.1	Heating and Energy Consumption	100	2	0.000 %	200
BB	1.2.3	Drinking Water Consumption	100	2	0.000 %	200
Health, Comfort and User Satisfaction						
BB	3.1.1	Actual Thermal Comfort in Winter	100	2	0.000 %	200
BB	3.1.2	Actual Thermal Comfort in Summer	100	2	0.000 %	200
BB	3.1.3	Actual Indoor Air Quality	100	2	0.000 %	200
BB	3.1.9	Actual User Satisfaction	100	2	0.000 %	200
PROCESS QUALITY OF USE AND OPERATION (CRITERIA GROUP 2)					100.0%	1900
BB	5.3.1	User Satisfaction Management	100	3	15.789 %	300
BB	5.3.2	Management of Energy and Water Consumption	100	3	15.789 %	300
BB	5.3.3	Operation Costs Controlling	100	3	15.789 %	300
BB	5.3.4	Inspection, Servicing and Safety Precaution	100	2	10.526 %	200
BB	5.3.5	Eco-friendly and Health-safe Cleaning	100	2	10.526 %	200
BB	5.3.6	Technical Operations Management and Qualification of Technical Staff	100	2	10.526 %	200
BB	5.3.7	Building Documentation throughout the Life Cycle	100	2	10.526 %	200
BB	5.3.8	Informing and Motivating Users	100	2	10.526 %	200

Source: BBSR

sustainable building, use and management processes can be assessed in their totality and compared with a view to sustainability quality.

The Use and Operation BNB module also honours outstanding operator achievements. Using a uniform assessment approach combined with both transparent and objectively understandable system rules, it creates the required transparency for the achievements of all those involved in the use and operation of the building. The Use and Operation BNB module is used to assess use and management processes, along with additionally selected actual property quality (real qualities). For this reason, the module is made up of two criteria groups: “real qualities” and “process quality of use and operation”.

What is important about the Use and Operation BNB module is that it takes a comprehensive look at use and management processes. The quality of these processes is examined with a view to aspects of equal treatment, while at the same time taking ecological, economic, socio-cultural and technical aspects into account. The main criteria groups of the New Construction and Complete Refurbishment BNB modules, in other words, “ecological quality”, “economic quality”, “socio-cultural and functional quality” as well as “technical quality”, are partially reflected in the “real qualities” criteria group examined (see also table C3). The result of the process qualities of use and operation are expressed in the selected actual building qualities examined there. These are, however, strongly influenced by the given building quality.

4.3.1 System rules and methodology

The aim of the Use and Operation BNB module is to fully assess and compare the quality of use and management processes with a view to sustainability. Since these processes are always also an expression of the response to building qualities, the building qualities must also be generally known. Information regarding real qualities (criteria group 1) must be designated in the assessment of the sustainability of use and operation. However, the assessment is primarily carried out on the basis of the criteria of process qualities (criteria group 2) because these can be influenced by users and operators mainly during the use phase.

The result of the assessment is the total degree of fulfilment which reflects the ratio between the score actually reached and the maximum score possible. The “real qualities” criteria group has no share in the total degree of fulfilment, however, it is shown in the assessment and serves as information and is therefore a basic

requirement for testing the conformity of the assessment. Furthermore, this criteria group also results in additional requirements (see table C4) which must be generally adhered to in order to be able to reach a certain quality level. The following quality levels can be reached depending on the degree of fulfilment:

Q3	80 % or more total degree of fulfilment	Outstanding use and operation
Q2	65 % or more total degree of fulfilment	Very good use and operation
Q1	50 % or more total degree of fulfilment	Minimum level for sustainable building management

The quality levels of use and operation listed here are deliberately different from the certificate levels of the New Construction or Complete Refurbishment BNB modules (gold, silver or bronze) because this is not a

ADDITIONAL REQUIREMENTS FOR ACHIEVING CERTAIN QUALITY LEVELS

TABLE C4

Additional requirements	Quality level	Specific additional requirements	
		Criteria	Degree of fulfilment
The “real qualities” criteria group was assessed. A degree of fulfilment of 10 % or more was reached in each criterion.	Q3	<ul style="list-style-type: none"> Before the assessment period commenced, the target agreement table is defined according to section 4.3.4.2 Reached degrees of fulfilment of all criteria are larger than degrees of fulfilment according to the target agreement table 	
		BNB_BB 3.1.1 Actual Thermal Comfort in Winter	≥ 70 %
		BNB_BB 3.1.2 Actual Thermal Comfort in Summer	≥ 70 %
	Q2	BNB_BB 3.1.3 Actual Indoor Air Quality	≥ 70 %
		BNB_BB 3.1.9 Actual User Satisfaction	≥ 70 %
		BNB_BB 5.3.1 User Satisfaction Management	≥ 70 %
		BNB_BB 5.3.2 Management of Energy and Water Consumption	≥ 70 %
		BNB_BB 5.3.3 Operation Costs Controlling	≥ 80 %
		BNB_BB 3.1.1 Actual Thermal Comfort in Winter	≥ 50 %
		BNB_BB 3.1.2 Actual Thermal Comfort in Summer	≥ 50 %
		BNB_BB 3.1.3 Actual Indoor Air Quality	≥ 50 %
		BNB_BB 3.1.9 Actual User Satisfaction	≥ 50 %
		BNB_BB 5.3.1 User Satisfaction Management	≥ 50 %
		BNB_BB 5.3.2 Management of Energy and Water Consumption	≥ 50 %
		BNB_BB 5.3.3 Operation Costs Controlling	≥ 50 %
	Q1	BNB_BB 3.1.3 Actual Indoor Air Quality	≥ 50 %
		BNB_BB 3.1.9 Actual User Satisfaction	≥ 50 %
		BNB_BB 5.3.1 User Satisfaction Management	≥ 50 %

Source: BBSR

comparable assessment. The focus during the use phase is primarily on use and operation processes, whereas in the planning phase, it is largely the building qualities that are assessed. This distinct difference is expressed through another type of quality level.

The assessment using the module is carried out in retrospect so that the use and management processes of the past three years are assessed. The building forms the physical system boundary because it lies directly within the operator's range of influence. The assessment is then checked by a third party with a view to conformity with the assessment rules (conformity test). The purpose of this check is quality assurance, and the check is carried out by a conformity testing office appointed by the BMI.

4.3.2 Assessment motives

There are various reasons to perform a sustainability assessment during the use phase using the Use and Operation BNB module. The following motives can be generally distinguished due to their specific issues and decision situations:

Assessment motive 1	Continuous quality management to secure sustainable process and building qualities
Assessment motive 2	Identification of current building qualities in preparation of a building measure, if necessary, in conjunction with a building diagnosis
Assessment motive 3	Monitoring success after a new construction project or complete refurbishment
Assessment motive 4	First-time recording of an existing building, if necessary, in conjunction with a building measure or a comprehensive building diagnosis

This takes place according to the rules of section 4.3.4 "Quality management to secure sustainable process and building qualities".

4.3.3 Overall assessment and partial assessment

A full assessment (overall assessment) of the use phase using the two criteria groups of the Use and Operation BNB module is only possible for buildings that can be assessed with a system variant for which a Use and Operation module has been developed. The Sustainable Building Information Portal (www.nachhaltigesbauen.de) provides details of the system variants for which this module is available.

For all other types of buildings, a partial assessment is currently possible which is carried out exclusively using the "process quality of use and operation" criteria group. This is applied analogous to the overall assessment using the Use and Operation BNB module. All additional requirements according to section 4.3.1, which refer to the criteria of the "real qualities" criteria group, are not applicable.

4.3.4 Quality management to secure sustainable process and building qualities

A regular description and assessment using the Use and Operation BNB module can be carried out after building quality has been assessed using the New Construction, New Building Stock or Complete Refurbishment BNB modules. However, previous assessment of building quality is not necessary.

The Use and Operation BNB module must be used in the use phase of a building as a quality management tool. For this purpose, assessments of use and management processes must be repeatedly carried out at regular intervals throughout the entire use phase. In order for the assessment to be valid, however, the use and operation processes must also be as laid down in the BNB module. This means that in addition to regular description and assessment, the Use and Operation BNB module must also be continuously applied during use.

4.3.4.1 Cases of application

Existing buildings with the planning and construction phase previously assessed according to BNB

Quality management to secure sustainable process and building qualities using the Use and Operation BNB module should especially take place if the planning and construction phase of an existing building was already orientated towards the requirements of a BNB module. This also applies to buildings where the planning and construction phase was assessed with a BNB module and a degree of fulfilment of more than 50 percent was reached. The Use and Operation BNB module is used here with the following intention:

- Assessment of sustainability as a method for monitoring success by recording and analysing selected actual building qualities
- Assessment of sustainability to secure sustainable building management so that the qualities foreseen in the planning and construction phase are in fact implemented
- Assessment of sustainability as a measure to secure a building that is in fact sustainable

FEDERAL BUILDING It is recommended for federal government buildings that the Use and Operation BNB module usually be applied for the first time three years or five years at the latest after the building was handed over according to Section H of the RBBau Guidelines. In the interest of sustainable building management, the assessment must then be carried out regularly at intervals of no more than five years.

Other existing buildings

In order to objectively identify building quality, existing buildings where the planning and construction phase was not assessed with a BNB module (so-called “other existing buildings”) should also be assessed using the Use and Operation BNB module. In the case of other existing buildings, process and building qualities are identified and assessed in the use phase as part of an extended building diagnosis which not only includes the criteria of the Use and Operation BNB module, but also covers all technical, functional and other issues. In criteria group 2 “process quality of use and operation”, the assessment result thus makes the quality of the management processes visible.

The use of criteria group 1 “real qualities” makes it possible to examine whether and to what extent shortcomings exist with regard to key features and properties of the building so that it may be found that refurbishment is overdue. If a significant deviation from the minimum requirements or from a level that appears reasonable for the age and condition of the building is found, the reasons for such deviation must be examined in more detail. In order to secure optimum building management with a view to sustainability, the so-called other existing buildings should also be regularly assessed with the Use and Operation BNB module.

FEDERAL BUILDING In the case of federal buildings, the operator should gear management processes as closely as possible to the Use and Operation BNB module. Every five years, the management processes must undergo partial assessment in which the criteria of “process quality of use and operation” are exclusively assessed. It is recommended that a complete assessment with the Use and Operation BNB module be carried out at regular intervals of no more than ten years and that this be coordinated with the required renewal of the energy consumption certificate.

4.3.4.2 Application of the BNB module

In as far as sustainability is to be regularly assessed with the Use and Operation BNB module, this must be carried out during use. This is the only way in which a positive assessment result (in excess of 50 percent degree of fulfilment) can be reached and hence sustainable building management ensured.

Since the sustainability assessment is a retrospective assessment, the application of the BNB during use has a steering effect. When it comes to steering management processes, three phases must be distinguished:

Phase 1 Goals	Before the assessment period commences, goals are defined accordingly as part of a target agreement.
Phase 2 Steering	During the assessment period, management processes are steered so that the goals set can be reached.
Phase 3 Assessment	After the end of the assessment period, the final BNB assessment and the subsequent conformity test are carried out.

Phases in the assessment with BNB module

Goal phase

In preparation of the target agreement, a preliminary assessment with the Use and Operation BNB module must be carried out at the beginning of the goal phase so that the current status of building and management qualities is known. As part of the goal phase, the operator must make an agreement involving the authority using the building in which the quality goals are defined on the basis of the criteria of the Use and Operation BNB module. The operator and the authority using the building must enter into this agreement, also subject to agreement with the building realisation level and the operational monitoring service taking into account their areas of responsibility pursuant to the RBBau Guidelines.

A target agreement table must be drawn up for the target agreement as shown in Annex C7 to this Guideline and must contain at least the following details for each criterion:

- Minimum degree of fulfilment for each individual criterion
- Target value for each individual criterion
- The services to be performed in order to reach the goals set
- The verifications to be furnished
- Responsibilities
- Time schedule

Once the target agreement has been made, the operator must identify measures based on the agreement which must be implemented before the assessment period begins so that the goals can be reached. It is especially important here that the organisational structures needed to secure the required process qualities are established and that suitable tools are drawn up for operating staff.

Steering phase

The steering phase describes the phase of the assessment period that lasts at least three years. During the steering phase, intermediate assessments of the assessment status reached must be carried out at least once a year. The administration using the building, the building realisation level and the operational monitoring service must be notified of the intermediate result at the end of each year.

Assessment phase

Following conclusion of the steering phase, final assessment is carried out using the Use and Operation BNB module. Documentation and verifications must be prepared according to the provisions of the BNB audit manual. Once the assessment and verifications have been completed, the complete assessment documents must be submitted to the conformity testing office in charge for examination.

4.4 Assessment of new building stock as a special case

In the transition phase at the beginning of the use phase (see figure C5), the New Construction or Complete Refurbishment BNB modules can be used in combination with the Use and Operation BNB module for existing buildings which must still be classified as so-called new building stock.

These are existing buildings which:

- were accepted under construction law and handed over to the authority using the building following erection of a new construction or refurbishment no more than five years previous, and
- were occupied and put into operation either fully or partially by the authority using the building.

The new building stock is described and assessed with a variation of the New Construction BNB module or with a variation of the Complete Refurbishment BNB module. In this case, the New Construction or Complete Refurbishment BNB modules are supplemented and replaced in some areas with the criteria of the Use and Operation BNB module. The variations of the two BNB modules are referred to below as the **New Building Stock BNB transition module**. The variation affects the following issues:

- The assessment methodology of the criteria of environmental impacts and resource consumption (criteria: BNB_BN 1.1.1 to 1.1.5 and 1.2.1) deviates in the section on “Calculation methods for the use scenario”. In this case, the energy consumption rates from BNB_BB 1.2.1 (see section 3.2.3.2 “Energy consumption”) must be used in the New Building Stock BNB transition module instead of the final energy consumption from the calculation pursuant to the EnEV. This does not affect the remaining assessment methodology.
- The assessment methodology of the criterion of building-related costs in the life cycle (criterion: BNB_BN 2.1.1) deviates in the section on “Selected operation costs”. In the New Building Stock BNB transition module, actual supply and disposal costs (cost categories 310 and 321 according to DIN 18960), as well as actual cleaning costs (cost category 330 according to DIN 18960), must be used as a basis for

calculating life cycle costs. The results of the BNB_BB 1.2.1 and BNB_BB 1.2.3 criteria must also be used here (see section 3.2.2 “Operation costs controlling”). This does not affect the remaining assessment methodology.

- Assessment of actual thermal comfort (BNB_BN 3.1.1 is replaced by BNB_BB 3.1.1 and BNB_BB 3.1.2)
- Assessment of actual indoor air quality (BNB_BN 3.1.3 is replaced by BNB_BB 3.1.3)
- Additional integration of actual user satisfaction (BNB_BB 3.1.9)
- Assessment of the process qualities of use and operation instead of the process qualities from the planning and construction phase (criteria BNB_BN 5.1.1 to 5.2.3 are replaced by BNB_BB 5.3.1 to 5.3.8)

Annex C6 contains the criteria table of the New Building Stock BNB transition module based on the example of the “Office and Administration Building” system variant. This has no effect on the other rules, including the rules of the New Construction and Complete Refurbishment BNB modules concerning the degree of total fulfilment and quality level (gold, silver or bronze) (see Part A).

Two application cases for the New Building Stock BNB transition module must be distinguished and are explained in the following sections.

4.4.1 Continuation of the conformity-tested assessment of the planning and construction phase

The New Building Stock BNB transition module should be applied to existing buildings which are classified as new buildings and for which a conformity-tested assessment with the New Construction or Complete Refurbishment BNB modules is available (first-time building assessment). The implementation of the process qualities of use and operation in the assessment ensures that, apart from the building quality achieved, the organisational foundation for a permanently sustainable use phase has also been laid. In this case, the first-time building assessment must be updated as required by the New Building Stock BNB transition module by applying the Use and Operation BNB module and then subjected to a conformity test (second building assessment).

The result of the second building assessment must be submitted to the conformity testing office responsible for the first-time building assessment no later than five years after the building was handed over to the authority using the building. If the first-time building assessment resulted in a gold, silver or bronze award for the level of quality, the BMI can revoke this award following a recommendation by the conformity testing office in charge if:

- the second building assessment was not submitted on time,
- the first-time assessment of the building showed a gold award for the level of quality and the degree of fulfilment in the second building assessment is below 65 percent,
- the first-time assessment of the building showed a silver award for the level of quality and the degree of fulfilment in the second building assessment is below 50 percent.

The New Building Stock BNB transition module is based on the version of the New Construction or Complete Refurbishment BNB module which already formed the basis for the first-time building assessment. This must be combined with the current version of the Use and Operation BNB module.

4.4.2 First-time assessment of new building stock

If no conformity-tested assessment with the New Construction or Complete Refurbishment BNB modules is available, this can be subsequently carried out for construction projects which are classified as new building stock using the New Building Stock BNB transition module. In this case, the New Building Stock BNB transition module is based on the version of the New Construction or Complete Refurbishment BNB module currently valid at the time the building is handed over to the authority using the building. This must be combined with the currently valid version of the Use and Operation BNB module. It is not permitted to assess new building stock using the New Construction or Complete Refurbishment BNB modules.

4.5 Preparation of a measure to cover an identified demand

The use phase of existing buildings can be assessed in two different phases of covering demand, each with different depths of examination:

- Examination of procurement variants
- Identification of building qualities as a basis for planning construction projects

Examination of procurement variants

It does not make sense to perform a complete sustainability assessment using the Use and Operation BNB module during this phase of the project preparation. However, the different procurement variants can be compared using the consumption and GHG emissions criteria (BNB_BB 1.1.1, 1.2.1 and 1.2.3). With a view to existing buildings, the criteria can be applied according to the assessment methods described in the criteria profiles. For buildings which have not yet recorded any consumption data, planned values or target values must be used as a basis for assessment. Generally speaking, a complete target agreement for building and process qualities in the use phase can be carried out according to the Use and Operation BNB module (see section 4.3.4.2). As part of this target agreement, minimum qualities must be defined which must be generally fulfilled by each procurement variant.

Identification of building qualities as a basis for planning construction projects

With a view to the sustainable development of existing buildings, a building diagnosis must first be carried out in order to describe and assess the current condition of the existing building. Combined with a more in-depth examination, the Use and Operation BNB module can help to identify and analyse shortcomings in the existing building examined compared to an existing or a future requirement level. The BNB module is used in this context as an element of a comprehensive building diagnosis. The identification, analysis and assessment of operation costs, consumption rates and user satisfaction offer an important insight into the actual quality of the building. These findings can serve as a basis for planning for decisions regarding refurbishment, modification or conversion.

The ideal starting point for a building measure in an existing building is when the Use and Operation BNB module has already been applied continuously and at regular intervals during use. In this case, other important information regarding actual building quality is supplied by the management of energy and water consumption, cost controlling, user satisfaction management, inspection and servicing planning and building documentation throughout the life cycle.

A comprehensive building diagnosis with integrated application of the Use and Operation BNB module, for instance combined with the New Construction or Complete Refurbishment BNB modules, can help to identify building quality compared to a new building or to identify strengths and weaknesses as well as the potential for optimisation and the risks with the existing building. The further goals of the building diagnosis vary depending on the intended depth of intervention into existing buildings. If the building measure foreseen involves complete refurbishment, a comprehensive building diagnosis can also serve as a tool for determining the qualities worth protecting. In the case of partial refurbishment, on the other hand, it is also necessary to determine the scope of the building measure actually needed. Part D of this Guideline addresses the application of the Use and Operation BNB module in order to identify building qualities as a basis for planning building measures in existing buildings.

4.6 BNB sustainability coordination in the use phase

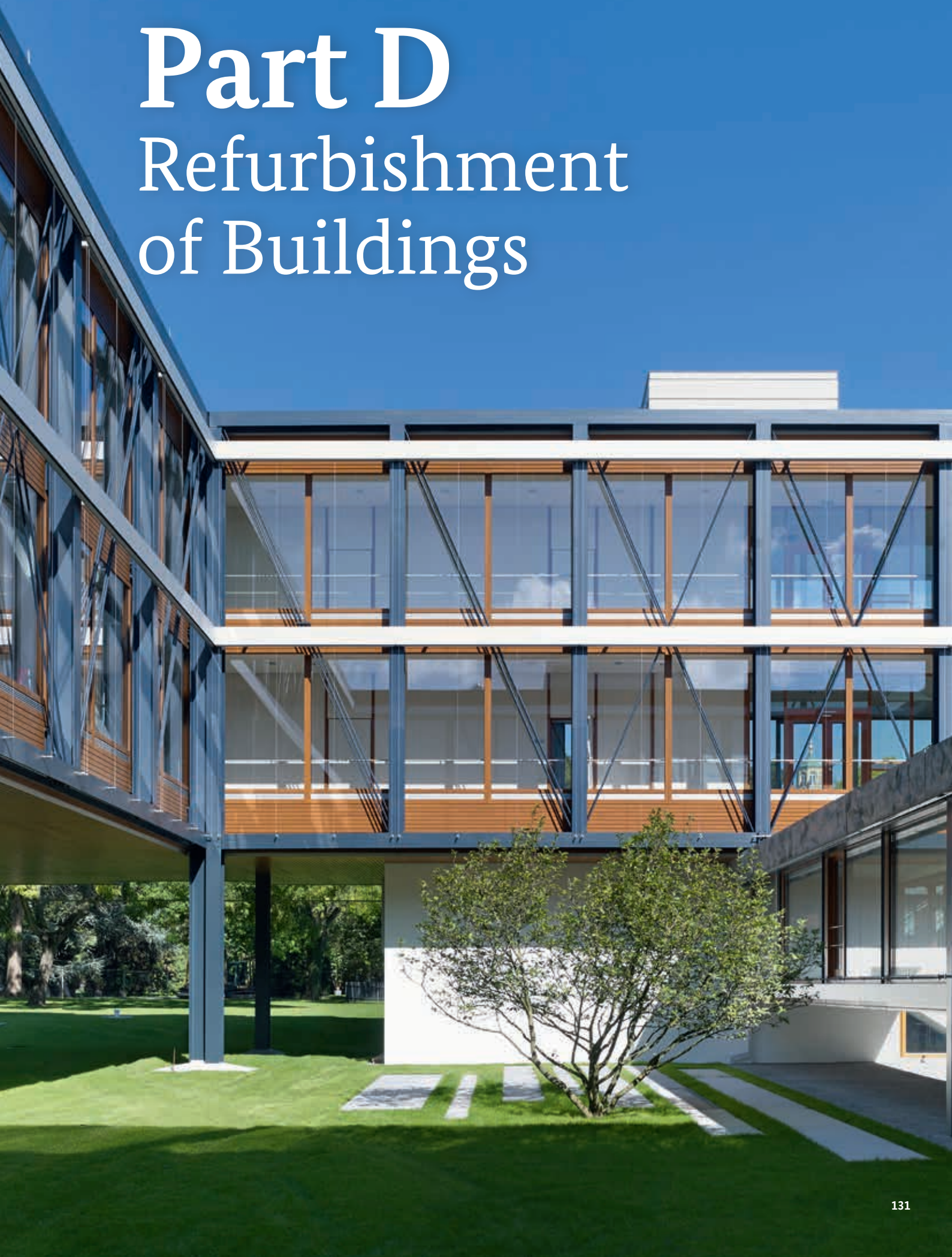
The operator must appoint a BNB sustainability coordinator for each existing building. This coordinator is commissioned by the operator to check the building management processes for compliance with the Guideline for Sustainable Building, to coordinate sustainability in the use phase and to perform sustainability assessments. The sustainability coordinator is supported by the authority using the building, the building realisation level and the operational monitoring service.

When the Use and Operation BNB module is applied during use, the sustainability coordinator coordinates the goal phase. For this purpose, he performs a preliminary assessment according to BNB and coordinates the target agreement as well as the measures to prepare the steering phase. This is where the BNB sustainability coordinator compiles the information relevant for the assessment and performs intermediate assessments. On behalf of the operator, he is responsible for the reporting obligations pursuant to section 3.2.10.

The BNB sustainability coordinator performs the final BNB assessment and hands over the complete assessment, including verifications, to the conformity testing office according to its requirements. When requested by the conformity testing office, the sustainability coordinator revises the assessment and submits it once again for inspection. He supplies digital copies of the conformity-tested documents to the authority using the building, the building realisation level and the operational monitoring service.

Part D

Refurbishment of Buildings



Part D – Refurbishment of Buildings

1. Sustainable development of building stock	133	4.3	Socio-cultural and functional quality	150
2. Terminology of sustainable building stock development	134	4.3.1	Design and urban quality.....	151
2.1 Refurbishment projects	134	4.3.2	Art in architecture.....	153
2.2 Types of measures	134	4.4	Technical quality	153
2.3 Complexity of measures	135	4.5	Process quality.....	154
2.4 Structural substance of an existing building	136	4.5.1	Stock-taking.....	154
3. Principles of refurbishment.....	138	4.5.1.1	Structural survey	156
3.1 General principles and principles applicable to existing buildings.....	138	4.5.1.2	Building diagnosis.....	158
3.2 Comparison of new construction and refurbishment projects	138	4.5.2	Demolition planning and demolition measures.....	161
3.3 Framework conditions for building stock development	139	4.5.2.1	Demolition planning	162
4. Specific criteria for sustainable building refurbishment	140	4.5.2.2	Concept for selective demolition	162
4.1 Ecological quality.....	141	4.5.2.3	Examination of waste separation and disposal options	162
4.1.1 Eco-balancing.....	141	5. Sustainability assessment of refurbishment measures	163	
4.1.1.1 Handling existing building structures.....	142	5.1	Sustainability assessment of complete refurbishment measures.....	165
4.1.1.2 Comparative effect estimation of new and existing building measures.....	142	5.2	Sustainability assessment of partial refurbishment measures.....	166
4.1.1.3 Balancing of the building substance	142	5.3	Analogous application	166
4.1.1.4 Balancing the supply during use.....	142			
4.1.1.5 Balancing disposal	143			
4.1.1.6 Eco-balance assessment.....	143			
4.1.2 Risks for the local environment	145			
4.1.2.1 Assessment of risks from construction products in old building structures.....	145			
4.1.2.2 Assessment of risks from construction products in new building structures	146			
4.1.3 Sustainable material extraction/ biodiversity	146			
4.1.4 Land consumption	147			
4.2 Economic quality.....	147			
4.2.1 Building-related life cycle costs.....	147			
4.2.1.1 Life cycle cost analysis methodology for refurbishment projects.....	148			
4.2.1.2 Assessment of life cycle costs	149			
4.2.2 Adaptability.....	150			

1. Sustainable development of building stock



The old building at Stresemannstrasse 128 in 2005. (left)
Today, the new BMU office building creates an exciting mix of old and new.

Buildings owned by the Federal Republic of Germany account for a large share of total energy consumption and a significant portion of total greenhouse gas emissions. In an effort to counteract this, the planning, design and implementation of energy-efficient new buildings have been promoted for many years. Besides this, however, society as a whole must be committed to tapping into the enormous potential to save energy in existing buildings with approximately 18 million residential and some 1.5 million non-residential buildings. Around two thirds of existing buildings were erected before the first Ordinance on Heat Conservation came into effect in 1977, and most of them have not yet undergone complete energy efficiency modernisation.

Furthermore, existing buildings represent the resources and energy consumed during their construction so that they are usually of high ecological value. Extending the period of use for existing buildings through re-use, refurbishment and/or conversion can be an essential part of a solution to save resources and protect the environment.

Since existing buildings are key to how urban spaces are perceived, they help to shape identity. As part of the sustainable development of existing buildings, this must be taken into account just as much as the activation of any potential for optimisation. The value of existing buildings for society is expressed by their cultural diversity and the distinguished and location-specific appearance of our cities.

Existing buildings and hence the related economic value are certainly worth preserving with a view to sustainable development. Whether a building can still meet requirements, for instance, in terms of its economic efficiency, functionality and safety, is a matter that needs to be examined. If such requirements cannot be met through refurbishment or conversion, the question then is whether these requirements can be met by another building or, in exceptional cases, by a new replacement building, although the latter should generally be the last resort.

Against this background, measures to maintain, refurbish and convert existing buildings are particularly important. The principles of sustainable development must be implemented in much the same way as in the case of new buildings. When it comes to qualifying and converting existing buildings, the same ecological, economic and socio-cultural aspects must hence be equally taken into consideration.

2. Terminology of sustainable building stock development

2.1 Refurbishment projects

Refurbishment projects for the purposes of this Guideline include projects to enhance the value of existing buildings (see also Sections D and E of the RBBau Guidelines). Refurbishment projects encompass a host of terms that are used for work on existing buildings, such as rehabilitation, improvement, conversion or refurbishment. Many of the terms used colloquially have no standard definitions in the industry.

The types of measures are defined in the Guideline for Sustainable Building in line with the terminology used in the “Official Scale of Fees for Services by Architects and Engineers” (HOAI) and analogous to the structure of DIN 18960 “Use Costs of Buildings”. Projects designed to achieve the target condition (maintenance work within the meaning of the HOAI, repair and inspection services) do not constitute refurbishment for the purposes of this Guideline (see also Section C of the RBBau Guidelines and Part C of the Guideline for Sustainable Building). This Guideline differentiates between refurbishment projects according to their type and degree of complexity.

2.2 Types of measures

The definitions below apply to the different types of measures.

Types of refurbishment measures

- **Repair:** measures to restore the condition suitable for the original purpose (target condition) of a building, building part, component or system.
- **Refurbishment:** construction measures other than extension, conversion or repair work designed to achieve a sustainable increase in the use value of the building.
- **Modification:** measures to convert an existing building, including changes in structural design. Modification measures are essentially designed to change the layout of an existing building.
- **Interior measures:** work related to the interior design of existing or the creation of new interior spaces without any major intervention in building structures or building design. Such measures include new construction, extension, conversion, refurbishment, maintenance and repair activities.

- **Extension measures:** measures to supplement an existing building, typically leading to greater building use. Extension measures are usually annexes or additional storeys, often in combination with other types of measures. Whether the Complete Refurbishment BNB module or the New Construction BNB module can be applied to an extension measure depends largely on the structure of the measure itself and is carried out in co-operation with the appropriate Conformity Testing Office. Irrespective of this, Part D of this Guideline must be observed in any case for the existing building.
- **Conversion measures:** designed to change the type of use. Besides the legal component, these measures are usually also related to refurbishment work, which often encompasses several types of projects. Therefore, reuse usually also calls for far-reaching conversion and refurbishment. A change in the type of use also leads to a change in allocation of the applicable system variant of the Assessment System for Sustainable Building (see Part A, section 2.1).

Other types of measures

- **Reconstruction:** restoring destroyed structures on the basis of existing building or system parts. For the purposes of this Guideline, these structures are considered to be new buildings.
- **Maintenance:** measures to preserve the target condition of a building. Maintenance measures are not refurbishment measures for the purposes of this Guideline, but instead represent use and operation processes (see Part C of this Guideline).

2.3 Complexity of measures

The complexity of refurbishment is a function of the scope of the measure, its depth of intervention in the building and the type of measure. Similar to the customary terminology used for the types of measures, there is also no clear-cut definition of the terminology used to describe the complexity of measures. Terms which are often used for differentiation include “core rehabilitation”, “full rehabilitation” or “partial rehabilitation”, even though these terms cannot be clearly distinguished and are used differently from case to case and depending on who is using them. The term

“rehabilitation”, also, lacks a precise definition. The colloquial use of the term encompasses, to different degrees, both the type of measure and its degree of complexity so that this term is not suitable for defining either of them.

The term “rehabilitation” is therefore avoided in this Guideline. When it comes to describing the complexity of a measure, the terms “complete refurbishment” and “partial refurbishment” are used on the basis of the definitions given below (see also figure D1, page 137):

Complete refurbishment

Complete refurbishment is characterised as follows:

- **Scope of the measure**
Complete refurbishment means construction work on an independent, existing structure in its entirety.
- **Depth of intervention in the building**
The purpose of complete refurbishment is to provide an existing building in its entirety with characteristics and features that correspond largely to those of a new building. During complete refurbishment, existing buildings are largely stripped down to the structurally relevant elements of the building (load-bearing and reinforcing elements).
- **Type of measure**
Complete refurbishment encompasses comprehensive work on existing buildings and generally several types of measures. Complete refurbishment is characterised by interaction between:
 - Repair work in order to achieve more or less the same service life of the building components as in the case of new buildings
 - Refurbishment work in order to provide the building with technical properties as well as building structures and building system features largely identical to those of new buildings
 - Conversion work in order to adapt the physical structure to new requirements
 - Interior work in order to renew or modify interior design

Partial refurbishment

Partial refurbishment encompasses all kinds of work on existing buildings other than complete refurbishment. Measures are typically characterised as partial refurbishment if one of the following conditions is met:

- **Scope of the measure**
Partial refurbishment means that a construction measure involves parts of a building or building elements which form part of the existing building rather than an independent building in its entirety.
- **Depth of intervention in the existing building**
Partial refurbishment means that it is not the purpose of the construction measure to refurbish the existing building in its entirety to a condition with characteristics and features that are largely equivalent to those of a new building. This is typically the case if refurbishment does not mean the almost complete stripping of the building down to the structurally relevant (load-bearing and reinforcing) elements.
- **Type of measure**
Partial refurbishment usually means refurbishment which is not characterised by interaction between multiple types of measures.

One of the main differences between complete refurbishment and partial refurbishment is that partial refurbishment projects mostly lead to an analogous application of the Complete Refurbishment BNB module (see Annex A1) since the individual aspects cannot be fully mapped.

FEDERAL BUILDING At the time the Decision-making Documents (ES-Bau) are drawn up for a refurbishment measure, the level responsible for technical oversight analyses whether the criteria for complete refurbishment according to the Guideline for Sustainable Building are fulfilled. The level responsible for technical oversight communicates the result of the analysis to the supreme technical authority and the appropriate BNB Conformity Testing Office. The supreme technical authority classifies a refurbishment project as complete refurbishment on the basis of the opinion of the appropriate BNB Conformity Testing Office and in agreement with the project sponsor (owner).

The building realization level has to inform the level responsible for technical oversight when it is found during the further course of the project (for instance, after completion of a design competition) that the criteria for complete refurbishment according to the Guideline for Sustainable Building are not completely fulfilled. The level responsible for technical oversight then checks whether the criteria for complete refurbishment according to the Guideline for Sustainable Building are fulfilled and communicates the result to the supreme technical authority and to the appropriate BNB Conformity Testing Office. The supreme technical authority classifies the construction project as a partial refurbishment on the basis of the proposal by the appropriate BNB Conformity Testing Office and in agreement with the project sponsor (owner). In this case, a decision must be made as to whether certification is to be carried out within the scope of analogous application.

If it is found during the course of a partial refurbishment project that the criteria for complete refurbishment are fully fulfilled, the analogous procedure must be applied. In the event that this is found at a time when planning/design and construction work has advanced to such an extent that it is unlikely that complete verification according to the Assessment System for Sustainable Building will still be possible, the supreme technical authority then has to decide in agreement with the project sponsor (owner) to what extent it is still possible to adopt the BNB complete refurbishment system variant in the sense of complete verification and certification.

2.4 Structural substance of an existing building

Refurbishment work usually does not preserve the entire structure of an existing building so that once again different terms must be developed here for application of the Guideline.

A distinction must hence be made between:

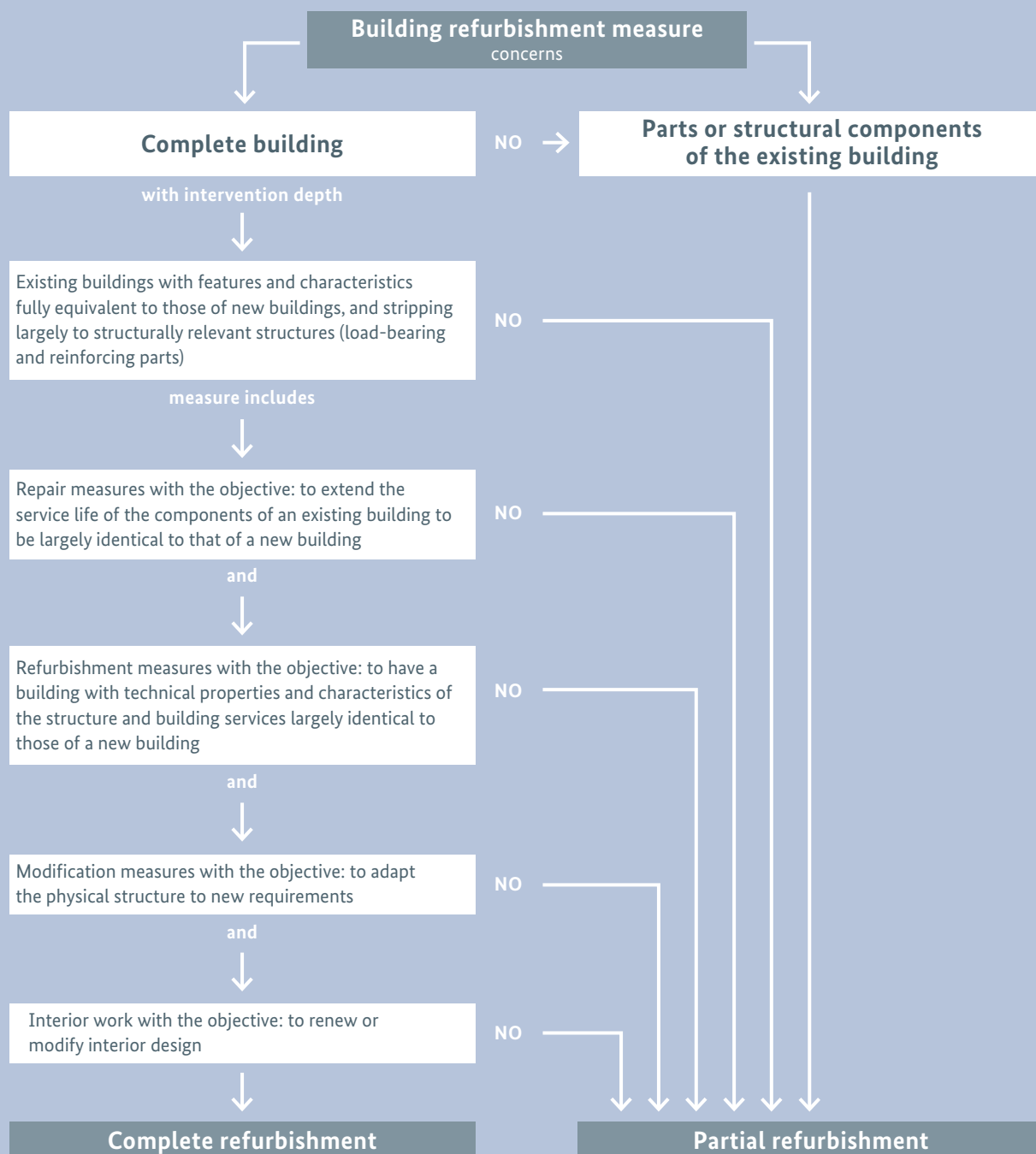
- **Old building structures** (structure and building services), broken down into:
 - Old building structures which remain in use (unchanged, continued use at the site)
 - Reused old building structures (recycling of components or construction materials at the construction site)
 - Dismantled old building structures
- **New building structures** (building structure and building services) to be integrated into the existing building in the course of the refurbishment project

In terms of their effects both in and on the building, old building structures and new building structures must generally be observed separately in building assessments.



Passage from the old to the new BMU building on Stresemannstraße during construction

INTERVENTION DEPTH – DISTINCTION BETWEEN COMPLETE REFURBISHMENT (LISTED AND NOT LISTED) AND PARTIAL REFURBISHMENT
FIGURE D1



Source: BBSR

3. Principles of refurbishment

D3

3.1 General principles and principles applicable to existing buildings

Part A of this Guideline introduces the principles of sustainable building. These principles apply to both new building projects and, with certain modifications, to refurbishment projects. The same applies to the methods for integrating sustainability aspects into the planning and design process explained in Part B. In this case too, new building and refurbishment projects differ only in part. That being said, a host of special building-specific aspects do need to be addressed. The need to distinguish between these different aspects is due to the fact that the planning and construction processes in refurbishment projects differ in many ways from those in new construction projects. On the other hand, certain sustainability aspects must be looked at when dealing with existing buildings.



Preserving the high design and use quality during the complete refurbishment of the German Federal Constitutional Court in Karlsruhe

This Part D deals with the special characteristics of sustainability in refurbishment projects and hence supplements the information in Parts A and B. In as far as Part D does not contain any specific explanations, recommendations or rules for action applicable to existing buildings, Parts A and B are also applicable to refurbishment projects.

3.2 Comparison of new construction and refurbishment projects

Users often expect that refurbishment measures in existing buildings can achieve a quality that is comparable to that of new buildings. This is often the case. However, certain building-specific aspects of existing buildings can prevent this. These are, on the one hand, due to the history of the building as well as the fact that it is not technically possible to change the way the building was erected. Furthermore, certain minimum legal requirements differ for existing and new buildings.

One example of this is that refurbished buildings cannot always achieve the energy quality of the building envelope of new buildings. However, this does not mean that refurbished buildings cannot reach high sustainability levels. The construction of new buildings, and especially of their structure, involves significant energy and material flows and consequently impacts the environment to a higher degree than refurbishment work. This example illustrates the principles of addressing new and existing buildings. Any isolated, direct comparison of individual quality aspects of new building and refurbishment projects should be avoided, whilst the features and characteristics of new and existing buildings call for a different assessment of certain criteria. That being said, however, the assessment of building quality should not differ significantly for new and existing buildings where quality requirements are concerned.



Reconstructed, listed facade of the German Federal Constitutional Court following pollutant cleanup

D 3

3.3 Framework conditions for building stock development

Refurbishment projects are characterised not only by the given structural and technical condition of a building. Refurbishment projects can be subject to even more restrictive legal conditions than new construction projects. Any intervention in the structure of a building must abide by the applicable laws and regulations which are additionally subject to interpretation and the resultant case law of higher and supreme courts. Building planning laws and regulations, as well as fire protection regulations related to these, are particularly important. Existing buildings frequently fail to comply with applicable law and very often require high or even unreasonable effort and cost to be upgraded to a level that complies with the relevant legal situation. One particularly important aspect is grandfathering, which ensures protection against retroactive changes in laws and regulations. These provisions may also apply to parts of the building which are not directly affected by conversion. Monument protection sometimes also has a role to play as a basis for exceptional treatment (for instance, Section 24 (1) of the EnEV) or additional requirements for the building.

Historic monuments bear witness to cultural history and have a significant impact on the way cities are perceived. They are of strong identity-creating and social relevance. Measures with buildings worth listing must be performed in a manner that complies with the needs of such buildings and thus constitute an important aspect of sustainable construction. Within the framework of the BNB application, alternative procedures and special rules are therefore used in the relevant, stock-specific criteria in the assessment of existing listed buildings.

A building is classified as a listed building for the purpose of this Guideline if:

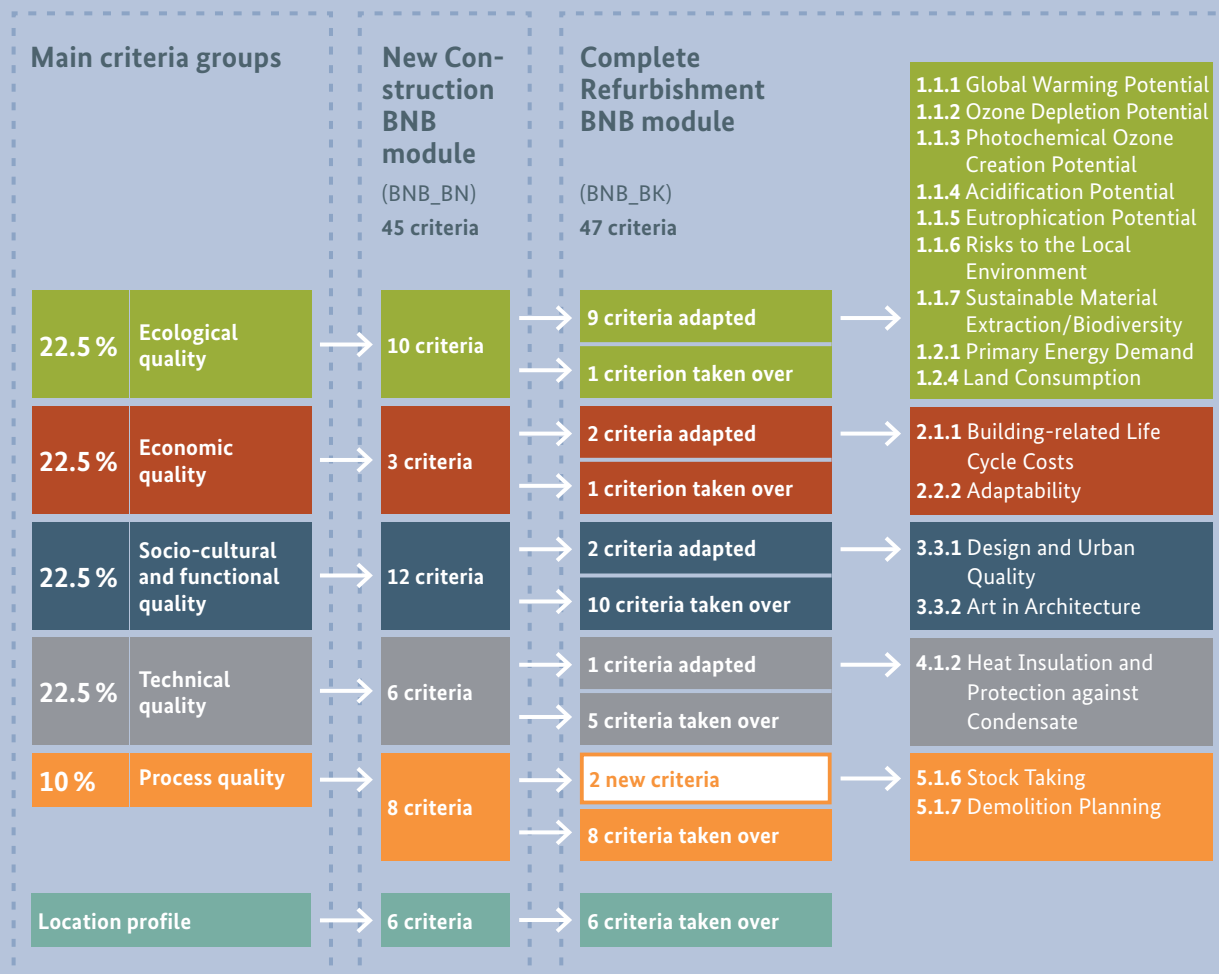
- the building is a monument within the meaning of the listed buildings legislation of the respective federal state (monument),
- the building forms part of an area or a group, complex or collection of buildings protected under the listed buildings legislation of the respective federal state (monument area),
- the building is of monument value due to its historic, artistic, scientific or urban importance (monument-worthy building). Monument-worthiness can be confirmed, for instance, by an expert opinion.

4. Specific criteria for sustainable building refurbishment

With a view to sustainable development, refurbishment projects are subject to the same requirements as new construction projects. However, the special features of the existing building must be taken into consideration without generating excessive costs in relation to the benefits. As can be seen in figure D2, the Complete Refurbishment BNB module is derived from the New

Construction BNB module. Refurbishment projects must hence consider the following specific requirements of sustainable refurbishment in addition to the requirements of Parts A and B of this Guideline.

ADAPTED AND NEW CRITERIA IN THE COMPLETE REFURBISHMENT BNB MODULE
FIGURE D2



Source: BBSR

4.1 Ecological quality

4.1.1 Eco-balancing

The energy and material flows that are embodied in the building structures of existing buildings reflect a building's past consumption of resources and environmental pollution. The primary energy spent on the construction of a building is often also called "grey energy". Preserving existing buildings hence also always implies a potential to avoid new pollution due to the construction and equipping of the building. This potential is then used if a new building does not have to be erected because existing buildings can be developed and remain in use. This reduces resource consumption and thus avoids the environmental burdens that result from the manufacture of construction products and the construction of buildings. Enhancing the functional, technical and energy-related qualities of buildings as part of refurbishment projects with the aim of achieving maximum use rates in existing buildings thus helps to reduce the need for new buildings and thereby essentially contributes towards the protection of resources and the environment.

In order to assess the ecological benefits of refurbishment projects, the determination of the resultant environmental impact and resource consumption is indispensable. Analogous to the concept for new construction projects, this assessment is to be based on a building-specific eco-balance. The life cycle assessment methods should also be generally applied to refurbishment projects. Life cycle assessments allow resource consumption and impacts on the global environment to be identified and assessed. Life cycle assessments for refurbishment projects also aim at influencing design, planning and construction work as well as building use in order to help to reduce environmental impacts and resource consumption. One possible solution is to technically extend the residual service life for the remaining building components whilst at the same time exploiting the potential for optimisation between old and new building component layers.

Life cycle assessments for refurbishment projects are based on the same criteria as those applied to new buildings (see Part A, section 3.1.3). The assessment methodology and the assessment standards were examined in all criteria with a view to the specific characteristics of refurbishment projects and adapted when necessary.

The most important issue is to avoid energy and material flows as well as unwanted effects on the environment. This is achieved by avoiding new construction projects and by continuing to use existing buildings, whilst at the same time enhancing energy quality and meeting present and future user demands.

It is unreasonable and often pointless to determine and assess the energy and material flows already embodied in a building as well as its past impacts on the environment. Existing buildings were erected under historical conditions and typically by using different processes so that their environmental influences differ from those of modern methods. It is hence not normally possible to find an adequate data base for an eco-balance for existing buildings. Irrespective of this, it is both a complex and pointless task to determine and assess the energy and material flows already embodied in a building.

The advantages of complete refurbishment must be presented in quantitative terms using the demonstrated eco-balance and the benchmarks for a new building,

4.1.1.1 Handling existing building structures

If existing building structures, which still have a certain use potential or a theoretical residual service life, are demolished as part of a building measure, this often means forfeiting the potential to avoid energy and material flows along with unwanted environmental impacts. As part of an eco-balancing measure, the basic rules for handling existing building structures must be observed.

The following convention is applicable in conjunction with this Guideline and the BNB:

1. The material flows and environmental impacts that took place in the past during erection and operation of the building (maintenance, dismantling, disposal) are not included in the balancing scope of complete refurbishment.
2. Remaining or reused old building structures must be balanced with the view to their future material flows and environmental impacts.
3. Modules A to C of DIN EN 15804 are included in balancing, and Module D is shown for information purposes. Production (Module A) refers exclusively to newly installed building materials and products. This means that in the case of old building structures that are to be used further or reused, maintenance/ replacement, dismantling and disposal must be mapped in quantitative terms with a view to the residual service life of components.

The example of a complete refurbishment project in figure D3 illustrates the period which is relevant for analysing energy and material flows. The task of minimising material flows and environmental impacts lies in the hands of the planners of the respective measure.

4.1.1.2 Comparative effect estimation of new and existing building measures

Depending on the requirements for the building, eco-balancing can be used to show in quantitative terms the advantages of complete refurbishment compared to a new building, but also of partial refurbishment compared to complete refurbishment. General, non-quantified statements regarding the advantages of basically preserving a building structure or the general advantages of a new building are not acceptable.

In addition to calculations, the design and planning process must adequately consider the existing building structures to be dismantled and examine reuse options on site. In the interest of the efficient use of resources, existing recycling potential must be identified and put to maximum use with a view to target rates for recycling. In the sustainability assessment of complete refurbishment projects, this aspect is addressed by criteria of process qualities (BNB_BK 5.1.6 “Stock-taking” and BNB_BK 5.1.7 “Demolition Planning”).

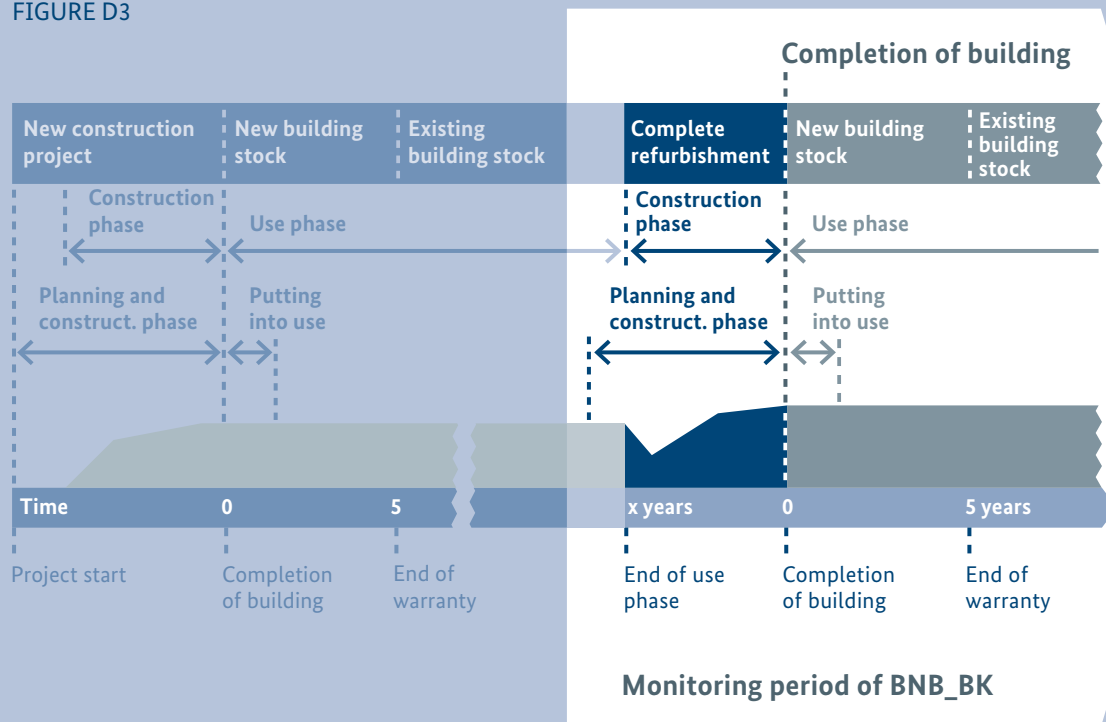
4.1.1.3 Balancing of the building substance

The eco-balance of existing construction measures includes in line with new construction projects the phases of production, use and disposal, with the difference that during the production phase only the newly introduced building substance is considered.

4.1.1.4 Balancing the supply during use

The material flows and environmental effects of the supply during use must be handled independently of the type of construction measure and therefore analogous to the assessment of new construction projects. In this connection, the final energy demand for electricity and heat is considered.

MONITORING PERIOD FOR MATERIAL FLOWS AND ENVIRONMENTAL IMPACTS
FIGURE D3



Source: BBSR

4.1.1.5 Balancing disposal

With regard to the disposal of individual components during use and the disposal of the entire building at the end, both, the components of the new substance and the used or reused old substance, must be taken into account.

4.1.1.6 Eco-balance assessment

Scope of the accounting

The eco-balance assessment has to be carried out according to the above convention and according to the criteria of the module complete modernization and evaluated quantitatively. For this purpose, the criteria BNB_BK 1.1.1 to 1.1.5 and BNB_BK 1.2.1 are available.

The energy and material flows, as well as the environmental impact of refurbishment projects, are essentially influenced by the depth of intervention in the existing building structures. An eco-balance assessment using benchmarks only makes sense if a comparable intervention depth is taken into account. A distinction is made here between complete refurbishment (with and without monument protection) and partial refurbishment (To distinguish between complete and partial modernization see figure D1):

- **Eco-balance of complete refurbishment projects**
Complete refurbishment projects must be completely balanced with a view to their environmental impacts and resource consumption.

Complete refurbishment of monuments is a special case and requires complete balancing, both with a view to the environmental impacts and resource consumption of such buildings. If the permissible improvements in the energy efficiency of buildings are limited due to monument preservation, this can be taken into account in the evaluation result.

■ **Eco-balance of partial refurbishment projects**

A BNB building assessment with a complete eco-balance does not make sense for partial refurbishment measures because the complete refurbishment benchmarks available are not suitable for this purpose. This is largely due to the variety of underlying conditions (such as age, type of construction) and the strongly varying degree of complexity of partial refurbishment projects. The resultant, wide range of all kinds of construction measures means that partial refurbishment projects cannot be reasonably compared using fixed benchmarks. That being said, it should be ensured that the respective measure is optimised in terms of its environmental impact and consumption of resources. The eco-balance must thus be used in partial refurbishment projects as a tool for comparing variants in order to identify the optimum variant with a view to environmental impact and resource consumption. The eco-balance methodology for partial refurbishment measures must also correspond to the above-mentioned convention and be carried out analogous to the methodology described in the criteria profile of the Complete Refurbishment BNB module.

Control potential of balancing

On the one hand, the eco-balance enables variant analyses. However, it can also be used to compare the design and planning options with other buildings or indicators. As a result the eco-balance becomes a control instrument for a resource-saving and environmentally friendly construction and contributes to an increase in quality in the decision-making processes of the project.

Planning-accompanying eco-balance is therefore essential to minimize the impact of a building on the global environment and resources. At the same time, the timing of the mission is critical:

■ **Time of the eco-balance**

The influence of design on a building's resource consumption and emission-related environmental influences declines as the design, planning and building process proceeds. The eco-balance as a steering instrument must be used at the earliest possible stage of the design, planning and building process. Suitable limit values (minimum requirements) for the eco-balance should hence be generally determined at the beginning of the project for the respective measure (project preparation or determination of fundamentals). After the limit values have been determined, estimates should be made at the earliest possible stage as soon as first design versions are available. The eco-balance estimate serves here as a tool for analysing and selecting suitable variants that can ensure compliance with the limit values.

■ **Updating the eco-balance**

The eco-balance as a steering instrument should be successively updated. The limit values determined must always be compared to the values achieved at the intermediate planning and design levels. This is the only way to ensure that deviations are identified and counter-measures initiated as quickly as possible (quality assurance).

4.1.2 Risks for the local environment

One of the most important criteria for refurbishment projects is the avoidance of risks to the local environment. This addresses not just the risk of pollutants (both during construction and during building use) that can enter waters, soil and air and can pose a risk to health due to accumulation in the food chain and pollution of indoor air. During the course of refurbishment, the aim is to avoid or minimise pollutant levels and pollutants released both from existing (reused) building materials as well as new construction products. The resultant risk potential for future users should not be underestimated, and regular quality assurance is essential during the entire planning and construction phase.

As part of assessing risks to the local environment (BNB_BK 1.1.6), the following separate assessment must be carried out:

- Building materials of the old building structure
- New building products used during complete refurbishment

4.1.2.1 Assessment of risks from construction products in old building structures

Through meticulous stock-taking of existing building structures, the building materials must be recorded to the maximum extent possible. With a view to the materials that remain in the building, comprehensive refurbishment must be carried out for building structures with suspected risks.

The following pollutant groups are relevant for old building structures:

- Asbestos
- Polychlorinated biphenyls (PCBs)
- Wood preservatives (HSM)/biocides: pentachlorophenol (PCP), Lindan, DDT
- Polycyclic aromatic hydrocarbons (PACs)
- Old synthetic mineral fibres (SMFs)
- Lead
- Chlorofluorocarbons (CFCs)
- Softeners (postponed)
- Formaldehyde
- Mould
- Flame retardants (postponed)
- Radon from building materials (postponed)
- Pigeon excrement (postponed)
- Particulate matter (postponed)

The construction products in existing buildings are usually not documented. The risks from construction products in old building structures can thus only be assessed on the basis of an examination of building pollutants.

In contrast to new building structures, old building structures can also include materials that are no longer permitted or that even have to be removed under current legislation. An investigation by a pollutant expert in accordance with the criterion BNB_BK 5.1.6 inventory analysis is a basic requirement for a valuation according to the criterion BNB_BK 1.1.6, which depends on the scope of the remediation and partly also depends on the type of analysis. The purpose is to avoid the presence of highly polluted building components and to upgrade the building to the minimum quality standard which a new building must fulfil.

Further assessment is then carried out according to differentiated quality levels which are defined in terms of the degree of exposure caused by the respective building parts, construction products or substance compositions. It is not possible to apply the standards for new buildings to existing structures because the necessary data is usually not available for old buildings.

One feature which all quality levels have in common is that demolition or rehabilitation is not always necessary. If it can be demonstrated that the construction products that will remain in use will not pose any risk to the indoor air quality or the room air measurement proves that the defined limit value is undercut, such materials can continue to be used in the building.

For listed buildings exceptions may be allowed for particularly valuable components in coordination with pollutants experts and monument protection authority, if no monument-compatible pollutant remediation is possible and a further building use without health impairment is ensured.

4.1.2.2 Assessment of risks from construction products in new building structures

The risks which new building structures pose to the local environment are assessed analogous to the methodology for new construction projects. An exception can be made here for refurbishment projects subject to monument protection requirements in agreement with pollutant experts and monument protection authority if such an exception is not expected to result in any health risks. This exceptional case is relevant when certain construction products have to be used which do not comply with quality requirements.

4.1.3 Sustainable material extraction/biodiversity

Sustainable material extraction and the related aim to preserve biological diversity in nature is a clear aim of refurbishment projects. As such, global deforestation should be countered by promoting the use of wood from sustainable production sites. According to the rules for new buildings, the use of wood and wooden materials from tropical, subtropical and boreal forests with no forest stewardship certification must hence be avoided. Preference should therefore be given to products from sustainable forestry.

Since there is usually no information available regarding the origin of wood products or materials in old buildings, these products and materials are not assessed with a view to their extraction or origin even when they are left in the building. The reason for this practice is that active dismantling of products that could be critical would have no positive effect on material extraction or biodiversity. Moreover, replacing these products or materials would lead to additional intervention in nature.

This means that only wood and wooden materials to be newly installed are to be assessed in conjunction with sustainable refurbishment. With a view to the “Sustainable Material Extraction/Biodiversity” criterion, old structures are not taken into account, however, this does not apply to other criteria, such as risks to the local environment or the impact on user health, which must be assessed. In the event that intact wood products or wooden materials which are assumed to be of poor quality were used in existing buildings, any dismantling or replacement using higher quality products should be generally avoided. Instead, measures should be taken to extend the residual service life of the wooden products already used.

FEDERAL BUILDING The use of wood products in federal building from legal and sustainable forest management is governed by the joint decree by the Ministries from 2010 regarding the procurement of wood products.

4.1.4 Land consumption

Land consumption is a sub-aspect of the ecological dimension of sustainability. Unsealed land has a positive effect on water balance, microclimate as well as flora and fauna. The National Sustainability Strategy from 2002 contains a commitment to limit the daily increase in settlement and traffic areas to 30 hectares per day by the year 2020. A balanced land use record for Germany is the goal by 2050. This means that the sealing of new land is to be avoided or compensated for through suitable measures (BNB_BK 1.2.4). The land consumption analysis is limited to the real (construction) site. The sealing and restoration concept already serves as a steering instrument during the early design phase in order to implement measures designed to minimise, reduce and compensate for sealed surfaces (see BNB_BK 5.1.3). This concept encompasses the aspects of stock-taking, measure assessment, variant comparison and recommendations for action.

An analysis of land consumption must address the following aspects:

- Comparison of the ratio between sealed surface and usable space before and after refurbishment
- Classification of surfaces used for buildings according to the Federal Building Code (for instance, Section 34 of the BHO)
- Minimization of the sealed surfaces
- Historical burdens on the property, including existing pollution or ammunition
- Implementation of a green roof

The comparison of the ratios of sealed surface and usable space before and after refurbishment must be based on the property and the total surface areas of the existing and the extension building. The brochure “Sustainably Designed Outdoor Facilities on Federal Properties” by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) must also be considered in this context.¹

If optimisation in the sense of sustainability is aimed at by improving the ratio, this can be achieved by subsequently increasing the amount of useable space. However, this can also be achieved by reducing sealed surfaces, for instance, by restoring and planting previously sealed surfaces on the property.

4.2 Economic quality

When it comes to developing existing buildings further, the economic dimension of sustainability and, at the same time, the economic efficiency of the measures must be considered. The aim of the analysis of economic efficiency, even for refurbishment projects, is the integrated optimisation of economic parameters.

4.2.1 Building-related life cycle costs

Both new construction and refurbishment projects require a life cycle cost calculation and analysis. A comprehensive analysis not only covers production and construction costs, but, just like the methodology used for new buildings, also the cost of operation and maintenance. Solutions that may cost less in the short term, but require higher economic costs in total, can be identified and replaced with more advantageous variants at an early stage.

1 BBSR (2018 a)

4.2.1.1 Life cycle cost analysis methodology for refurbishment projects

A life cycle cost analysis considers the costs incurred during refurbishment, use and maintenance of the building. The result of the life cycle cost analysis is – just like in the case of a new building – the cash value in Euro of all payments for construction, operation and maintenance minus, if applicable, the cash value in Euro of energy sales to third parties per square metre of gross floor area according to DIN 277. Life cycle cost analyses must be performed in accordance with Part A, section 3.2.1 of this Guideline and take the special aspects discussed below into consideration.

An analysis of selected costs during the life cycle of the building must cover the following costs:

LIFE CYCLE COSTS OF REFURBISHMENT PROJECTS TABLE D1

Life cycle costs in the sustainability assessment	
Costs of manufacture according to DIN 276-1	Construction costs
Costs of building use according to DIN 18960	Operating costs
	Costs of cleaning, service and maintenance

Source: BBSR

The life cycle cost analysis according to the standards and system boundaries determined in the Guideline and in the Assessment System for Sustainable Building (BNB) is, first and foremost, a tool to optimise the life cycle costs of a concrete measure within a fixed scenario. One prerequisite for optimisation is the possibility to intervene. The given condition of a building before a measure commences can lead to costs during a refurbishment project which the design and construction process cannot influence or, if so, to a very limited extent only.

The general economic efficiency of a measure is often determined before the design and construction process starts with demand planning and the analysis of variants which can meet demand having an important role to play here. The life cycle cost analysis according to this Guideline and the BNB is based on the decision for a concrete procurement variant and continues to ensure economic efficiency through the design and construction process. The life cycle cost analysis methodology described below thus focuses on costs that can be influenced by the design and construction process so that the maximum steering effect can be achieved during the design and construction phase.

The sustainability assessment of the building on completion of the design and construction phase includes a life cycle cost calculation which has fewer cost types included than the analysis of the variants suitable to cover given demand which is performed during earlier planning phases. However, all costs that can be influenced by the design and construction processes are analysed in much greater detail.

The life cycle cost analysis according to Part D of this Guideline considers the costs that can be influenced during a refurbishment measure. For this purpose, the **eco-balance convention** (see section 4.1.1.1) used to balance old building structures is applied analogous to the calculation of costs of old building structures. This means that all costs that were already incurred when the building was first built or at the time of complete/partial demolition, disposal or recycling are assigned to the previous lifecycle and are therefore not taken into account in the construction work in the inventory. The reason given in the section on eco-balancing also essentially applies here to life cycle costs and in critical single cases must be coordinated with the appropriate Conformity Testing Office.

The methodology of calculating the life cycle costs of refurbishment projects is the same as the methodology for new construction measures according to Part B of this Guideline.

4.2.1.2 Assessment of life cycle costs

Construction costs in conjunction with refurbishment projects are strongly influenced by the given condition of the building and hence the necessary depth of intervention in the existing building structures. The resultant costs of the project depend heavily on the type and scope of the proposed conversion and reuse measures. It would hence be pointless to assess the costs of the new life cycle without considering the depth of intervention. A distinction must also be made here between complete and partial refurbishment.

The economic quality of a refurbishment project is assessed on the basis of the benchmarks of the New Construction BNB module.

Life cycle costs of complete refurbishment projects

The analysis of the life cycle costs of complete refurbishment measures must be generally carried out and evaluated in quantitative terms in accordance with the above-mentioned rules for handling existing building structures and on the basis of the criteria of the Complete Refurbishment BNB module. The BNB_BK 2.1.1 criterion is available for this purpose. Corresponding to the definition of the term “complete refurbishment”, the standard of the BNB criterion is based on the assumption that the existing building will be stripped almost completely to the structurally relevant structure and that the condition of the complete building will be largely equivalent to that of a new building on completion of the measure. This means that the old building structures which remain in use will not generate any significant repair and maintenance costs in the future because the reused parts are mainly structurally relevant elements that have been upgraded to an almost as-new condition as a result of the refurbishment project.

Life cycle costs of partial refurbishment measures

The analysis of the life cycle costs of partial refurbishment measures must be carried out according to the above-mentioned conventions and analogous to the BNB_BK 2.1.1 criterion. However, a quantitative assessment of the results of the life cycle cost analysis of partial refurbishment measures is generally not possible. The main reasons are the large variety of underlying conditions (such as age, type of construction) and the strongly varying degrees of complexity of partial refurbishment measures. The resultant, wide range of different construction measures means that partial refurbishment projects cannot be reasonably compared using generally valid, fixed performance indicators or benchmarks (see also Annex A1). As a result, it must be ensured that the respective measure is optimised in terms of its life cycle costs.

The life cycle cost calculation and analysis must thus be used in partial refurbishment projects as a tool for comparing variants in order to identify the optimum variant with a view to economic quality. The perspective and subject matter of the life cycle cost calculation must be determined on a project-specific basis depending on the effects of the respective measure. With regard to construction costs, the perspective can refer to those building parts or elements which will be influenced by the respective measure. However, it is generally necessary to analyse the implications for the use costs of the entire building and to perform a joint assessment of construction and use costs. The calculation method of the qualitative assessment of the BNB_BK 2.1.1 criterion should be applied analogously.

Assessment of the life cycle costs for historic monuments

A different assessment option for monuments is often necessary in order to reflect the specific characteristics of monument-compliant refurbishment whilst at the same time addressing their social importance. In the case of monuments, all measures must generally be performed which are compatible with the requirements of monument protection and monument preservation and which improve life cycle costs whilst also considering ecological quality. Additional expenses due to increased structural requirements can therefore be claimed as special conditions for listed buildings.

4.2.2 Adaptability

The future adaptability, as well as conversion and reuse capability of structures, is also very important for sustainable building in conjunction with refurbishment projects. Fulfilment of the requirements of functionality, flexibility and adaptability to changing conditions can influence the acceptance of a building, its service life and the resultant building-related costs during the life cycle as well as material flows and impacts on the environment. A building features a high level of adaptability under aspects of sustainability if adaptation to changed use or conditions of use is possible at a reasonable cost and effort. The mere performance of adaptation measures during construction does not imply any additional value.

The following criteria are relevant when it comes to assessing adaptability just as much as with new buildings:

- Building geometry: headroom, building depth, vertical development
- Ground plans: dimensions and development of use units
- Construction: type and design of interior walls and partition walls
- Technical equipping: scope, flexibility, accessibility



German Federal Constitutional Court within its urban context

In order to ensure a minimum level of adaptability in completely refurbished buildings, a qualitative assessment of the basic adaptability can be carried out according to criterion BNB_BK 2.2.2 instead of the quantitative one.

In the case of listed buildings, it is sometimes possible to grant exceptions with regard to the requirements for the building cubature and the floor plans if the fulfillment of the requirements would not be possible or only with disproportionate effort due to the requirements of monument protection.

4.3 Socio-cultural and functional quality

Socio-cultural and functional qualities are very important for assessing a building from the user perspective and must hence be included in the planning and design of refurbishment projects just like in new construction projects. However, the criteria of the “Securing design quality” group must be examined with a view to building-specific aspects which are explained in this section (see sections 4.3.1 and 4.3.2) in addition to the information contained in Parts A and B.

An important goal of any construction measure is to achieve a high degree of user satisfaction with workplace and building conditions in order to promote employee creativity and productivity. In the case of refurbishment projects, feedback from previous users can also be used (see also BNB_BK 5.1.6) in order to identify existing shortcomings.



History meets modernity at the BMU building on Stresemannstrasse: careful development of existing structures as the key to true sustainability

4.3.1 Design and urban quality

Existing buildings characterise how public areas are perceived and help to shape identity. The public sector, in particular, and its buildings are particularly visible to the general public. Maintaining and correctly handling cultural assets is an important social task. The public sector is not only committed to this task, it should also act as a role model here.

As part of qualitative upgrading of building stock, the design and urban development qualities of an existing building must be maintained or improved whenever sensible and possible so that the diversity of building culture and the unique, location-specific appearance can be preserved in its urban context.

Just like with new buildings, an important tool for ensuring design quality is the assessment of competitions and the involvement of prize winners in the further course of design and planning. Another two important aspects must be considered for the design and urban quality (BNB_BK 3.3.1) of refurbishment projects:

- Taking stock of existing quality
- Upgrading existing quality

Taking stock of existing quality

The basis for high-quality building stock development is the stock-taking, assessment and documentation of the design and urban qualities of the existing building when the project starts.

A general distinction is made between building stock with and without listed building features. As part of basic stock-taking, an examination must be carried out and documented (minimum scope: see table D2).

ASPECTS TO DESCRIBE THE URBAN AND DESIGN QUALITY OF BUILDING STOCK

TABLE D2

Examination of the existing design quality of building stock without listed building features	
Building description including any relevant information	Regarding planning-law conditions
	Regarding the urban environment of the building
	Regarding outdoor facilities
	Regarding building design
	Regarding structural elements
	Regarding permanent and non-permanent features (furniture and works of art)
	To be supplemented by photo documentation
Assessment of the building and individual parts with a view to	Urban quality
	Design quality and/or cultural values
Documentation	As-built drawings (layouts, sections, views)
	Existence of high urban or design quality and/or cultural value

Source: BBSR

High quality or cultural importance can be assumed to exist if in retrospect the existing building:

- is executed in terms of its scope and quality at a level that is essentially equal to the competition work of one of the prize winners of a planning competition, or
- was awarded a recognised architectural award for high design quality after its completion, or
- was classified by the municipality as “other building structures particularly worth protecting”, or
- was classified as featuring “good architectural quality” of its design by a recognised, independent body of experts, or
- is a protected monument, protected area or a building worthy of monument protection.

Upgrading existing quality

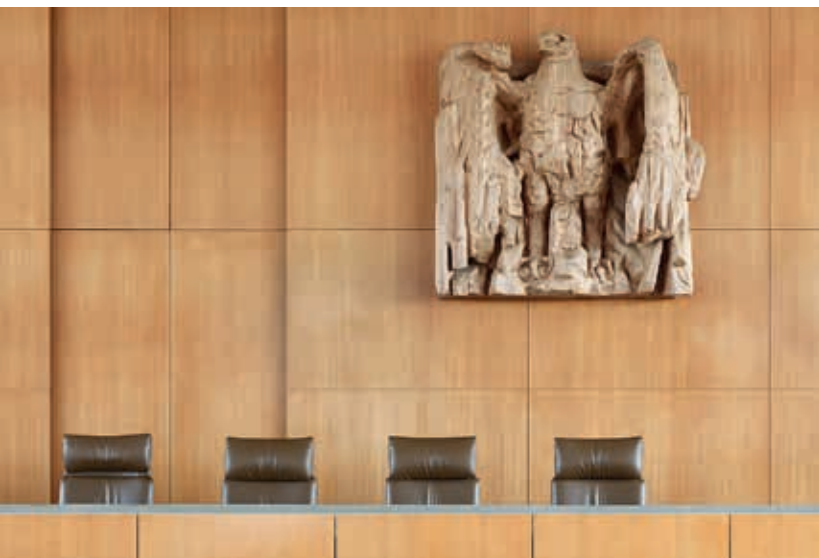
Once the existing design and urban quality has been recorded, this must then be given sufficient consideration in the further development of the building stock. The procedure here depends heavily on the respective type of measure and the depth of intervention. A distinction must hence be made here between complete and partial refurbishment.

Analogous to the approach for new construction projects, design competitions are also the appropriate solution to ensure the design quality of complete refurbishment measures. In order for a design competition to yield a solution that adequately addresses the given design and urban quality, the handling of the existing building structures must be expressly included in the competition brief. Furthermore, documentation of the existing design and urban quality must be available to the entrants.

In individual cases, a planning competition may also be the appropriate solution even for partial refurbishment. However, this will not apply very often because for many partial refurbishment projects the costs and efforts involved in a design competition would be unreasonable or because design aspects have a very marginal role to play, for instance, when it comes to revamping technical systems. If no design competition is held although certain design aspects have to be considered as part of the measure in question, alternative instruments will have to be used in order to ensure design quality, such as design concepts, variant comparisons, colour and material registers, or the involvement of an independent advisory design body.

Buildings with listed building features

In the case of monuments and monument areas, design and construction support by the public authorities responsible for the protection of built heritage usually ensures design quality. However, this must also cover those areas which are not subject to any requirements by the monument protection authorities. In individual cases, a planning competition may be the appropriate solution even for buildings with listed building features. If this is not the case, alternative instruments must be used in order to ensure design quality (see the section on partial refurbishment projects).



Dealing with existing art at the German Federal Constitutional Court

4.3.2 Art in architecture

When it comes to refurbishment, the aspect of new works of art in architecture is supplemented by the question as to how existing works of art in architecture are to be handled. Existing works of art must be described, preserved and communicated according to their value in order to handle them in the appropriate manner as part of the refurbishment measure. The federal government's "Art in architecture"² guidelines address the creation of new and the treatment of existing works of art in architecture. The assessment methodology of the BNB_BK 3.3.2 criterion is designed according to the "Art in architecture" guidelines. The implementation of the contents of these guidelines is a prerequisite for assessment according to the Complete Refurbishment BNB module.

FEDERAL BUILDING Construction projects by federal organisations should earmark funds for art in architecture, both for new construction and for refurbishment projects. Graphic artists must be commissioned if this is justified by the purpose and importance of the building (See RBBau K 7).

4.4 Technical quality

Users often expect that refurbishment projects can achieve a quality that is comparable to that of a new building. Given these expectations, the technical quality of new construction projects is generally also the benchmark for refurbishment. The only exception permitted under the Complete Refurbishment BNB module are cases in which deviations are absolutely necessary due to the specific conditions of the existing building.

Functioning fire protection and sound insulation, a high degree of cleaning and maintenance-friendliness, as well as resistance to natural risks are important aspects of a sustainable building and at the same time also a fundamental demand on the part of owners and users. With regard to these aspects, the standards for new buildings also apply in full to refurbishment projects.

Heat insulation and protection against condensate

Many building-specific aspects must be considered for heat insulation and protection against condensate. Heat insulation and protection against condensate (BNB_BK 4.1.2) serve to minimise heat demand for air conditioning whilst at the same ensuring a high degree of thermal comfort and avoiding damage to the building. This is characterised in existing and refurbished buildings by the heat and humidity protection quality of the building envelope. In this respect, the following criteria must also be considered in refurbishment projects:

- Component-based average heat transfer coefficient
- Penalty for thermal bridges
- Air permeability (joint permeability)
- Condensation water volume within the structure
- Air-permeability of the building envelope
- Solar radiation index

2 See BMVBS (2012 b)

These criteria cannot always be directly transferred from new constructions to refurbishment projects. That being said, the aim of refurbishment projects should be to achieve qualities that are comparable to those of a new building, in as far as this can be influenced. There are various reasons why existing buildings, especially if they are listed buildings, may not be retrofitted or, if so, only at considerable cost and effort. This is also why the Energy Saving Ordinance distinguishes between new construction and refurbishment projects when it comes to building part requirements.

Criterion BNB_BK 4.1.2 includes suitable differentiation on the basis of the target values for new buildings in order to adequately consider the special conditions of refurbishment projects. In order to be able to take account of the special interests and specifications for listed buildings in the evaluation, the converted building quality in relation to the maximum achievable quality is to be represented comprehensibly for such buildings by a special energy consultant for historical monuments. With regard to the evaluation of the heat transfer, a distinction is made between three different intensities of the specifications given by monument protection and monument preservation (see Table D3).

**INTENSITY LEVELS OF MONUMENT PROTECTION
IN CRITERION BNB_BK 4.1.2**
TABLE D3

Case 1	The complete building has features of a listed building.
Case 2	Parts (for instance, wings) of the building have features of a listed building.
Case 3	Individual elements (such as façade, windows) have features of a listed building or are classified by an expert of monument protection as being particularly worth protecting.

Source: BBSR

The BNB_BK 4.1.2 criterion can also be applied to partial refurbishment projects in as far as these lead to a change in energy quality. Fulfilment of the minimum thermal protection requirements according to DIN 4108 is mandatory in order to ensure thermal protection from the perspective of building protection and hygiene.

4.5 Process quality

The future quality of a building is essentially determined by decisions which are made at an earlier design stage. This is why the quality of the design process has a key role to play in refurbishment projects too because the possibilities to influence environmental impacts, resource savings and costs are best at the beginning of the measure. Especially when it comes to refurbishment projects, the legal, technical, functional, urban and architectural basis must be identified at an early stage as part of the determination of fundamentals. This information forms the basis for feasibility studies, economic efficiency analyses and life cycle analyses (LCC and LCA) as well as the starting point for the ongoing planning and design process. Planning and design of refurbishment projects must also include concepts for the demolition of existing building parts. The following sections explain the procedure for determining the condition of the building and for demolition planning.

4.5.1 Stock-taking

The purpose of stock-taking is to identify the strengths, weaknesses, potential and risks of an existing building. These result from the condition of the building to be refurbished and from the general conditions of stock development (see section 3.3). Very important aspects in this respect include, for instance, the legal situation, such as grandfathering, monument protection, neighbour law or immission control. The stock-taking process described below covers the stock-taking of the building condition as well as the building diagnosis and is based on the complete identification and subsequent consideration of the legal conditions as well as the generally accepted state of the art.

The major elements of stock-taking (BNB_BK 5.1.6) are holistic recording of the as-is condition as well as of the building condition using a qualified building diagnosis. Both analytical steps are based on the systematic exploration of the existing building structures. This exploration basically consists of the following elements:

1. Stock-taking

- Geometric stock-taking
- Stock-taking of the building structure and building materials
- Stock-taking of building services
- Exploration of the building and use history
- Stock-taking of exposure

2. Building diagnosis

- Load-bearing structure
- Energy quality
- Pollutants
- Humidity and salt exposure
- Pest infestation

The quality of stock-taking basically has a decisive impact on the planning, design and construction process of a refurbishment project. Comprehensive and meticulous stock-taking as part of project preparation work enables a significant reduction in planning uncertainty which is usually much more common in refurbishment projects. Stock-taking enables efficient and optimised construction with a view to technical building quality and construction costs as well as environmental impacts and resource consumption. As one major prerequisite, both stock-taking and building diagnosis must be performed systematically, carefully and to a reasonable extent.

Whilst stock-taking first processes all basic data and features of the existing building for the subsequent planning and design process, the building diagnosis systematically explores key criteria which enable a detailed assessment of the condition of the building.

The stock-taking phase always provides results regarding the geometry, existing building structures and construction materials of the building as well as the building services installed at the time of examination. Furthermore, the property's building history can be helpful if the original purpose of the building or major structural modifications during the use period provide important information regarding boundary conditions for planning and design. Finally, specific influences on the existing building should be addressed with a view to exposure aspects in as far as such influences are due to location or ambient conditions (such as groundwater exposure, high thermal loads in summer or high ambient noise exposure).

The building diagnosis usually aims at generating detailed information regarding the building's load-bearing structure, its energy quality, possible hazards for users and the environment due to pollutants, pests as well as increased humidity and salt exposure. In this respect, preliminary diagnostic examinations at the level of the entire building, as well as detailed individual examinations of specific structural elements, are important.

Numerous examinations of the structures of the building must be carried out during both stock-taking and the building diagnosis. Such examinations often require the local exposure of structures, intervention in the building structures as well as sampling operations. However, in cases like these which can hardly be avoided, a reasonable ratio between the gain in information and the foreseeable loss of structures should be aimed at. This principle applies to all kinds of building stock, but particularly to monuments of high historic value as well as works of art.

The service life of a structural or technical component is defined as the period of time after which the component is likely to need replacement. Typical reference values are mean values which also consider technical, functional and aesthetic aspects as well as legal requirements. One important tool to this effect is the “Service life table”³ from the BBSR as well as VDI 2067.

When performing building diagnostic activities, designers and planners are often faced with the challenge of capturing all the data necessary for the ongoing design and planning process with maximum reliability and at a reasonable technical and cost effort. Phased implementation of building diagnosis activities is often advisable, with different steps of the analyses being dependent upon upstream results. It should be generally remembered that a poor building diagnosis often leads to a significant lack of information, which may jeopardise the success of a repair measure or involve a high cost risk. Planners and designers must hence meet high standards of expertise. This applies not just to specialists and experts, but also to general technicians who are responsible for the overall success of the construction project.

The results of the stock-taking exercise enable the identification of the existing building structures in terms of their structure and quality, design, condition as well as any risks to users and the environment generated by these structures. Furthermore, the structural elements which are suitable for continued use and those which should be removed are systematically examined. Stock-taking (recording of the as-built condition, building diagnosis) forms the basis for the planning of all necessary refurbishment measures. Stock-taking must form part of the project preparation phase. To this effect, the BNB_BK 5.1.6 criterion must be applied to both complete and partial refurbishment projects in as far as the latter involve a significant change in building stock and energy quality. In order to ensure that the stock-taking results are considered during planning, design and execution, these results must be generally made available to all planners and designers.

4.5.1.1 Structural survey

Geometry

All the geometric data and boundary conditions of the building are initially recorded at a very early stage of the stock-taking process. Existing as-built drawings and construction documents may also be used in this context if their quality and suitability is verified in the building.

Geometric stock-taking is a prerequisite for the sustainable development of an existing building. In addition to providing a set of up-to-date planning and design documents for the existing building, it can be used as a basis for developing optimum solutions. This must be available in digital form (CAD) and include at least the following drawings and plans:

- Layouts of all storeys proper, basement and attic storeys as well as usable roof spaces
- Sections for all structurally independent building parts
- Sections of all stairwells
- Views of all façades
- Roof top views

The accuracy of geometric stock-taking and the scale for the planning and design documents depend on the size of the existing building as well as on the scope and intensity of structural intervention. A minimum scale of 1:100 must be chosen for planning and design documents. Important details of existing buildings must additionally be shown at a reasonable scale of between 1:1 and 1:25.

Geometric stock-taking, especially for large buildings, is an interdisciplinary exercise for surveyors and civil engineers. The quality of the results of the analysis is thus also influenced by appropriate communication.

³ www.nachhaltigesbauen.de/de/baustoff-und-gebaeuedaten/nutzungsdauern-von-bauteilen.html

Building structure and building materials

Structural stock-taking systematically explores the building structure, including all relevant designs and construction materials. In this context, the structure of the unfinished building is particularly important in as far as this structure is relevant for the load-bearing structure and future use. However, stock-taking is also performed for the building envelope as the interface between the heated building space and the outdoor air. The structural layers of typical wall, ceiling and floor structures, as well as roof cross-sections, are analysed and documented. The results of structural stock-taking are documented both in the form of (building) descriptions and as drawings (as-built details).

The result of structural stock-taking is detailed information regarding existing building structures and designs, construction materials as well as relevant layer structures of the different designs. This is an important basis for the technical assessment of existing buildings with a view to their preservation worthiness and continued use. These results are subsequently supplemented by the results of the building diagnosis. Another central precondition for the continued use of existing structural elements is compliance with and/or the ability to implement construction law and other legal requirements. The considerable expertise of individual stakeholders is generally a prerequisite for this complex subject.

Building services

Stock-taking of building services for the property concerned should be performed parallel to structural stock-taking. This step of the analysis addresses all heating, ventilation and sanitary installations, electrical installations as well as existing air conditioning and building automation systems. This work requires skilled building services engineers.

When assessing the reuse potential of building services, it must be generally considered that their average service life is significantly shorter than that of typical building structures. This means that the analytical depth can be reduced in the case of building services where ongoing use is no longer reasonable in view of their technical obsolescence or wear and tear.

Building and use history

The analysis of a property's construction and use history is not an end in itself for interested experts. Instead, it explores the basic influences from the building's construction and use phases which can be demonstrated to have an influence on building stock. Aspects which have an important role to play in this respect include the time of construction and its technical, economic and political conditions, the original client and the original purpose of the building. Furthermore, important conversion and repair work or extensions, including the time of their performance, should be explored. The results of historic stock-taking can help, for instance, to explore special structural characteristics and shortcomings of existing buildings, problems due to previous intervention as well as pollution risks typical for the period of construction.



Restoring the foyer of the old building at Stresemannstraße 128 with a strong focus on monument preservation and the building's history

Besides the construction history of the building, reliable information concerning its use phase can also be very important in order to identify weaknesses, the potential for optimisation as well as building qualities worth preserving. In this context, the building can be assessed on the basis of data and experience regarding its ongoing use (such as information from users, data from facility management, consumption data). In the case of federal government building measures, the past use phase can be evaluated for this purpose on using the Use and Operation BNB module.

Exposure

This sub-aspect of the stock-taking exercise encompasses an analysis of special influences on a building that result from its location or surroundings. Besides the status quo at the time of the analysis, development during the use phase following refurbishment should also be assessed.

The exposure aspect should especially consider environmental influences, such as groundwater or flood risks, radon or high thermal exposure in summer (location in hot urban zones). In the case of a seasonal flood risk, the specific pre-warning times at the location should also be considered. Special anthropogenic influences can occur, for instance, in the form of high noise emissions in surrounding areas.

In any case, however, exposure analyses consider only those external influences at the location which are not covered by customary design and rating algorithms (for instance, for wind and snow loads) and/or which exceed the applicable characteristic values in individual cases.

4.5.1.2 Building diagnosis

Load-bearing structure

When it comes to analysing and assessing the existing load-bearing structure and to developing a structural model, the experts involved initially refer to the results of geometric and structural stock-taking and, under some circumstances, historic stock-taking. Additional building diagnosis is required for a more precise assessment of the condition of structural and design elements. The existing building structures are assessed according to the criteria of load-bearing capability (also with a view to future requirements), durability (long-term preservation of the value of the asset) and suitability for use (unrestricted usability).

The specification, scope and intensity of the diagnosis of the load-bearing structure depend on the particular design and the established intensity of damage. In any case, the task involves exploring the structural design (unless this was already part of structural stock-taking) as well as the extent and intensity of damage, including the implications for load-bearing capacity. Typical aspects of the building diagnosis include, for instance:

- **Wooden structures:**
identification of plant and animal wood pests, including extent and intensity of damage
- **Brickwork:**
assessment of single-shell or multi-shell structures, composite characteristics of brickwork and material, properties of bricks and mortar
- **Reinforced concrete:**
analysis of reinforcement layers and direction, carbonisation depth and reinforcement condition
- **Foundations:**
assessment of subsoil properties, permissible subsoil compaction and settlement sensitivity
- **Reinforced-concrete parts with corrosion damage:**
analysis of remaining cross-sections with load-bearing capability

In the case of the analysis of the load-bearing structure, the results of the building analysis are directly considered in the structural calculations as a basis for concepts for structural rehabilitation measures or reinforcing structures.

Energy quality

The evaluation of energy quality considers the status quo prior to commencing refurbishment and the potential for energy-related rehabilitation as part of a complete refurbishment project. This evaluation must be based on the results of stock-taking of geometry, structure and building services.

The technical stock-taking and evaluation of the existing and possible energy quality of the existing building must specifically address the following aspects:

- Energy balance of the current condition according to the valid version of the Energy Saving Ordinance
- Identification of relevant energy-related weak points
- Evaluation of the consumption structure of the building
- Identification of physical problems and shortcomings of the building (detailed analysis)
- Variant analysis in order to determine the potential for energy-related rehabilitation

The potential for energy-related refurbishment should be determined in the form of a rough variant analysis. A host of options and differentiated levels usually apply to the type and extent of energy-related building refurbishment measures. The analysis of the initial energy condition and of the optimisation variants should cover at least the following variants:

- Minimum variant
- Optimised variant
- Target variant

Modernisation measures for the building envelope and building services must be examined in all variants. The final contents of the variants and the differences between them should be determined separately for each refurbishment project. Measures for buildings with listed building features must be generally limited to measures suitable for monuments. The influence of energy-related refurbishment on annual energy consumption and energy costs must be shown for each variant. The resultant life cycle costs of the different variants must then be compared (see section 4.2).

Modernisation measures of the minimum variant are designed to comply with minimum legal requirements for existing buildings in terms of thermal insulation and humidity protection as well as energy efficiency. Besides the requirements under the Energy Saving Ordinance, absence of damage during future use, as well as compliance with the hygienically required minimum thermal protection according to DIN 4108-2, must be ensured.

In the case of the optimised variant, it must be examined to what extent ecological, economic and socio-cultural aspects can be considered at the same time and with equal priority. This means that environmental impacts, resource consumption, economic efficiency, functionality and design must be brought in line with each other. An alternative option is to consider specific targets, such as energy-related rehabilitation of a building to new building standards according to the Energy Saving Ordinance.

In the target variant, the possibility of particularly demanding energy-related building stock modernisation should be explored. In this way, the option of a nearly zero energy building could be examined if the building in question has no listed building features. In the case of buildings with listed building features, consideration could be given to monument-compliant refurbishment to new building standards according to the Energy Saving Ordinance.

Pollutants

Characteristic building pollutants are to be found in almost every existing building. Since pollutants can directly affect user health, this issue must be a top priority. If pollutants are suspected in a building, or if this cannot be generally ruled out, more in-depth examinations are then always necessary. In the interest of sustainable refurbishment of buildings, measures must be taken to ensure that pollutants will not pose a risk to human health or to the environmental resources of groundwater, surface water, soil and air. This is why it is essential that a pollutant report be drawn up, if possible, during the project preparation phase. The assessment of pollutants and pollutant cleanup is carried out as part of the criteria profile “Risks to the Local Environment” (see BNB_BK 1.1.6).

The building diagnosis regarding pollutants in buildings should consider the results of structural and historical stock-taking and, if applicable, of building services too. Significant correlation is often found between certain periods of construction, the building designs and technical equipment typical for such times as well as the resultant risk from characteristic pollutants. Certain past building uses can also suggest the existence of certain pollutants.

The handling of pollutants in buildings and the preparation of a pollutant report are subject to several inter-related laws which provide for a number of obligations for clients. These laws include labour protection and chemical substances laws as well as the Social Code and the related accident prevention regulations. Some regulations to be specifically considered are the “Construction Site Ordinance on Protection of Health and Safety” (Construction Site Ordinance) as well as the Technical Rules for Hazardous Substances.

FEDERAL BUILDING Furthermore, the federal government’s “Guidelines for Recycling” (www.arbeitshilfen-recycling.de) were introduced for federal refurbishment projects in order to lay down rules for the preparation of pollutant reports and the elimination of pollutants.

The involvement of an expert in the assessment of pollutants and a parallel assessment of the potential for risks for humans and the environment should be mandatory. A detailed documentation of the pollutant analysis must be provided in a pollutant register. If pollutants remain in the building, suitable measures must be implemented in order to rule out any future potential risks for humans and the environment. Transparent communication of any remaining pollutants, in particular, to building users and recording in the as-built documentation for the building are necessary.

The result of a pollutant report must prove or exclude any need for action regarding the elimination of any risk potential due to pollutants. If the report identifies any need for action, the corresponding measures must be introduced.

Humidity and salt exposure

Humidity and salt exposure is a typical problem in existing buildings. This problem occurs particularly often in the following areas of a building:

- Building parts in contact with or covered by soil
- Building parts in contact with inadequate roof covering and, in particular, roof sealing, including connecting areas and openings
- Areas near particularly exposed structural elements, such as roof terraces, balconies, pergolas or recessed storeys

Such areas should be carefully inspected in order to identify the extent and intensity of existing humidity exposure and to determine repair measures suitable for the respective construction materials involved on this basis. Humidity analyses can be performed using various methods, from first humidity indications at the building right through to laboratory methods for the precise identification of root causes. Increased humidity exposure generally causes not only aesthetic problems, but also adversely affects room climate and material properties, such as thermal conductivity or the strength of certain construction materials. Furthermore, wet component surfaces are a very good basis for secondary damage processes, such as mould or damage caused by cyclic frost and thaw exposure.

Dealing with harmful salts

Typical damage mechanisms related to humidity ingress into capillary and porous materials often support ingress of dissolved harmful salts into the material if such a source exists. Relevant harmful salts in this context are chlorides, sulphates and nitrates. These salts adversely affect material properties because the crystallisation pressure primarily causes near-surface structural damage in the evaporation zone and because increased hygroscopicity of wet construction materials, for its part, leads to permanent humidity burdens. Strongly increased salt concentrations always lead to significantly higher rehabilitation costs and, in a few extreme cases, may even require demolition of complete building parts. The recommended methods for diagnosis are qualitative and quantitative salt analyses as a result of which the specific exposure intensity and the resultant repair measures have to be defined.

4.5.2 Demolition planning and demolition measures

The results of stock-taking must be considered when it comes to demolition planning and the subsequent tendering and commissioning of demolition projects (BNB_BK 5.1.7). The following criteria must hence be examined and coordinated during demolition projects:

- Demolition planning
- Selective demolition (considering whether or not the remaining building is used)
- Examination of options for waste separation and disposal

Demolition planning at an early stage not only addresses requirements related to sustainability, but is also based on a host of legal requirements (such as the Construction Site Ordinance). The “Technical Guidelines”⁴ include standards to be applied when it comes to planning and performing demolition work.

4 BMI (2018b)

4.5.2.1 Demolition planning

Demolition planning must be performed on the basis of stock-taking (see section 4.5.1) in order to determine building parts and materials that can be reused as well as pollutants and historical contamination. Qualified staff must plan the demolition work before this is carried out. The result of demolition planning is a demolition and disposal concept which should include the following aspects:

- Logistics concept
- Analysis of susceptibility to vibration
- Consideration of nuisance to the environment/surrounding area
- Concept for the handling of construction rubble and contaminated materials
- Time schedule
- Demolition methods
- Responsibilities

FEDERAL BUILDING The “Guidelines for Recycling” address the extent and contents of demolition planning for construction measures for existing federal buildings.

4.5.2.2 Concept for selective demolition

In contrast to construction sites for new buildings or building stock that has become vacant, refurbishment work on buildings which remain in use calls for special precautions because users are in the building and/or because spaces continue to be used while construction work is being carried out. These cases call for the preparation of a demolition concept and compilation of the necessary user information. Measures must be taken in order to ensure the continued trouble-free use of building areas not affected by work, and a suitably coordinated construction schedule must be drafted.

4.5.2.3 Examination of waste separation and disposal options

Relevant requirements during the course of demolition work concern not just the physical safety of individuals but also the controlled disposal of demolition and packaging materials. Since correct waste separation must be controlled and monitored, responsibilities for waste separation must be defined, and a corresponding reporting system in the form of a construction site journal must be ensured.

5. Sustainability assessment of refurbishment measures



German Federal Constitutional Court in Karlsruhe: first complete refurbishment project to be awarded the silver certificate

D5

The set of criteria of the Complete Refurbishment BNB module is made up of unchanged criteria for new buildings, modified criteria for new buildings as well as specific criteria for existing buildings. This reflects the special nature of refurbishment projects. The only structural difference exists in the two additional criteria Stock-Taking (BNB_BK 5.1.6) and Demolition Planning (BNB_BK 5.1.7), which the Complete Refurbishment BNB module additionally contains in conjunction with the description and assessment of process quality.

The Complete Refurbishment BNB module provides a holistic assessment system for refurbishment projects which considers the ecological, economic, functional and technical requirements at the same time and on an equally important basis. This module can be used to describe in a transparent, measurable and verifiable manner the contribution of a refurbishment measure to sustainable development.

In the case of a refurbishment project, the entire building is always the focus of examination. This means that the building which results from refurbishment or

conversion will be considered. The focus is hence not on individual structural intervention measures alone. Accordingly, the products and building parts already installed into and remaining in the existing building are considered in conjunction with the selected assessment criteria and calculations. This is then relevant if such products can have a negative impact on humans and the environment during current and future use phases, or if products and parts can develop a negative impact as a result of refurbishment projects, for instance, dismantling and disposal.

The integration of sustainability aspects into the planning and design process according to the Official Scale of Fees for Services by Architects and Engineers (HOAI) or the RBBau Guidelines is structurally described in Part B of this Guideline and must be analogously applied to the refurbishment of existing buildings. According to figure D5, the following application case belongs to the refurbishment phase:

- III.1 – Complete refurbishment with assessment time c (see section 5.1)

CRITERIA TABLE – OFFICE AND ADMINISTRATION BUILDINGS SYSTEM VARIANT, VERSION 2015

FIGURE D4

COMPLETE REFURBISHMENT BNB MODULE (VERSION 2017)				
Sustainability criteria			Factor of relevance	Percentage share of overall result
ECOLOGICAL QUALITY				22.5%
Effects on Global and Local Environment				
BK	1.1.1	Global Warming Potential (GWP)	3	3.750%
BK	1.1.2	Ozone Depletion Potential (ODP)	1	1.250%
BK	1.1.3	Photochemical Ozone Creation Potential (POCP)	1	1.250%
BK	1.1.4	Acidification Potential (AP)	1	1.250%
BK	1.1.5	Eutrophication Potential (EP)	1	1.250%
BK	1.1.6	Risks to the Local Environment	3	3.750%
BK	1.1.7	Sustainable Material Extraction/Biodiversity	1	1.250%
Demand of Resources				
BK	1.2.1	Primary Energy Demand	3	3.750%
BN	1.2.3	Drinking Water Demand and Quantity of Wastewater	2	2.500%
BK	1.2.4	Land Consumption	2	2.500%
ECONOMIC QUALITY				22.5%
Life Cycle Costs				
BK	2.1.1	Building-related Life Cycle Costs	3	11.250%
Economic Efficiency and Value Stability				
BN	2.2.1	Space Efficiency	1	3.750%
BK	2.2.2	Adaptability	2	7.500%
SOCIO-CULTURAL AND FUNCTIONAL QUALITY				22.5%
Health, Comfort and User Satisfaction				
BN	3.1.1	Thermal Comfort	3	2.935%
BN	3.1.3	Indoor Air Quality	3	2.935%
BN	3.1.4	Acoustic Comfort	1	0.978%
BN	3.1.5	Visual Comfort	3	2.935%
BN	3.1.6	Influence of the User	2	1.957%
BN	3.1.7	Use Qualities	1	0.978%
BN	3.1.8	Safety	1	0.978%
Functionality				
BN	3.2.1	Barrier-free Building	2	1.957%
BN	3.2.4	Accessibility	2	1.957%
BN	3.2.5	Mobility Infrastructure	1	0.978%
Ensuring Design Quality				
BK	3.3.1	Design and Urban Quality	3	2.935%
BK	3.3.2	Art in Architecture	1	0.978%
TECHNICAL QUALITY				22.5%
Technical Execution				
BN	4.1.1	Sound Insulation	2	4.500%
BK	4.1.2	Heat Insulation and Protection against Condensate	2	4.500%
BN	4.1.3	Cleaning and Maintenance-friendliness	2	4.500%
BN	4.1.4	Dismantling, Waste Separation and Utilisation	2	4.500%
BN	4.1.5	Resistance to Natural Disasters	1	2.250%
BN	4.1.6	Maintenance Friendliness of Building Systems	1	2.250%
PROCESS QUALITY				10.0%
Management and Design				
BN	5.1.1	Project Preparation	3	1.200%
BN	5.1.2	Integrated Design and Planning	3	1.200%
BN	5.1.3	Complexity and Optimisation of Planning	3	1.200%
BN	5.1.4	Invitation to Tender and Contract Awarding	2	0.800%
BN	5.1.5	Preconditions for Optimum Utilisation and Management	2	0.800%
BK	5.1.6	Stock Taking	3	1.200%
BK	5.1.7	Demolition Planning	1	0.400%
Building Construction				
BN	5.2.1	Building Site/Building Processes	2	0.800%
BN	5.2.2	Quality Assurance of Building Construction	3	1.200%
BN	5.2.3	Controlled Commissioning	3	1.200%
LOCATION PROFILE				
Location Profile				
BN	6.1.1	Risks at the Micro-Site	2	–
BN	6.1.2	Conditions at the Micro-Site	2	–
BN	6.1.3	Image and Character of Location and Quarter	2	–
BN	6.1.4	Traffic Connections	3	–
BN	6.1.5	Vicinity to Use-specific Services	2	–
BN	6.1.6	Supply Lines/Site Development	2	–

Source: BBSR

EVALUATION TIME OF COMPLETE REFURBISHMENT
FIGURE D5



Possible assessment times:

- a Assessment of new construction project
- b Classification of new building stock as new construction (special solution for the transition phase)
- c Assessment of complete refurbishment
- d Classification of new building stock as complete refurbishment (special solution for the transition phase)
- e Assessment of the Use and Operation module (examples)
- f Special case of building diagnosis not linked to a measure (example)

Source: BBSR

5.1 Sustainability assessment of complete refurbishment measures

The Complete Refurbishment BNB module must be applied to refurbishment projects during the design, planning and construction phase if the measures qualify as “complete refurbishment” as defined in this Guideline (see section D 2.2). The assessment criteria must already be considered during the project preparation (ES-Bau) phase. An overview can be found in figure D4. The Complete Refurbishment, as well as the New Construction module, must be used at the time of handover and commissioning at the latest in order to quantify sustainability aspects and determine the

total degree of fulfilment. The analysis covers the building (including interaction with the property) in the as-built condition as well as the planned course of use. The explanations in Part A of this Guideline are applicable to the Complete Refurbishment module too. The minimum requirements according to Annex B7 of this Guideline are also applicable.

5.2 Sustainability assessment of partial refurbishment measures

The determination of the total degree of fulfilment with the Complete Refurbishment BNB module usually means an unreasonable level of effort when performed for partial refurbishment measures and is hence dispensable. Furthermore, a quantitative assessment of partial refurbishment measures using benchmarks is generally impossible for certain criteria because a common benchmark cannot exist in view of the wide range of different construction measures. It is, however, advisable to update an existing BNB assessment which was already performed in advance of the measure. In this case, the results of the criteria affected by partial refurbishment can be exchanged. Irrespective of performing a sustainability assessment, property documentation must also be updated following partial refurbishment projects.

The individual measures performed within a partial refurbishment project must be in line with the requirements of sustainable building. The contents and requirements of section 4, “Specific criteria for sustainable building refurbishment”, must be generally fulfilled by partial refurbishment projects. Moreover, all deliveries and services necessary for a partial refurbishment project must be obtained in a sustainable manner and from sustainable sources. The “Sustainability Compass” of the Deutsche Gesellschaft für internationale Zusammenarbeit⁵ is available as a tool for this purpose.

Beyond these requirements, partial refurbishment projects additionally require analogous application of the relevant criteria of an existing Complete Refurbishment BNB module, depending on current administrative decrees for federal building. Analogous to Annex B1 of the Guideline for Sustainable Building, a target agreement chart must be set up for this purpose without determining the total degree of fulfilment nor any partial degrees of fulfilment. Instead, those qualitative requirements must be laid down which ensure the sustainability of the measure. The quality levels of the

relevant criteria of the Assessment System for Sustainable Building have to be used for this purpose. The target agreement chart becomes part of the project preparation documents. The target agreement remains binding throughout the entire term of the project.

In this case, the criteria of the Complete Refurbishment BNB module that must be identified first are the criteria that can be influenced by the measure in question (influenced criteria). The target agreement is only necessary for these influenced criteria. The construction administration has to prepare the target agreement chart with the support of a BNB sustainability coordination officer who ensures analogous application of the relevant criteria. The BNB sustainability coordination officer must document the implementation of the target agreement as part of the planning, design and construction process analogous to the validation procedure of the Assessment System for Sustainable Building.

5.3 Analogous application

In the case of refurbishment projects where no Complete Refurbishment BNB module exists for the respective building and type of use, the Complete Refurbishment BNB module can only be applied analogously. More detailed information can be found in a separated work guideline.

⁵ www.oeffentlichebeschaffung.kompass-nachhaltigkeit.de/en

Appendix

Glossary

Abiotic resources: an action category which describes the reduction in the global stock of raw materials and commodities due to the consumption of non-renewable, abiotic resources, such as minerals, fossil fuels.

Discounting: this compound interest computation method serves to determine initial capital (if end capital, interest rate and term are known).

Federal building administrations: BBR and the federal-state administrations working on behalf of the federal government.

Final energy: the energy volume (such as fuel oil) which is available to the end user and which results from the useful energy (the energy, such as heating energy, which the end user needs) plus losses during conversion, distribution and delivery.

Heating and/or cooling period: pursuant to DIN 13790, that period of the year during which significant heating and/or cooling demand exists.

Heating demand: pursuant to DIN 4108-2, the calculated heat supply via a heating system which is necessary to maintain a defined average room temperature in a building or in a zone of a building – also referred to as net heating energy demand.

Improvement: pursuant to DIN 31051, the combination of all technical and administrative as well as management measures designed to enhance the functional reliability of an item without changing the functionality this item is expected to provide.

Inspection: pursuant to DIN 31051, a measure to identify and assess the actual condition of an item, including the determination of causes for wear and tear as well as the identification of the necessary consequences for future use.

Maintenance: pursuant to Section C of the RBBau Guidelines, this includes all consumptive measures to maintain buildings, including technical building equipment and outdoor facilities. Scheduled servicing and inspection do not form part of building maintenance nor does preparation work which becomes necessary due to a new function (see Section C of the RBBau Guidelines).

Material flow: pursuant to VDI 4091, a substance and material flow from point A to point B resulting from the extraction, processing, use/consumption and disposal (recycling/removal) of raw, ancillary and operating substances, energy, products and waste.

Primary energy demand: pursuant to DIN 4108-6, the amount of energy that is needed to cover annual heating and hot water (drinking water) energy demand, including the additional energy resulting from upstream process chains outside the building boundaries, namely during production, conversion and distribution of the respective fuels.

Quality assurance: term used to describe the organisational and technical measures to ensure specifications-compliant concept and execution quality. Quality assurance encompasses quality planning (selecting the quality features for a product), quality management (specifying the planned execution requirements and monitoring, and adjustment when necessary) and quality control.

Refurbishment: pursuant to the HOAI, construction measures other than extension, conversion or repair work designed to achieve a sustainable increase in the use value of the building.

Repair: pursuant to the HOAI, construction measures to restore the condition suitable for the original purpose (target condition) of a building, building part, component or system.

Room air conditioning: heating, cooling, ventilation, humidification, lighting and hot drinking water supply using energy in order to achieve defined interior conditions in rooms.

Service life: pursuant to DIN 18960, the handover and optimisation, operation, refurbishment and return phase until the beginning of the disposal phase.

Servicing: pursuant to DIN 31051, measures to delay the reduction of the existing wear reserve.

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Abbreviations

AMEV	Arbeitskreis Maschinen- und Elektrotechnik staatlicher und kommunaler Verwaltungen (Mechanical and Electrical Engineering Working Party of National, Regional and Local Authorities)	BMVg	Bundesministerium der Verteidigung (Federal Ministry of Defence)
AP	Acidification Potential	BNB	Bewertungssystem Nachhaltiges Bauen (Assessment System for Sustainable Building)
ASR	Technische Regeln für Arbeitsstätten (Technical Rules for Workplaces)	CAFM	Computer-aided Facility Management
ATR	Allgemeine Technische Vertragsbedingungen für Bauleitungen (General Technical Terms and Conditions for Construction Work)	CLP	Classification, Labelling and Packaging; Regulation (EC) No. 1272/2008
BauGB	Baugesetzbuch (Building Code)	CO₂	Carbon dioxide
BauNVO	Baunutzungsverordnung (German Federal Land Utilisation Ordinance)	DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen (German Sustainable Building Council)
BBR	Bundesamt für Bauwesen und Raumordnung (Federal Office for Building and Regional Planning)	DIN	Deutsches Institut für Normung e.V. (German Institute for Standardisation)
BBSR	Bundesinstitut für Bau-, Stadt- und Raumforschung (Federal Institute for Research on Building, Urban Affairs and Spatial Development)	EEWärmeG	Erneuerbare-Energien-Wärme-Gesetz (Renewable Energies Heat Act)
BFR GBestand	Baufachliche Richtlinien Gebäudebestandsdokumentation (building-related guidelines for documentation of existing buildings)	EMIS	Energie- und Medieninformationssystem des Bundes und der Länder (energy and media information system of the federal government and federal states)
BFR Verm	Baufachliche Richtlinien Vermessung (building-related guidelines for surveying)	EnEV	Verordnung über den energiesparenden Wärmeschutz und energiesparende Anlagentechnik bei Gebäuden (Energieeinsparverordnung) (Energy Saving Ordinance)
BGF	Bruttogrundfläche (gross floor area)	EP	Eutrophication Potential
BGG	Behindertengleichstellungsgesetz (German Act on Equal Opportunities for Disabled Persons)	EPD	Environmental Product Declaration
BHO	Bundeshaushaltsordnung (Federal Budget Code)	ES-Bau	Entscheidungsunterlage – Bau (Decision-making Documents)
BImSchG	Bundes-Immissionsschutzgesetz (Federal Immission Control Act)	EW-Bau	Entwurfsunterlage – Bau (Design Specification Documents)
BMF	Bundesministerium der Finanzen (Federal Ministry of Finance)	GED	Gemeinschaft Energielabel Deutschland (German Energy Label Group)
BMI	Bundesministerium des Innern, für Bau und Heimat (Federal Ministry of the Interior, Building and Community)	GEMIS	Globales Emissions-Modell Integrierter Systeme (Global Emissions Model for Integrated Systems)
BMU	Bundesministerium für Umwelt, Naturschutz und Nukleare Sicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)	GHG	Greenhouse Gas
BMVBS	Bundesministerium für Verkehr, Bau und Stadtentwicklung (Federal Ministry of Transport, Building and Urban Development)	GWP	Global Warming Potential
		HOAI	Honorarordnung für Architekten und Ingenieure (Official Scale of Fees for Services by Architects and Engineers)
		ImmoWertV	Immobilienwertermittlungsverordnung (Ordinance Regarding the Principles for the Determination of the Fair Value of Properties)
		INKA	Instrument für Nutzerbefragungen zum Komfort am Arbeitsplatz (tool for user surveys on comfort at the workplace)

KFA	Kostenflächenarten (cost of space value)	UBA	Umweltbundesamt (Federal Environment Agency)
KG	Kostengruppe (cost category)	VDI	Verein Deutscher Ingenieure (Association of German Engineers)
KrW-/AbfG	Kreislaufwirtschafts- und Abfallgesetz (Closed Substance Cycle and Waste Management Act)	VOB	Vergabe- und Vertragsordnung für Bauleistungen (General Provisions Relating to the Award of Construction Contracts)
LAK	Liegenschaftsbezogenes Abwasser-entsorgungskonzept (Estate Sewage Disposal Concept)	VOC	Volatile Organic Compounds
LCA	Life Cycle Assessment	VV	Verwaltungsvorschrift (administrativ regulation)
LCC	Life Cycle Costs	WECOBIS	Webbasiertes ökologisches Baustoff-informationssystem (Web-based Ecological Building Material Information System)
LFBB	Leitfaden Barrierefreies Bauen (Guideline Accessibility in Building Design)	WertR	Richtlinien für die Ermittlung der Verkehrswerte (Marktwerte) von Grundstücken (Guidelines for the Determination of Fair Values (Market Values) of Properties)
NRF	Netto-Raumfläche (net floor area)	ZBau	Baufachliche Ergänzungsbestimmungen (additional engineering criteria)
ODP	Ozone Depletion Potential		
OHS	occupational health and safety		
OTI	Oberste Technische Instanz (supreme technical authority)		
PEe	Primary energy demand (renewable)		
PEne	Primary energy demand (non-renewable)		
PLAKODA	Planungs- und Kostendatenmodule der Länder und des Bundes (planning and cost-data module of the federal states and federal government)		
POCP	Photochemical Ozone Creation Potential		
POE	Post Occupancy Evaluation		
PPP	Public Privat Partnership		
RBBau	Richtlinien für die Durchführung von Bauaufgaben des Bundes (Federal Construction Guidelines)		
RLT	Raumluftechnik (air handling systems)		
RPW 2013	Richtlinie für Planungswettbewerbe 2013 (2013 Design Competition Guideline)		
RÜV	Richtlinie für die Überwachung der Verkehrssicherheit von baulichen Anlagen des Bundes (Guideline for Monitoring the Safe Use of Federal Government Buildings and Structures)		
SiGe-Plan	Sicherheits- und Gesundheitsschutzplan (Safety and Health Plan)		
SLA	Service Level Agreements		
SNAP	Systematik für Nachhaltigkeitsanforderungen in Planungswettbewerben (System for Sustainability Requirements in Design Competitions)		
TGA	Technische Gebäudeausstattung (technical equipping)		
TRGS	Technische Regeln für Gefahrstoffe (Technical Rules for Hazardous Substances)		

Annexes

- B1** Target agreement tables
- B1.1** Target agreement table New Construction
- B1.2** Target agreement table Complete Refurbishment
- B2** Criteria according to the BNB in the phases of the RBBau Guidelines (differentiated in each case according to new construction or complete refurbishment with / without monument protection)
- B2.1** Overview of the criteria to be considered during the phases of the RBBau Guidelines
- B2.2** Verification requirements during the ES-Bau phase
- B2.3** Verification requirements during the EW-Bau phase
- B3** Pre-check (Sample)
- B4** Energy Target Specifications (Sample)
- B5** Sustainability assessment report (Sample)
- B6** Sustainability requirements in design competitions
- B7** Minimum requirements for federal buildings
- B8** Health

- C1** Minimum requirements and recommendations for use and operation
- C2** Template questionnaire for operation and repair costs with minimum degree of detail
- C3** Criteria table for building maintenance measures (quality assurance check-list)
- C4** Operator sustainability report (check-list)
- C5** Assessment table for the Use and Operation BNB module
- C6** Criteria table for the New Building Stock BNB transition module
- C7** Target agreement table Use and Operation

- D1** Criteria table for the Complete Refurbishment BNB module
- D2** Assessment table for the Complete Refurbishment BNB module

The annexes can be downloaded from the Sustainable Building Information Portal www.nachhaltigesbauen.de under the “Leitfäden und Arbeitshilfen” (guidelines and tools) heading.

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