VDI Zentrum Ressourceneffizienz

On behalf of:

Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection

of the Federal Republic of Germany

Resource efficiency in construction

From planning to the building

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INTRODUCTION

The protection of natural resources is of existential importance for the preservation of our planet.[1]

For several years now, German environmental and sustainability policies have increasingly focused on the subject of resource efficiency. As the construction industry uses large amounts of raw materials, it plays a key role in ensuring resource efficiency.

Resource efficiency includes not only energy efficiency but also material efficiency. Energy efficiency, which is regulated by law in the German Energy Savings Ordinance, is already an integral part of all construction planning. On the other hand, the discussion of material efficiency in the construction industry is still very much at an early stage.

However, in recent years it has gained in prominence due to a growing global shortage of raw materials. Besides diminishing resources, some German regions are also approaching their limits of landfill capacities.

Many aspects relating to resource efficiency are embedded in sustainable construction. Sustainability rests on three pillars: environmental, economic and socio-cultural aspects. All three pillars are equally important and must be treated as such. Environmental conservation is about the protection of natural resources and ecosystems, and one strategy to reach those goals is to increase resource efficiency. This brochure focuses exclusively on the area of resource efficiency.

However, to be truly holistic, planning needs to cover all aspects of sustainability.

The aim of future construction should be to address resource efficiency across the entire lifespan of a building. This brochure provides an overall definition of resource efficiency as well as ways to integrate resource efficiency aspects from the planning phase to construction. In addition, the brochure provides several pages with further details and helpful tools as well as practical examples that illustrate how resource efficiency measures can be implemented.

Use of resources

Approximately 90% of mineral raw materials consumed in Germany are used in the production of building materials.[1]

Energy consumption

Up to 40% of Germany's overall energy consumption is due to the use of buildings.[1]

Waste volume

About 54% of Germany's total waste volume derivates from the construction sector.[1]

The construction sector has a substantial share in the overall use of resources, energy and waste volume.
(Credits from left to right: © Harald Biebel/Fotolia.com, Olivier Le Moal/Fotolia.com, TakerWalker/PantherMedia)

WHAT ARE THE BENEFITS OF RESOURCE-EFFICIENT PLANNING AND CONSTRUCTION?

Competitive benefits for planners and contractors

- Creation of additional business
- Expansion of service/product range
- New economic sectors
- Greater efficiency within your company
- Positive corporate image

Resource-efficient construction conserves both natural resources and the environment. From the owner's perspective, resource-saving construction means benefits in terms of high quality and long-term value retention. However, keeping an eye on resource efficiency aspects is equally attractive for planners and building contractors.

There is a high demand for suitably skilled companies that can carry out construction projects in a manner that is truly sustainable and resource-efficient. After all, for many owners, the issue of saving resources has become an important part of their sustainable business management. There is a large number of examples which show that both corporate and private owners have already been implementing aspects of sustainability and resource efficiency in their construction projects.

This offers the opportunity to generate additional construction contracts by acquiring the relevant skills, e.g. through staff training.As a result, it is possible to open up a future market and create access to innovative expertise and technologies, which ensures competitiveness in the long term. In this way, both planners and building contractors can expand the product and service ranges. This also makes it possible to develop new business models deriving from circular economy principles.

Moreover, resource-efficient planning and construction increase the level of efficiency within the company.

Owners, planners and building contractors alike can generate an positive corporate image through the use of sustainable and resource-efficient construction. this is not only attractive to customers, but also leads to a better identification of the employees with the company.

"For us, sustainability is not a buzzword but a day-to-day principle. As one of the first climate-neutral IT companies, we've been implementing a range of measures, so that we can be as resource-efficient and emission-free as possible in our work. This has also been a major consideration for us in our new hybrid timber construction project."

Sebastian Hamann,
CEO of shopware AG

photo: © RMA Architekten

"Act now, plan for the future. This is our motivation for sustainable construction."

Klaus Peter, lead baker and owner
of the bakery business Bakery Peter

WHAT DOES RESOURCE EFFICIENCY MEAN?

Resource efficiency can be defined as the relation between a specific benefit or result and the resource usage required to achieve it.[2]

The focus of this definition from the VDI Guideline 4800 Blatt 1 (2016) is on the efficient and sparing use of natural resources.
The benefit of a product or service is its fulfilment of certain functions and properties. The description of this benefit should be solution-neutral. Use of resources is defined as the use of natural resources. In this context, natural resources comprise renewable and non-renewable primary raw materials, energy resources, air, water, land and ecological services.

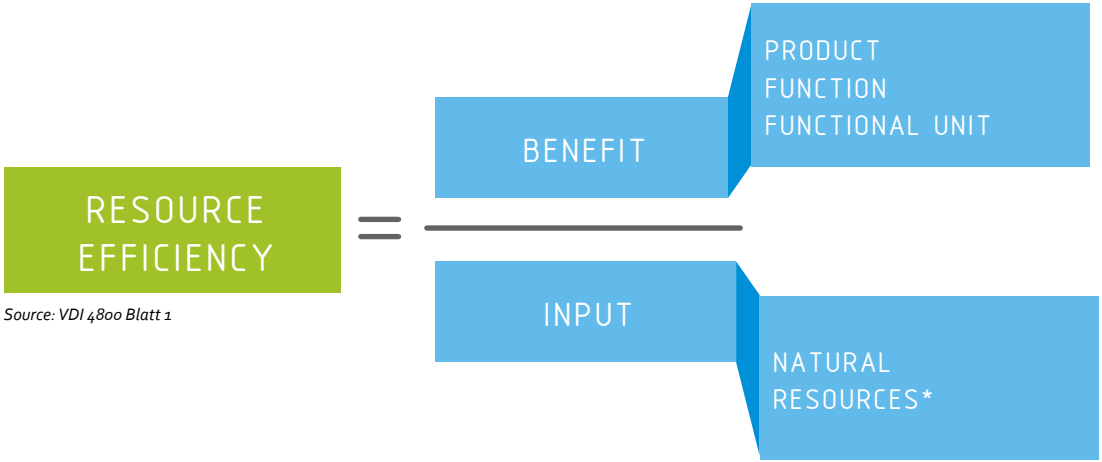
The balancing of resource usage covers the entire lifespan of a product (or building), i.e. from the extraction of raw materials to the end of its lifetime. There are two ways to increase efficiency: 1. Reduce the use of resources while continuing to deliver the same benefit; 2. Increase benefit while keeping the same energy input.

Note the following example where the benefit of a component has been described: The aim is to ensure that the planning of an exterior wall is as resource-efficient as possible.

Benefit: The first step is to define the necessary properties of the exterior wall: 1 m^2 opaque exterior wall with a heat transfer coefficient of 0.15 $W/(m^2K)$ and a lifespan of 50 years. The more precisely these properties are described, the easier it is to compare the different solutions.

Input: To deliver the benefit, there may be a variety of solutions, which are then compared in terms of their use of resources. This involves calculating energy and material inputs in the production, use and end of life of each building material of a given solution. It is important to cover all inputs in the lifespan of a product as well as the replacement cycles of individual elements.

When looking at the resource efficiency of a building, all the resources of that building must be included throughout its entire lifecycle, from the extraction of raw materials to the use and dismantling of the building.



Source: VDI 4800 Blatt 1

*Primary raw materials, energy resources, air, water, land and soil, ecosystem services

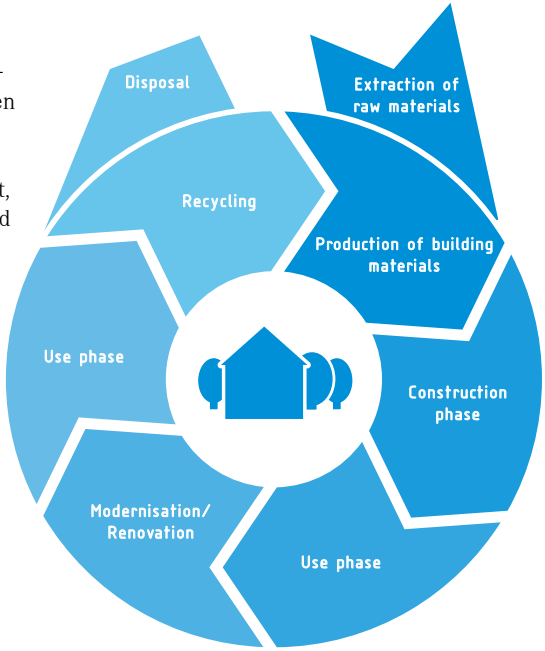
To increase the resource efficiency of a building, it is essential to consider its life cycle in detail.

The aim of a lifecycle assessment is to maximise the quality of the building and the quality of its use while keeping the material flows, environmental impact and lifecycle costs as low as possible.

If individual phases in the lifecycle are optimised, the impact on other phases must be analysed so as to avoid localised optimal effects to the detriment of other phases. This means looking at all the phases from the extraction of raw materials to recycling/disposal.

The building design can have an impact at any stage. The choice of building products, for example, influences the amount of resources needes for these products. In contrast to material efficiency, optimising energy consumption in the use phase has already been accepted in planning for several years.

If deconstruction is also taken into account, far more building materials can be recycled and used as secondary building materials for the construction of new buildings or infrastructure, resulting in a reduced extraction of primary raw materials protection of the environment.



Simplified visualisation of a building-lifecycle

EXTRACTION OF RAW MATERIALS:

incl. extraction, processing and transport of raw materials

Use of resources:
material, energy, water, land, ecosystem services

Possible influences:
extraction of raw materials, production of buil-ding materials, building design/ planning (indirectly)

PRODUCTION OF BUILDING MATERIALS:

incl. production of building materials, prefabrication of building components, transport

Use of resources:
material, energy, water

Possible influences: production of building materials, building design (indirectly)

BUILDING CONSTRUCTION:

incl. property-specific and site-specific construction of building, transport

Use of resources:
material, energy, water

Possible influences:
building planning, building construction

USE PHASE:

incl. energy supply in the building, plumbing

Use of resources: energy, water

Possible influences: use phase, building planning

MODERNISATION/RENOVATION:

incl. replacement/renewal of building components and HVAC, integration of new HVAC, additional measures for thermal insulation, transport

Use of resources:
materials, energy

Possible influences:
modernisation/renovation, building planning

DISMANTLING/RECYCLING:

incl. demolition, processing, transport
Use of resources:
energy, water

Resource output:
material

Possible influences:
deconstruction/recycling, building planning

DISMANTLING/DISPOSAL:

incl. demolition, deposit in landfill, thermal treatment, transport

Use of resources:
energy, ecosystem services

Resource output:
energy (with thermal treatment)

Possible influences:
deconstruction/disposal, building planning

RESOURCE EFFICIENCY: FROM PLANNING TO THE BUILDING

photo: © johannesspreter/AdobeStock

For planners and building contractors, the integration of resource efficiency aspects in their processes has numerous benefits.

In the following chapters, we will therefore present information on resource-efficient planning and construction.

The brochure offers a wide range of aspects in form of checklist questions. This overview is not meant to be exhaustive but is intended to show a broad spectrum by focusing on a wide range of essential points. Based on HOAI (the Official Scale of Fees for Services by Architects and Engineers), the relevant resource efficiency aspects are listed for the planning, tendering and contracting, construction and handover phases. In addition, further details on each of the areas as well as information about tools are provided. Furthermore, the brochure depicts various practical examples, showing the approaches of other planners and building contractors.

As there is a particularly high consumption of it in the building sector, the brochure focuses primarily on material efficiency, energy efficiency and specific aspects of land use efficiency (incl. soil protection), disregarding water efficiency, air or ecosystem services.

"Materials and components are selected not only for their environmental and health benefits but also, above all, their recyclability. So when the building comes to the end of its lifetime, the raw materials will have retained their quality, and the building can serve as a resource depot."

Ursula Feld, architect
kadawittfeldarchitektur

photo: © Jens Kirchner

photo: © ZRS Architekten

"As planners, we believe it's our responsibility to minimise as much as possible any dependency on fossil resources and their use. Together with our highly motivated customers and partners, we aim to use local and renewable resources and develop intelligent structures with flexible layout options that can significantly increase the lifespan of a building, especially in the commercial sector."

Andreas Pohl, architect
ZRS Architekten GvA mbH

Resource efficiency aspects in planning

The greatest opportunities to increase resource efficiency can be leveraged in the planning phase, as this is when fundamental decisions are made about its resource efficiency, affecting the entire lifetime of the building. First, a number of basic questions are asked concerning usage requirements and site analysis.

To present the different resource efficiency strategies as clearly as possible, they are divided into material efficiency, energy efficiency and land use efficiency. The three areas affect one another, and therefore various interactions between them are shown at a glance.

At the beginning of the process, it is important to identify the usage requirements. The following questions need to be answered:

- How long will the building be used for? (Adjust the construction method and building components to the planned service life)
- Will there be any need for resource-intensive construction parts (e.g. basement)?
- What are the temperature requirements of the required rooms?
- Is it possible to obtain any synergies within the building (waste heat suppliers, e.g. a server room)?
- Which areas are necessary, and are their dimensions as small as possible?
- Is it possible to increase the usage density?

A status analysis can reveal the resource efficiency potential of the existing building and its surroundings:

- Is it possible to continue using an existing building?
- If a building in the vicinity is to be dismantled, are there any building materials that can be re-used/ recycled?
- Are there any potential waste heat suppliers in the surroundings?
- How great is the potential for renewable energies at this location?
- Is it possible to use already existing sealed surfaces, so that no new surfaces need to be sealed?
- Is it possible to increase the density or add more floors at a later stage?

MATERIAL EFFICIENCY

There are three main strategies to increase the **material efficiency** of a building:

1. Reduce "grey energy"

"Grey energy" is the energy required for the production, transport, storage and disposal of materials.[3]

To reduce "grey energy", the following aspects can be addressed:

- Has attention been paid to, for instance, ensure a simple structure, smart design and multifunctional construction elements in order to keep the use of materials as low as possible?
- Is it possible to use building materials with a low level of "grey energy"? Quite often, recycled materials (e.g. RC aggregate), re-usable components and materials based on renewable raw materials (e.g. wooden materials) require relatively little energy in production.
- Is it possible to reduce the transport distance for building materials (e.g. by using regional manufacturers)?
- Is it possible to reduce the amount of waste at the construction site (e.g. by prefabricating building components)?

2. Extending the lifetime of the building/ component

The longer it is possible to use resources, the greater their benefit and thus also their resource efficiency.

- Are the building materials and designs robust and durable?
- Has attention been paid to high reparability, among other things through good interchangeability, accessibility and consideration of replacement cycles (e.g. through modular construction)?
- Is there a post-usage concept (e.g. flexible layouts, high ceilings or possible payload reserves), allowing for alternative uses?

3. Recyclability of building components

The concept of circularity includes the re-use of components and the recycling of materials with the aim of conserving primary raw materials and saving manufacturing energy.

- Are the used materials recyclable? Are they free of harmful substances? Do recycling structures exist (e.g. manufacturer take-backs)?
- Is it possible to simplify separation into different material groups in the dismantling process, e.g. by reducing material diversity?
- Is attention paid to detachable connections and demountable structures/designs/ constructions (e.g. screws instead of adhesive)? Are the relevant details and instructions documented and made available for future dismantling?

ENERGY EFFICIENCY

In recent years, there has been a considerable amount of attention on increasing **energy efficiency** during the utilisation phase. We will therefore deal with it only briefly.

The following three strategies can be used to increase energy efficiency:

1. Saving energy

- Has attention been paid to compact dimensions, sufficient insulation, and have thermal bridges been avoided in order to reduce heat loss?
- Is it possible to avoid ventilation heat loss (e.g. through airtight construction)?
- Is it possible to prevent overheating by providing thermal protection during the summer (e.g. through high storage mass or shading)?

2. Efficient building services equipment (BSE)

- Is BSE efficient (e.g. heating, cooling, ventilation and lifts)?
- Are there any plans to monitor the utilisation phase in order to control and readjust energy consumption?

3. Use of renewable energy and waste heat

- Is it possible to integrate renewable energies (e.g. solar thermal energy, ambient heat)?
- Is it possible to use renewable energies passively (e.g. via heat input through windows or passive ventilation)?
- Is it possible to receive (industrial) waste heat from neighbouring companies?

LAND USE EFFICIENCY

Two strategies can be used to increase **land use efficiency** on a property:

1. Avoidance of surface sealing

- Can land be built over or redensified as efficiently as possible?
- Is it possible to use surfaces that have already been sealed?
- Is it possible to use already existing infrastructure (e.g. in a city or village, not on a greenfield site)?
- Is it possible to avoid unnecessary sealing, e.g. through an intelligent mobility concept (e.g. by using public transport or sharing schemes)?

2. Efficient use of space

- Is it possible to avoid unnecessary space through intelligent layout planning?
- Is it possible to increase repurposability through flexible layout planning, so that the space can be used for longer?
- Is it possible to create ecological compensation areas, e.g. green roofs?
- Can some spaces take on multiple uses (e.g. green roofs: recreation, rainwater retention)?

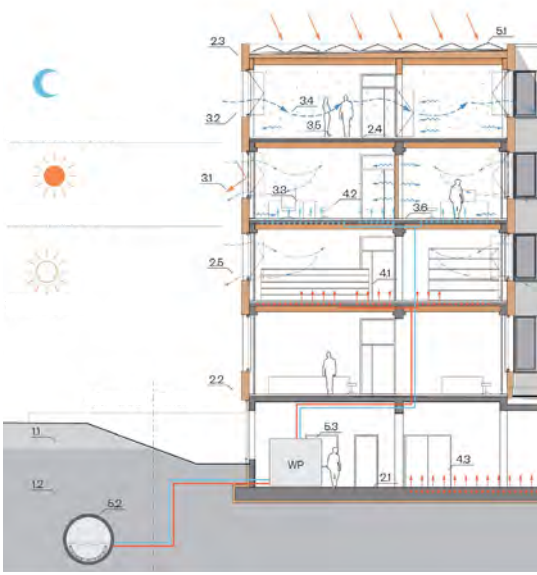
INTERIM CONCLUSION

To find a holistic resource-efficient solution throughout the entire life cycle, the interactions must be taken into account. The thicker the insulation, the lower the heat loss via the exterior wall but the higher the use of resources in terms of insulating material.

Or: By planning for payload reserves, it is possible to increase the useful life of a building, but this also increases the use of materials.

Integral planning can ensure that resource efficiency aspects are holistically catered for and optimised. This puts the focus on the entire lifecycle of the building.

Meticulous **documentation** during the planning stage is important to ensure that the relevant details are preserved until the building comes to the end of its lifetime. Although HOAI service phase 9 includes documentation, it is frequently left out when the relevant jobs are commissioned. Also, no building certificate or materials passport with precise details and dimensions of the relevant materials needs to be supplied. However, this point, too, should be covered and carefully implemented at the beginning of the planning.[4, 5, 6]



Climate concept for new Flexim GmbH-building
(photo: © ZRS Architekten)

ADVANCED KNOWLEDGE

GENERAL INFORMATION

Leitfaden Nachhaltiges Bauen
Zukunftsfähiges Planen, Bauen und Betreiben von Gebäuden (Guide to sustainable construction – sustainable planning, construction and operation of buildings), German Federal Ministry of the Interior and Community, Berlin 2019: www.nachhaltigesbauen.de/fileadmin/pdf/Leitfaden_2019/BBSR_LFNB_D_190125.pdf

Assessment System for Sustainable Building (BNB)
German Federal Ministry of the Interior and Community, Catalogue of Criteria – also accessible in English: https://www.bnb-nachhaltigesbauen.de/en/

Resource efficiency in construction,
VDI Zentrum Ressourceneffizienz GmbH, 2019: https://www.resource-germany.com/topics/construction-industry/

dena – Deutsche Energieagentur GmbH
Information on energy efficiency and energy transition, 2019: https://www.dena.de/en/home/

Fact sheets – buildings and infrastructures,
Nachhaltigkeitsmanagement für außeruniversitäre Forschungseinrichtungen (Sustainability management for non-university research institutions) (LeNa), 2016: www.nachhaltig-forschen.de/fact-sheets/gebaeude-und-infrastrukturen/

MATERIAL AND ENERGY EFFICIENCY TOOLS

ELCA
free lifecycle assessment tool, Ökobaudat database, Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) – also accessible in English: www.bauteileditor.de

CAALA
energy predimensioning and lifecycle assessment software, beta version, free of charge, Ökobaudat database, application at draft stage, Caala GmbH – also accessible in English: https://caala.de

INFORMATION ON MATERIAL EFFICIENCY

Ökobaudat
standardised database for lifecycle assessment, German Federal Ministry of the Interior and Community (BMI) – also accessible in English: https://www.oekobaudat.de/en.html

Environmental Product Declarations
(EPD), description of building materials and building products in terms of environmental impact, technical and functional properties, Institut Bauen und Umwelt e. V. – also accessible in English: https://ibu-epd.com/en/

WECOBIS – ecological building material information system
provision of product-neutral environmental and health-related data, German Federal Ministry of the Interior and Community, Bavarian Chamber of Architects: www.wecobis.de

Overview of the service life of components (Microsoft Excel tool)
German Federal Ministry of the Interior and Community: www.bnb-nachhaltigesbauen.de/fileadmin/anlagen/2015/Anlage_1_Nutzungsdauern_Instandhaltung_%C3%96kobilanzierung.xlsx

Building Material Scout
list of sustainable building products with eco-labels and product ratings, Building Material Scout GmbH – also accessible in English: https://building-material-scout.com/en/

Leitfaden Dämmstoffe 3.0 – mit dem Schwerpunkt Naturdämmstoffe (Insulating Materials Guide 3.0 – with a focus on natural insulating materials), ecological assessment of insulation materials, City of Munich, 2017: www.muenchen.de/rathaus/dam/jcr:c44833ca-c8b6-4b63-ba37-3c5c588d3b53/leitfaden_daemmstoffe_3_0.pdf

INFORMATION ON ENERGY EFFICIENCY

Leitfaden Wärmebrücken in der Bestandssanierung (Guide to thermal bridges in the refurbishment of existing buildings), dena: www.dena-expertenservice.de/fileadmin/Fachinformationen/Waermebruecken/dena-Leitfaden-Waermebruecken-Webfassung.pdf

Informationen zur Flächeneffizienz Redevelopment - Leitfaden für den Umgang mit vorgenutzten Grundstücken und Gebäuden
(Redevelopment – Guidelines for dealing with previosly used land and buildings), gif Gesellschaft für Immobilienwirtschaftliche Forschung e. V., Wiesbaden, 2016: https://gif-ev.com/produkt/redevelopment-leitfaden-fuer-den-umgang-mit-vorgenutzten-grundstuecken-und-gebaeuden/

BEST PRACTICE: FLEXIM - FLEXIBLE INDUSTRIEMESSTECHNIK GMBH

FLEXIM develops, manufactures and sells process measuring instruments for industrial applications. The medium-sized company operates worldwide.[7]

Due to its steady growth, it no longer had enough space at its old location. As a first step, the company therefore erected two buildings in the vicinity and then occupied those buildings in 2017. The planning of the buildings focused not only on energy but also on material and land use efficiency.

Usage requirements: The architectural concept envisages a modular structure in several construction phases, which will gradually create space for the company's further expansion. This way, future space requirements can be accommodated while ensuring that the current space is no larger than necessary.

A **status analysis** showed that municipal wastewater from the sewers can be used as a heat source and that there is also potential for the use of solar power. Both points were considered in the energy concept.

Material efficiency: The building was designed with a hybrid structure. Due to high loads, the lower levels were fitted with reinforced concrete columns and binding beams. The external façade is a prefabricated, curtain-wall timber frame façade insulated with cellulose. The use of renewable raw materials means that CO2 is stored within the building. Also, the use of prefabricated components reduces the waste volume at the construction site.

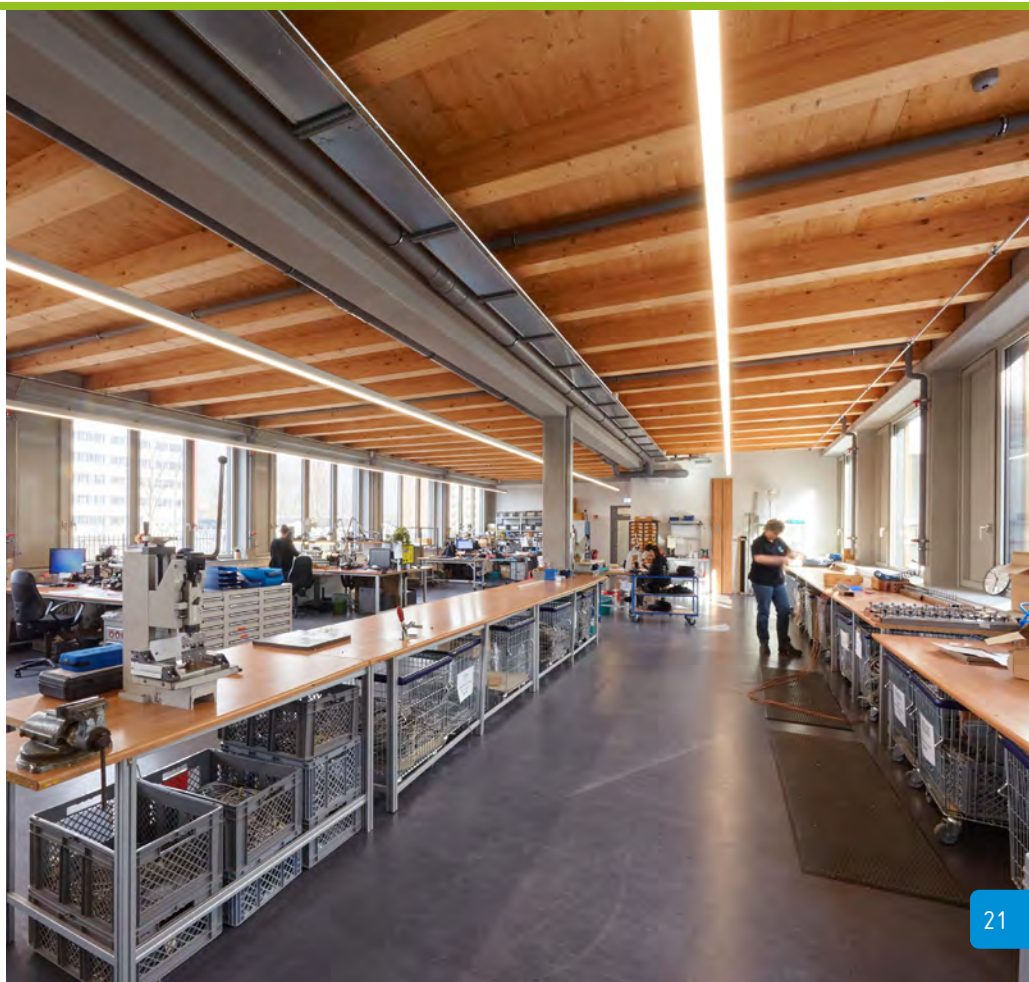
Energy efficiency: Heat loss is effectively reduced by the compact shape of this low-energy building, its well-insulated exterior walls and its green roof. The amount of ventilation equipment was substantially reduced through natural, “free” ventilation and night cooling, so that the equipment is only necessary in the interior rooms on the ground floor.

80% of the heat supply is provided by a heat exchanger in the wastewater channels of the property. It is supplemented by a gas condensing boiler, operating as a peak-load boiler and by solar panels on the roof.

Efficient use of space : When the layout was planned, production and logistics processes were taken into account and rooms that are flexibly usable were planned.[8]

PLANNING

- efficient land use
- Extendable buildings complex
- Renewable raw materials
- Recyclable building materials
- Prefabricated components
- Compact building shape
- Insulation of building envelope
- Summer thermal insulation
- Accessible service ducts
- Efficient ventilation equipment
- Use of renewable energies and waste heat
- Flexible layouts



Interior view of the low-energy building of FLEXIM GmbH
(photo: © ZRS Architekten)

Resource efficiency aspects in tendering and contracting processes

Once the planning is finished, the **tender for the construction work** begins and the **contracting** is prepared. The resource efficiency requirements are defined at the planning stage and then realised through tendering and contracting.

TENDER

Prior to awarding a contract, a tender invitation or performance specifications are drawn up, including a quantity takeoff.

The following points need to be assured in the tender concerning resource efficiency:

1. General preliminary remarks

- Do the specifications include technical aspects to increase resource efficiency, such as durability, ease of cleaning, maintenance and dismantling?
- Do the specifications include generally applicable requirements on the environmental compatibility of construction materials?

2. Requirements for the development of the building site

- Do the specifications include an on-site usage requirement for excavated soil? (Local use of excavated soil, e.g. as concrete aggregates)

3. Specific requirements for building products

- Do the specifications include environmental and health & safety requirements for building products for each trade involved in the construction project?
- Do the specifications include requirements concerning product origins/local sourcing?
- Do the specifications include requirements on technical aspects to increase resource efficiency?
- Do the specifications include details concerning the fulfilment of labels and certificates (e.g. FSC or PEFC certification for the use of timber)?
- Do the specifications include a requirement to use recycled building materials and secondary raw materials for specific components or the re-use of components (e.g. R-concrete)?
- Functional tender: Does the tender include a list of specific requirements or exclusion criteria for the selection of building materials?

4. Specifications for the building process

- Are there specifications for the building process concerning waste reduction and separation, soil protection and the reduced consumption of resources?

5. Documentation

- Does the tender include details of the required documentation, such as data-sheets, installation site, photos, operating instructions as well as inspection and servicing instructions?

SUITABILITY CRITERIA

By specifying suitability criteria (e.g. expertise), it is possible to check whether a bidder is capable of carrying out the project.

- Does the company have evidence of suitability in terms of resource-efficient construction, such as attended trainings?
- Does the company have proven relevant practical experience as well as specialists in the selected areas?
- Can the company provide evidence of corporate environmental protection (e.g. EMAS certification)?
- Does the company use environment-friendly means of transport?

AWARD CRITERIA

- In a functional tender, does the company give preference to the most economical offer rather than the cheapest? (The most economical offer includes lifecycle expenses as well as additional criteria.)
- Does the company include aspects of resource conservation as award criteria, and are such aspects given a high priority? (The award criteria must be described in an objective, output-related and comprehensible manner concerning construction work, materials and their properties.)
- Does the company compare offers using a utility analysis, and is the evaluation carried out by an interdisciplinary planning team?

ADVANCED KNOWLEDGE

GENERAL INFORMATION

Leitfaden Nachhaltiges Bauen
Zukunftsfähiges Planen, Bauen und Betreiben von Gebäuden (Guide to sustainable construction – sustainable planning, construction and operation of buildings), German Federal Ministry of the Interior and Community, Berlin 2019: https://www.nachhaltigesbauen.de/fileadmin/pdf/Leitfaden_2019/BBSR_LFNB_D_190125.pdf

Assessment System for Sustainable Construction (BNB)
German Federal Ministry of the Interior and Community, Catalogue of Criteria – also accessible in English: https://www.bnb-nachhaltigesbauen.de/en/

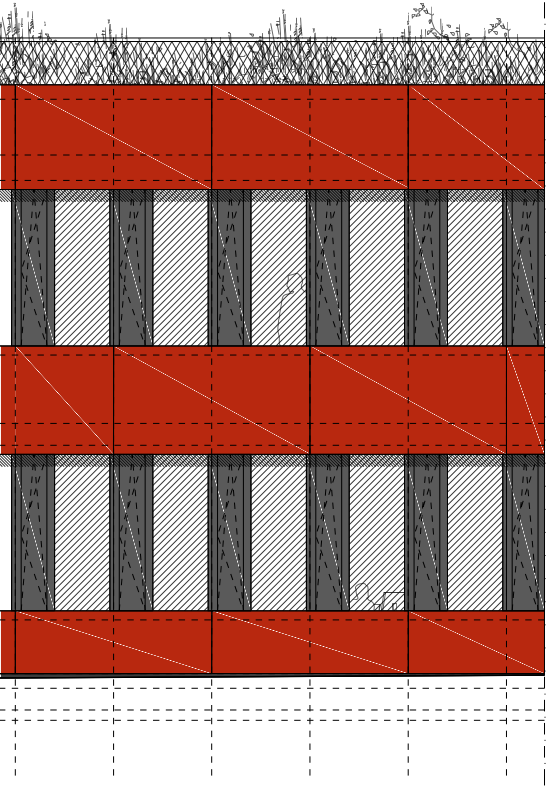
Nachhaltigkeit gestalten
Leitfaden für Architekten, Innenarchitekten, Landschaftsarchitekten, Stadtplaner, Fachingenieure, Bauherren und Interessierte (Shaping sustainability – Guide for architects, interior designers, landscape architects, urban planners, specialist engineers, building owners and interested parties), Bayerische Architektenkammer (Bavarian Chamber of Architects), Munich, 2018: https://www.byak.de/planen-und-bauen/architektur-technik/energieeffizientes-und-nachhaltiges-bauen/publikation-nachhaltigkeit-gestalten.html

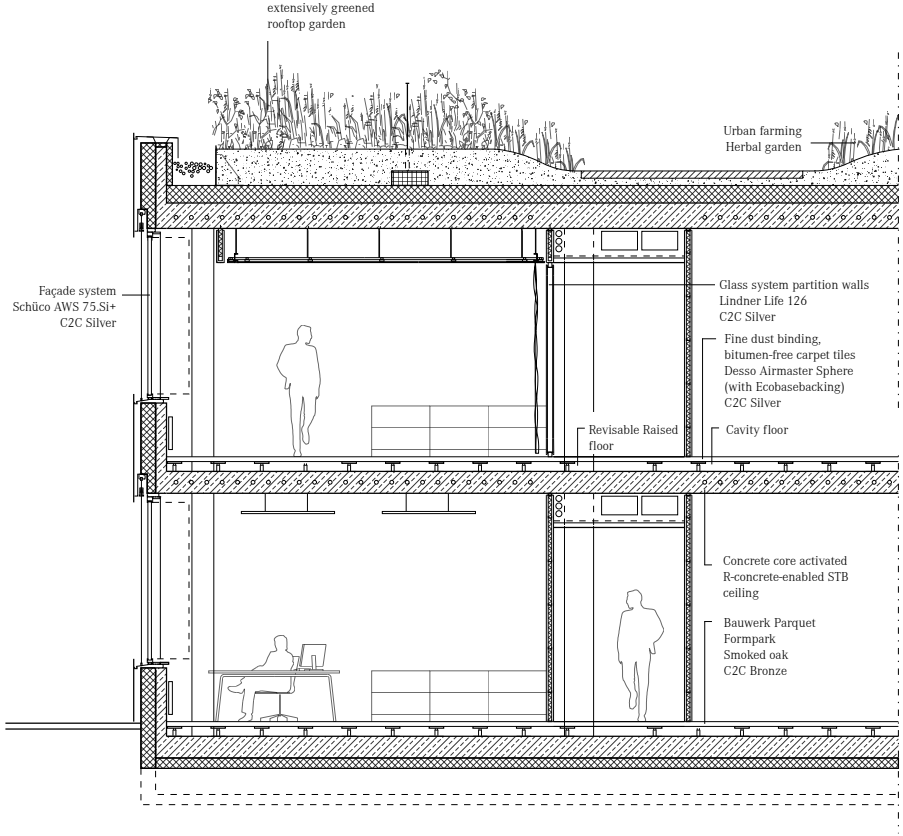
Sicherung der Nachhaltigkeitsaspekte in Ausschreibung und Vergabe
(Ensuring sustainability aspects in tendering and awarding), DGNB system – catalogue of criteria for new buildings PRO 1.4, Version 2018: https://static.dgnb.de/fileadmin/de/dgnb_system/version2018/06_PRO1.4_Sicherung-Nachhaltigkeitsaspekte-Ausschreibung-und-Vergabe.pdf?m=1526471367&

TOOLS

WECOBIS planning and tendering assistance (P&A) module
German Federal Ministry of the Interior and Community and Bavarian Chamber of Architects, Berlin: https://www.wecobis.de/p-a.html

Formulation assistance for (product) tenders
Fachagentur Nachwachsende Rohstoffe e. V., Gülzow-Prüzen: https://beschaffung.fnr.de/service/ausschreibungsempfehlungen/formulierungshilfen-fuer-produkt-ausschreibungen/





Façade cross-section of the new building of the RAG-Stiftung and RAG AG in Essen
(photo: © kadawittfeldarchitektur)

BEST PRACTICE: THE RAG-STIFTUNG AND RAG AG

RAG AG and the RAG-Stiftung have both moved to the premises of the Zollverein Coal Mine Industrial Complex (Zeche Zollverein), a World Heritage site. They now occupy a new building that has won awards for its sustainability (DGNB Platinum Certificate 2018).

The former colliery was used for the new building, and former industrial space was "recycled". The built-over area is offset by an extensively greened rooftop, which is used not only as a "green" recreational space for employees but also for the generation of energy. The pergolas where the solar panels are installed also provide shade during the summer. The roof area is thus used as efficiently as possible, as it has several functions. (Fig. 8) Any rainwater collected on the property is used for the green roof irrigation and the toilets. The solar panels are supplemented by a geothermal system for heating and hot water.

As well as ensuring energy and land use efficiency, the company paid special attention to the selection of materials and components for the building. This included, in particular, environmental and health aspects, but above all the recyclability of the materials and components. It used numerous cradle-to-cradle-certified (C2C-certified) building products – a certificate that acknowledges the recyclability and safety of a product for humans and the environment. The building was a pilot project under the EU research project Building as Material Banks (BAMB). All the materials were documented in a Materials Passport, so that they can serve as much as possible as a source of raw materials when the building comes to the end of its lifetime.

Thanks to comprehensive integrated planning, it was possible to implement the large number of resource efficiency aspects from the very beginning. In the tender, the company's ambitious goals concerning sustainability and resource conservation formed part of the general preliminary notes and, in some cases, even featured as a separate item. The resource efficiency aspects included in the planning and in the specific requirements (e.g. recyclability of products) formed an integral part of the tender. The requirements for the construction process (noise, waste, dust and soil protection) were also included in the tender invitations, and staff on site were given appropriate training.[10]

"In order to reach high standards in terms of resource conservation and recyclability of the building, it was important to include the aspects of sustainability and resource efficiency in the tender and to do so with great care."

Jutta Schmeka,
ZECH Bau Holding GmbH

TENDERING

- Inclusion of environmental compatibility and recyclability in the tender invitation
- Inclusion of specific requirements on building products (e.g. recyclability)
- Specifications for the construction process (e.g. low-waste construction site)
- Details of required documentation

New Building of the RAG-Stiftung and RAG AG in Essen
(photo: © Jens Kirchner)

Resource efficiency aspekts during construction

The planned building becomes reality in the **construction phase**. It involves a variety of challenges, such as coordinating the various trades and keeping within deadlines, which are mostly extremely tight. Strategies to increase resource efficiency help to conserve resources, ensure construction quality and reduce costs.

CONSTRUCTION SITE OPERATION

The specifications for an environmentally optimised construction process are usually defined at an early stage, i.e. in the tender. This is when the most important resource efficiency aspects are put in place at the construction site:

1. Precautionary soil protection

- Is there a soil protection concept?
- Has the company ensured that the soil is not contaminated by chemical pollutants?
- Is the soil protected from mechanical impact (e.g. unnecessary compaction)?

2. Planning efficient construction site logistics

- Does the company use the shortest possible transport routes for supply and disposal logistics?
- Does the company use vehicles with the best possible emission ratings and efficient construction site machinery?

3. Reducing waste volume

- Does the company avoid waste materials resulting from damage, destruction during transport and storage at the construction site?
- Does the company minimise waste on site?

4. Separating waste correctly

- Where transport packaging waste is accumulated on the construction site, is it re-accepted by suppliers as required under the German Packaging Ordinance?
- Have those involved in the construction process received training in waste avoidance and separation (e.g. the German Circular Economy Act, KrWG)?
- Does the company avoid mixing residual materials, and does it feed them into recovery of the highest quality?

5. Natural drying of the shell

- Is the shell dried out naturally without heating or building dehydration? (duration: approx. 30 days, depending on the season)

SITE MANAGEMENT

The construction work should be continually monitored on site. Correct implementation of the plans is important to ensure, for instance, proper recyclability of the building. The following questions need to be answered:[1,5,11]

- Are the building materials being used as specified in the tender?
- Is the design being implemented as specified in the plans? (e.g. no adhesive)
- Are the building materials documented using product descriptions and safety datasheets?
- Are further quality checks being carried out, such as construction site inspections, blower door tests and measurements of harmful substances?
- Are residual substances/materials separated, and are the collection points used correctly?

Construction site of the new shopware AG building *(photo: © Brüninghoff)*

ADVANCED KNOWLEDGE

GENERAL INFORMATION

Leitfaden Nachhaltiges Bauen
(Guide to sustainable construction – sustainable planning, construction and operation of buildings), German Federal Ministry of the Interior and Community, Berlin 2019: www.nachhaltigesbauen.de/fileadmin/pdf/Leitfaden_2019/BBSR_LFNB_D_190125.pdf

Assessment System for Sustainable Building (BNB)
German Federal Ministry of the Interior and Community, Catalogue of Criteria – also accessible in English: https://www.bnb-nachhaltigesbauen.de/en/

SOIL PROTECTION

Soil protection during construction
Documentation on the website of North Rhine-Westphalia State Agency for Nature, Environment and Consumer Protection (www.lanuv.nrw.de/bodenschutz-beim-bauen), Recklinghausen, March 2009: www.lanuv.nrw.de/fileadmin/lanuv/boden/bodenschutz/bodenschutz_bauen/pdf/Bodenschutz_beim_Bauen_v2.pdf

WASTE AVOIDANCE

German Circular Economy Act (KrWG)
It's aim is to stimulate a circular economy and improve the waste management.

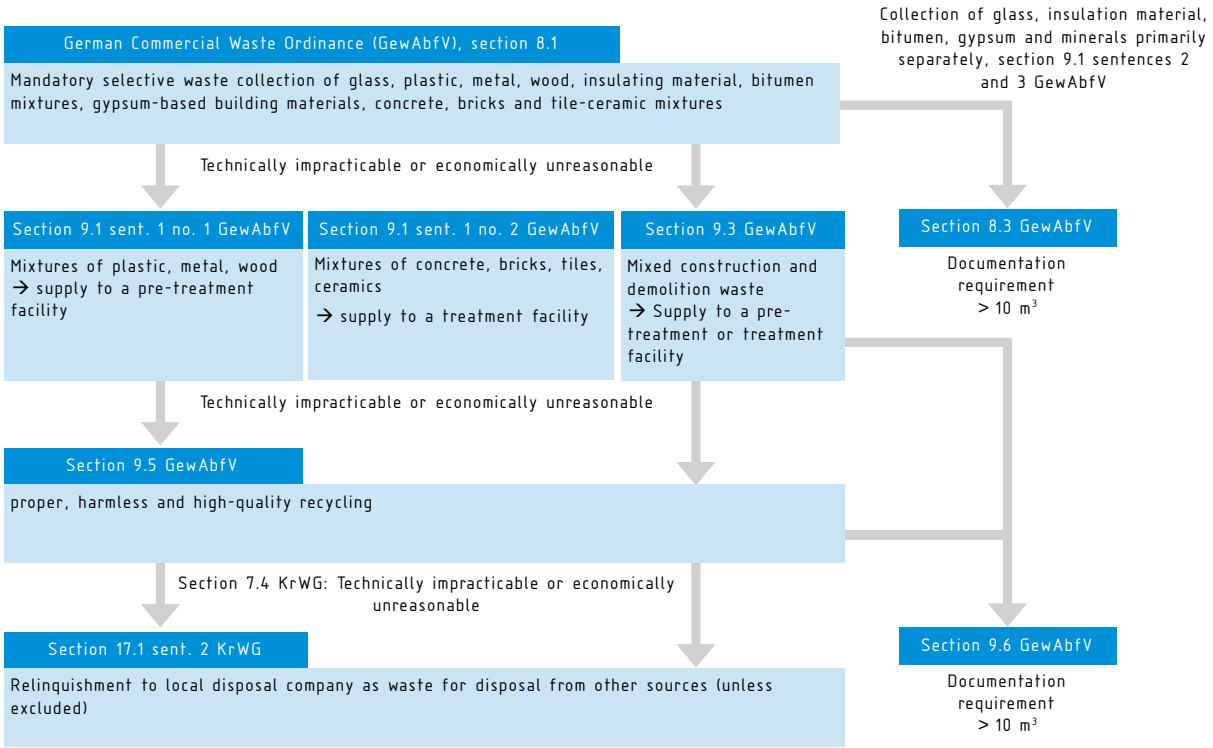
German Commercial Waste Ordinance
It stipulates the separation of specific waste fractions to ensure highest possible recovery qualities

Abfallvermeidung in der Baubranche
(Waste avoidance in the construction industry – information for building owners, architects and all those interested in construction), German Ministry for the Environment, Climate and Energy Management, Stuttgart 2016: https://um.baden-wuerttemberg.de/fileadmin/redaktion/m-um/intern/Dateien/Dokumente/2_Presse_und_Service/Publikationen/Umwelt/Abfallvermeidung_in_der_Baubranche.pdf

WASTE SEPARATION

Gewerbeabfall: So trennen und dokumentieren Sie richtig
(Commercial waste: how to separate and document correctly), handwerk.com, Schlüterschen Verlagsgesellschaft mbH & Co.KG, Hannover 2017: www.handwerk.com/neue-gewerbeabfallverordnung-so-trennen-und-dokumentieren-betriebe-abfaelle-richtig

Verwertung und Beseitigung von Bauabfällen in Recht und Praxis
(Recovery and disposal of construction waste – legal provisions and practice.), Landesverband Bayerischer Bauinnungen (State Association of Bavarian Construction Guilds), Würzburg 2017: https://docplayer.org/65849144-Verwertung-und-beseitigung-von-bauabfaellen-in-recht-und-praxis.html



Cascade showing the procedure for construction and demolition waste under the German Circular Economy Act (KrWG) and the German Commercial Waste Ordinance (GewAbf) (own adaptation)

BEST PRACTICE: SHOPWARE AG

Shopware AG is a medium-sized company that has delivered software solutions for online retailers since 2010. Thanks to substantial growth, the company started erecting another office building in 2018.[12] Many resource efficiency aspects were already covered during the planning.

Care was taken e.g. to cover the smallest possible surface with buildings, prompting the company to erect a tall building, six storeys high. Furthermore, a hybrid timber construction method was used, making it possible to leverage the benefits of both building materials through an intelligent combination of both timber and concrete. As a result, the plans were precertified with DGNB's (German Sustainable Building Council's) Gold Status, as the company had covered a large number of sustainability aspects.

However, sustainability and resource efficiency were also observed during construction phase.

Before **operations** started at the **construction site**, a soil protection concept was drawn up to prevent chemical contamination and mechanical impact on the soil. In addition, all the parties involved in construction were given training in **waste avoidance, separation and recovery**.

Due to the high degree of prefabrication and the resulting high quality of the construction components, it was possible to avoid a considerable amount of waste at the construction site. Any waste generated during the production of the components was separated and recovered at the factory.

Also, waste such as packaging material was re-accepted by the relevant suppliers. For example, any re-usable tarpaulin to protect prefabricated construction components was taken back by the contractor and re-used. The only waste containers at the construction site itself were a rubble skip and a large paper bin. This was possible because the contractor's plant was nearby, so that any of the other waste fractions, which were very small, could be taken back to the contractor's premises and then be separated there. Another benefit of the proximity of construction site and construction company was that the transport distances were very short.

The **site management** regularly checked the precise implementation of the plans and strategies (e.g. the soil protection plan) and carefully documented it. In addition, various quality checks were carried out, such as sound insulation tests, thermographic tests and VOC indoor air measurements.[13]

"Resource-efficient construction protects natural resources while also enhancing the quality of the construction process."

Frank Steffens, Managing Director
Brüninghoff Group

EXECUTION OF CONSTRUCTION WORK

- Soil protection concept
- Training of companies
- Waste avoidance through prefabrication
- Contractors' waste re-acceptance systems
- Re-use of component protection tarpaulins
- Waste separation
- Short transport routes

SITE MANAGEMENT

- Checking the implementation, building materials and policies (e.g. soil protection concept)
- Quality control

On the construction site, the 18 m long wall elements are assembled with the help of a crane.
(photo: © Brüninghoff)

Resource efficiency aspects during handover

The handover of a completed building marks the starting point for its use and further stages in its lifecycle (e.g. renovation, modernisation etc.). In this regard, it is essential that the handover is accompanied by complete documentation. However, to ensure that its utilisation phase is as (resource-)efficient as possible, the systematic commissioning of the building is equally important.

DOCUMENTATION

If the documentation contains all the essential details about the building, this can simplify the next phases in its life.

- Have the important project details been put together in the form of property documentation (including contact details of everyone involved in the construction, areas, use of space, design and constrcution of building components, technical equipment)?
- Are Strategies such as a dismantling strategie or a reuse strategie included?
- Have servicing, inspection, operating and care instructions been provided?
- Do the instructions cover the specific requirements of all the relevant stakeholders?
- Were the planning documents and calculations updated after construction?
- Has a user manual with relevant information on the (efficient) operation of the building been provided?
- Are the documents structured in a consistent and comprehensible way?

SYSTEMATIC COMMISSIONING

Systematic commissioning makes it possible to check the operability of the various systems and present them to the building operator. This allows the company to ensure the most efficient use of technical facilities within the building. Systems include e.g. heating and cooling equipment, air conditioning, building automation, lifts and shutters. [4,5,6,14,15]

- Is there an appropriate monitoring concept?
- Has the operapability of the building's services equipment been adequately checked?
- Have the building's technical systems been adjusted?
- Has the building operator received instructions in using the building equipment?
- Are there any plans to re-adjust the building equipment after the first operating phase?
- Have the commissioning and approval procedures been documented in full?

photo: © Alexander Raths/AdobeStock

ADVANCED KNOWLEDGE

GENERAL INFORMATION

Leitfaden Nachhaltiges Bauen
Zukunftsfähiges Planen, Bauen und Betreiben von Gebäuden (Guide to sustainable construction – sustainable planning, construction and operation of buildings), German Federal Ministry of the Interior and Community, Berlin 2019: www.nachhaltigesbauen.de/fileadmin/pdf/Leitfaden_2019/BBSR_LFNB_D_190125.pdf

Assessment System for Sustainable Building (BNB) German Federal Ministry of the Interior and Community, Catalogue of Criteria: https://www.bnb-nachhaltigesbauen.de/en/

Checkliste für Bauübergabe- und Revisionsunterlagen (Checklist for construction handover and review documents), Bau- und Liegen-schaftsbetrieb NRW (NRW Building and Property Management), 2015: https://docplayer.org/24970128-Checkliste-fuer-bauuebergabe-und-revisionsunterlagen.html

VDI 6039:2011-06 – Facility-Management
Managing of building commissioning – Methods and procedures for building- services installations

Guide to Building Automation – Quality assurance in planning and integration.
TÜV Süd, Work Guide 2018: https://www.tuvsud.com/de-de/-/media/de/industry-service/pdf/white-paper-reports-e-books-vortraege-artikel/is/guide-to-building-automation-is-eg.pdf

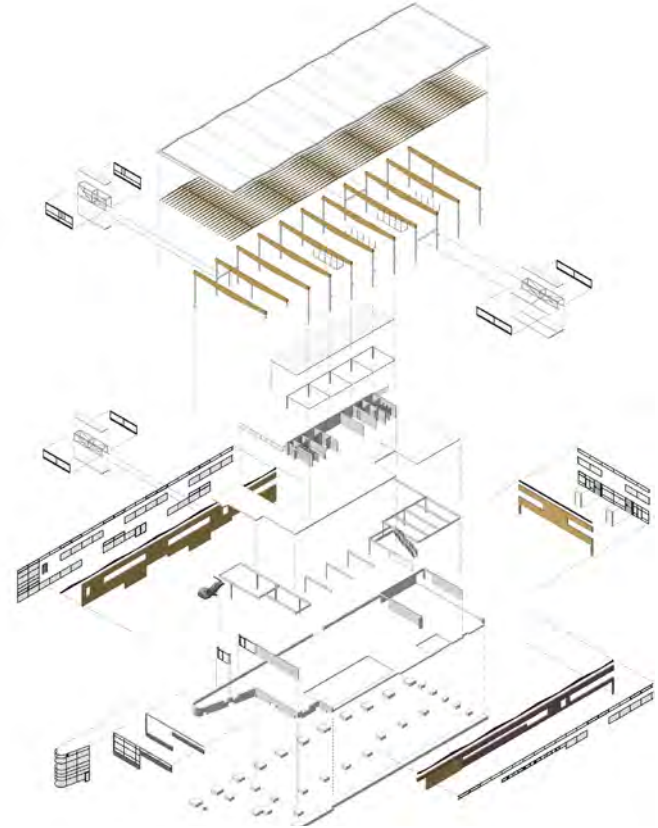
INFORMATION ON BUILDING INFORMATION MODELING (BIM)

BIM für Architekten – Leistungsbild, Vertrag und Vergütung (BIM for architects – scope of services, contract and remuneration), Bundesarchitektenkammer (German Federal Chamber of Architects), Brochure with application notes: www.aknw.de/fileadmin/user_upload/Publikationen-Broschueren/BIM-BAK-Broschuere-WEB.pdf

BIM – Mittelstandsleitfaden am Beispiel des Bauvorhabens Fachmarktzentrum Leinenfelde – Wie viel BIM verträgt ein Mittelstandsprojekt? (BIM – SME guide using the example of the Leinenfelde retail park construction project – How much BIM can an SME project take?) Bundesinstitut für Bau-, Stadt- und Raumforschung (German Federal Institute for Research on Building, Urban Affairs and Spatial Development), 2018: http://www.biminstitut.de/files/bim_institut/media/01_Forschung/BIM%20-%20Mittelstandsleitfaden/BIM-Mittelstandsleitfaden%20FMZ%20Leinefelde.pdf

Building Information Modeling (BIM) as a tool

BIM is a tool based on a digital, three-dimensional building model. It can cover the details of all the phases in the lifecycle of the building. All the planners and building contractors who are involved define the relevant details (e.g. geometric data, prices and sound permeability) and assign them to specific building components. BIM enables project participants to obtain a comprehensive picture of the entire lifecycle. For SMEs, however, this can involve substantial changes to their planning processes, and it may therefore be helpful to apply a standard procedure.[16]



Construction site of the new shopware AG building
(photo: © Brüninghoff)

BEST PRACTICE: BÄCKER PETER BAKERY

The family-run artisan bakery was established in 1905. The steady growth of the company prompted it to start building a second extension in 2011 and to do so with due regard to sustainability and resource efficiency (DGNB Gold certified in 2012).

Using the dynamic software package TAS, the company looked at the overall performance of the building with a view to ensuring optimum interaction between the building envelope, technical building equipment and process facilities.

By designing the building envelope under passive-house-standards, it was possible to minimise heat loss to the extent that air conditioning could largely be achieved through the existing process waste heat.

For cooling, an innovative two-stage compressor-based refrigeration system was used in cascade configuration. This made it possible to avoid the usual R 4004a coolant and its high level of greenhouse warming potential. At the same time, energy efficiency was increased through lower evaporator temperatures. The energy generated by solar panels is used for the operation of an LED lighting system and will soon also be used for the charging of electric delivery vehicles.

Furthermore, the company ensured that its building materials and technical systems are based on holistic material cycles and that they are free from harmful substances. Most components of the building can be recycled or used elsewhere. This is largely due to the skeleton frame beeing made out of a hybrid material involving a combination of wood and steel.

All the plans were created with the help of a 3D BIM model, which stores all the relevant details of building materials and technical systems and was continually updated right up until handover. The entire documentation was handed over to the building owner, including information about the recyclability of building materials as well as exploded view drawings showing the design and the individual modules. A detailed user manual on the ope-ration and special features of the building's service equipment as well as servicing, inspection and care instructions were also included in the handover. Systematic commissioning was applied, ensuring that the building equipment is adjusted and the building operators received appropriate instructions.[17]

„The aim of all integrated planning and documentation was to optimise the building in terms of energy consumption and sustainability while also ensuring a high level of reliable adaptability for future conversions."

Prof Jürgen Reichardt
RMA Architekten

HANDOVER

- Detailed documentation
- Basis: BIM: Autodesk Revit Model
- User manual incl. notes on service intervals
- Servicing, inspection, operating and care instructions

COMMISSIONING

- Adjusting of the building's technical equipment
- Building equipment instructions given to building operator

Entrance to the Bäcker Peter bakery
(photo: © RMA Architekten)

CONCLUSIONS

Resource efficiency is a crucial part of sustainability and therefore plays an increasingly important role in the public debate. Many building owners, but also planners and building contractors, are paying special attention to different aspects of sustainability and resource efficiency now. They are aware that resource-efficient planning and construction lead to savings in building-related costs throughout the lifecycle of a building, while also increasing its value for the owner in terms of flexibility and repurposeability. However, savings in material and energy can also be achieved by building contractors, while increasing the quality of the construction. Furthermore, it creates a positive corporate image, which can increase the company's competitiveness.

This brochure highlights a range of aspects of resource efficiency in planning, tendering/ awarding, construction and handover.

Many of these points are already part of day-to-day planning, while other aspects are still new. This collection of supplementary information and tools is intended to support planners and buil-ding contractors in including those elements in their planning. The examples presented here provide a brief overview of possible measures and different approaches.

They show how important it is to include resource efficiency aspects in the planning at an early stage. Together with integrated planning, the focus needs to be on the entire lifecycle of a building. By evaluating the interdependencies, it is possible to avoid optimising one phase of the lifecycle at the expense of another.

Another aspect that is crucial is the handover of the documentation with all the relevant information. Comprehensive documentation can simplify the utilisation phase and all other phases right up to the end of a building's lifetime, while ensuring that the relevant resources can be used more efficiently. One tool that is particularly helpful for this purpose is BIM (Building Information Modelling).

photo: © ArturVerkhovetskiy/PantherMedia

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