Green Building – Guidebook for Sustainable Architecture

Prof. Dr. Michael Bauer
Peter Mösle
Dr. Michael Schwarz

Drees & Sommer Advanced Building Technologies GmbH
Obere Waldplätze 11
70569 Stuttgart
Germany

info.green-building@dreso.com

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By Michael Bauer, Peter Mösle and Michael Schwarz

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Preface by the Authors

There are essential challenges for the future, such as taking a responsible approach towards nature. Also, there is the search for an environmentally-friendly energy supply that is easy on resources and climate. A further challenge is the search for clean sources of drinking water. Aside from novel and more efficient technologies than are currently in place, additional emphasis will thus need to be placed on reducing energy and water requirements without decreasing either comfort level or living standard. The building sector worldwide uses up to 40% of primary energy requirements and also a considerable amount of overall water requirements. Meanwhile, the service life of both new and renovated buildings reaches far into the future. Hence, these buildings considerably influence envisioned energy and water needs for the next 50 to 80 years. This means that, even today, they must be planned, constructed and run according to the principles of energy efficiency, climatic aspects, and water conservation. This applies even when global outlines to counteract climate change seem to lie too far in the future to grasp. Buildings that show these attributes of sustainability are called Green Buildings. They unite a high comfort level with optimum user quality, minimal energy and water expenditure, and a means of energy generation that is as easy as possible on both climate and resources, all this under economic aspects with a pay-back span of 5 to 15 years. Green Buildings are also capable of meeting even the most stringent demands for aesthetics and architecture, which is something that the examples given in this book clearly show. Planning these buildings, according to an integrated process, requires the willingness of all those involved: to regard the numerous interfaces as seams of individual assembly sections, the synergies of which are far from being exhausted yet. An holistic and specific knowledge is needed, regarding essential climatic, thermal, energy-related, aero-physical and structural-physical elements and product merits, which does not end at the boundaries of the individual trades. Further, innovative evaluation and simulation tools are being used, which show in detail the effects throughout the building's life cycle. The examples in this book show that a building can indeed be run according to the principles of energy and resource conservation when – from the base of an integrated energy concept – usage within a given establishment is being consistently tracked and optimized. The resulting new fields of consulting and planning are called energy design, energy management and Life Cycle Engineering. In this particular field, Drees & Sommer now has over 30 years of experience, as one of the leading engineering and consulting firms for the planning and operation of Green Buildings. Our cross-trade, integrated knowledge stems from Drees & Sommer's performance sectors of Engineering, Property Consulting and Project Management.

The contents of this book are based on the extensive experience of the authors and their colleagues – during their time at Drees & Sommer Advanced Building Technologies GmbH – in planning, construction and operation of such buildings. It documents, through examples, innovative architectural and technical solutions and also the target-oriented use of specialist tools for both planning and operation. This book is directed primarily at investors, architects, construction planners and building operators, looking for an energy approach that is easy on resources. It is meant as a guideline for planning, building and operation of sustainable and energy-efficient buildings.

At this stage, we would also like to thank all the renowned builders and architects together with whom, over the last years, we had the honour of planning, executing and operating these attractive and innovative buildings. The level of trust they put in us is also shown by the statements they gave us for this book and the provided documentation for many prominent buildings. For their kind assistance in putting together this book, a special thanks is due.

We would be pleased if, by means of this book, we succeeded in raising the level of motivation for erecting Green Buildings anywhere in the world, whether from scratch or as renovation projects. Engineering solutions to make this happen are both available and economically viable. Our sustainability approach goes even further, incidentally. The CO_2 burden resulting from the production and distribution of this book, for instance, we have decided to compensate for by obtaining CO_2 certificates for CO_2 reducing measures. Hence, you are free to put all your energy into reading this book!

We would now like to invite you to join us on a journey into the world of Green Buildings, to have fun while reading about it, and above all, to also discover new aspects that you can then use for your own buildings in future.

Heubach, Gerlingen, Nuertingen

Michael Bauer
Peter Mösle
Michael Schwarz

A

B

The Motivation behind the Green Building Idea

C D

Fig. A3 State Office Building in Berlin. Architects: Petzinka Pink Technologische Architektur®, Duesseldorf

Increased Public Focus on Sustainability and Energy Efficiency

Man's strive for increased comfort and financial independence, the densification of congested urban areas, a strong increase in traffic levels and the growing electric smog problem due to new communication technologies all cause ever rising stress levels in the immediate vicinity of the individual. Quality of life is being hampered and there are negative health effects. All this, coupled with frequent news about the global climate change, gradually leads to a change of thought throughout society.

In the end, it is society that must bear the effects of economic damage caused by climatic change. Due to the rising number of environmental catastrophes, there was in increase of 40% between the years of 1990 to 2000 alone, when compared to economic damage sustained between 1950 and 1990. Without the implementation of effective measurements, further damage, which must therefore still be expected, cannot be contained. Companies across different industries have meanwhile come to realize that only a responsible handling of resources will lead to long-term success. Sustainable buildings that are both environmentally and resource-friendly enjoy an increasingly higher standing when compared to primarily economically oriented solutions.

Aside from social and economic factors, steadily rising energy costs over recent years facilitate the trend towards sustainability. Over the past 10 years alone, oil prices have more than doubled, with an annual increase of 25% between 2004 and 2008. Taking into account both contemporary energy prices and price increases, energy saving measures have become essential in this day and age. A further reason for the conscientious handling of resources is a heavy dependency on energy import. The European Union currently imports more than 60% of its primary energy, with the tendency rising. This constitutes a state of dependency that is unsettling to consumers and causes them to ask questions about the energy policy approach of the different nations. Since energy is essential, many investors and operators place their trust in new technologies and resources in order to become independent of global developments.

Real Estate, too, is starting to think along new lines. End-users look for sustainable building concepts, with low energy and operating costs, which offer open, socially acceptable and communication-friendly structures made from building materials that are acceptable from a building ecology point of view and have been left in as natural a state as possible. They analyze expected operating costs, down to building renaturation, and they run things in a sustainable manner. Aside from looking at energy and operating costs, they also take an increasing interest in work performance levels, since these are on the

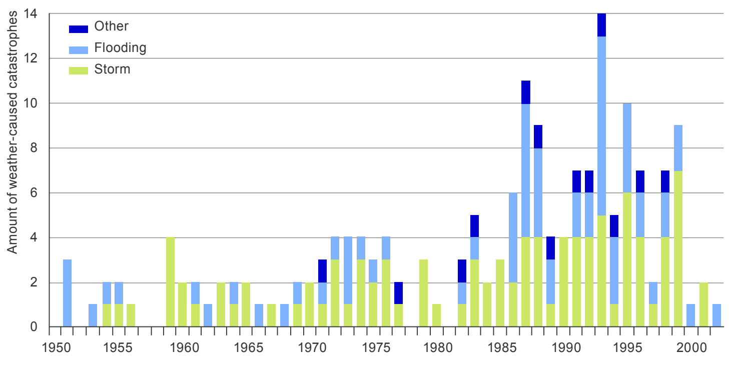


Fig. A1 Major weather-caused catastrophes from 1950 to 2000

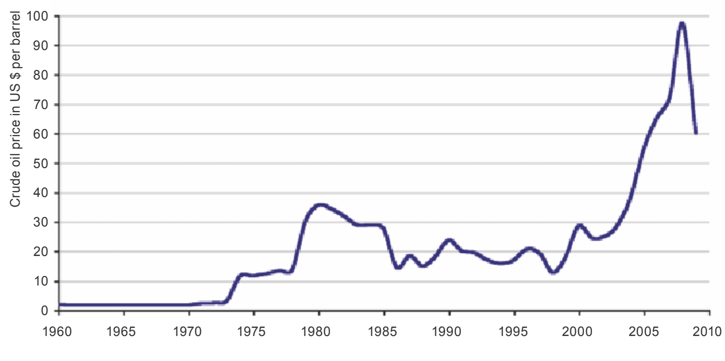


Fig. A2 Nominal Development of Crude Oil Prices from 1960 onward

rise for workers in Europe. Only when people feel good and are healthy they can work at their optimum performance level. By necessity, this means providing both a comfortable and healthy environment. Investors also know they should use sustainable aspects as arguments for rental and sale, since nowadays tenants base their decisions in part on energy and operating costs and are looking for materials that are in accordance with building ecology considerations. Green Buildings always offer a high comfort level and healthy indoor climate while banking on regenerative energies and resources that allow for energy and operating costs to be kept as low as possible. They are developed according to economically viable considerations, whereby the entire building life cycle – from concept to planning stage, from construction to operation and then back to renaturation – is taken into account. Green Buildings, therefore, are based on an integrated and future-oriented approach.

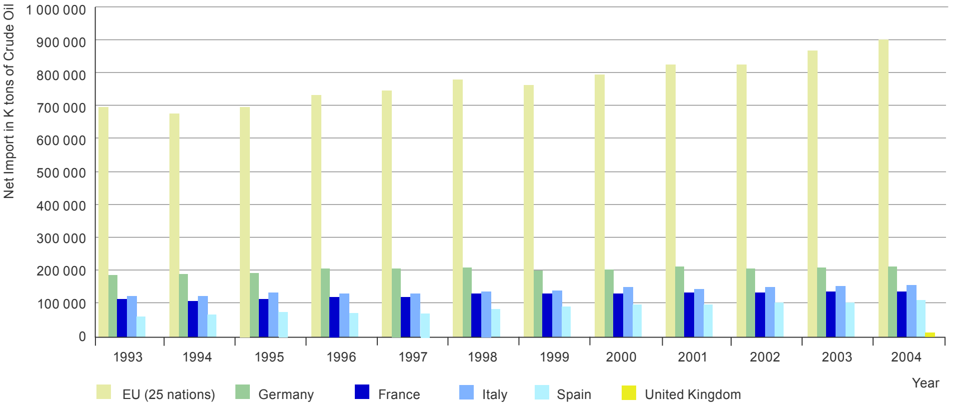


Fig. A4 European Union Dependency on Energy Imports

Supportive Framework and General Conditions

Owing to rising public interest in sustainable and ecological solutions, the last few years have resulted in the establishment of numerous framework conditions that facilitate the use of energy-saving technologies, energy sources that are easy on resources and sustainable products for the property sector.

The base of a sustainable energy policy can be found in various national, European and International laws, standards, norms and stipulations that specify measurable standards of energy efficiency for buildings and facilities. Further, the norms define the minimum standard for energy efficiency of buildings and facilities. The norms also set minimum standards for thermal comfort, air quality and visual comfort.

Across Europe, there is currently a drive to unify these standards. On an international level, however, the different nations are setting their own guidelines and these cannot necessarily be directly compared to each other. The standards are being supported by a variety of available and targeted grants for promising technologies that are currently not yet economical on a regenerative level. Examples for this in Germany would be the field of photovoltaics, for instance, or of near-surface geothermics, solar thermics, biogas plants or energy-conserving measures for the renovation of old buildings.

In the currently available laws, standards and stipulations, however, not all the essential building and facility areas are being considered. This means that many of these areas are unable to fulfil their true potential when it comes to the possibility of optimisation on an energy level. Further, legally defined critical values for energy consumption are generally below those required for Green Buildings. These critical values are usually set in a manner that allows for marketable products to be used. Laws and stipulations will, therefore, always be backward when compared to the actual market possibilities for obtaining maximum energy efficiency.

This gap can be bridged by the use of Green Building labels, guidelines and quality certificates, since these can at least recommend adherence to more stringent guidelines. The higher demands placed on true energy efficiency can also be justified by the fact that the technology in buildings and facility has a great lifespan. This means that a CO_2 emission limit specified today will have long-ranging effects into the future. Today's decisions, therefore, are essential aspects in determining future emission levels.

CO_2 Emission Trade

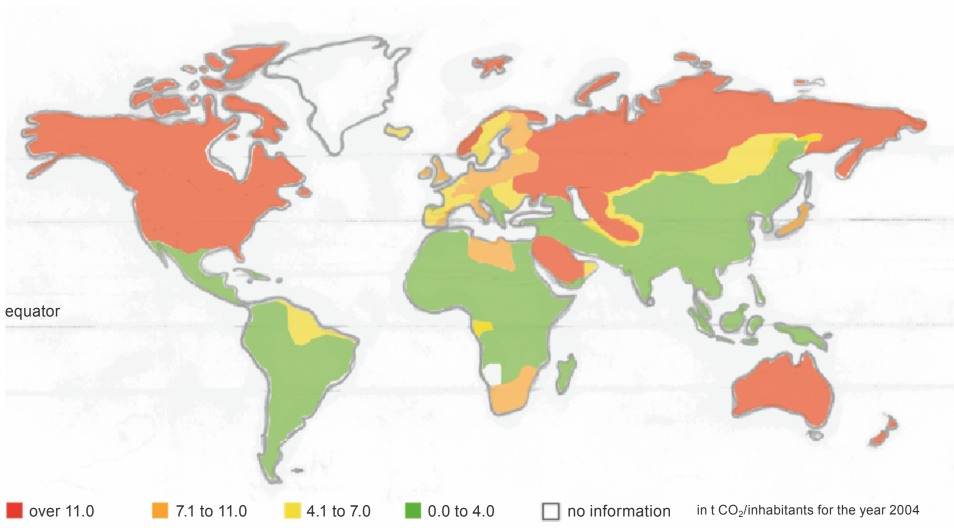


Fig. A5 CO_2 Emissions Distribution levels per Capita, World Population, for the year 2004

From February 2005, the Kyoto protocol applies. It is meant to reduce the levels of global greenhouse gas emissions. The origin of this protocol can be traced back to 1997. It stands for an international environmental treaty where the 39 participating industrial nations agreed, by 2012, to reduce their collective emission of environmentally harmful gases, like, for instance, carbon dioxide (CO_2) by a total of 5% when compared to 1990 levels. Within the European Community, the target reduction level is 8%, in Germany even 21%. As *Figure A6* shows, most industrial nations fall far short of meeting their targets at this time.

By means of CO_2 trade, a long-term corrective measure is supposed to be achieved for the human-caused greenhouse effect. The environment is hereby considered as goods, the conservation of which can be achieved through providing financial incentives.

Politicians have now recognized that environmental destruction, resulting from climatic change, firstly cannot only be counteracted by purely economic means and secondly must be regarded as a serious global problem. For the first time, the idea behind the CO_2 trade clearly unites both economical and environmental aspects. How precisely does CO_2 emissions trading work, then? For each nation that has ratified the Kyoto protocol, a maximum amount of climate-damaging greenhouse gases is assigned. The assigned amount corresponds to maximum permitted usage. The Greenhouse Gas Budget, which goes back to 1990, takes into account future development for each participating nation. Economies that are just starting to rise as, for instance, can be found in Eastern Europe, are permitted a higher degree of CO_2 emissions. Industrial nations, however, must make do every year with a reduced greenhouse budget.

For each nation, a certain number of emissions credits are assigned on the basis of the national caps on the emissions in that nation. These credits are assigned to the participating enterprises, according to their CO_2 emissions level. If the emissions of a given enterprise remain below the amount of emission credits that it has been assigned (Assigned Allocation Units or AAUs), for instance as a result of CO_2 emission reduction due to energy-savings measures applied there, then the unused credits can be sold on the open market. Alternatively, an enterprise may purchase credits on the open market if its own emission-reducing measures would be more costly than the acquisition of those credits. Further, emission credits can be obtained if a given enterprise were to invest, in other developing or industrial nations, into sustainable energy supply facilities. This means that climate protection takes place precisely where it can also be realized at the smallest expense.

In Germany, during the initial stage that runs up to 2012, participation in the emissions trade process is only compulsory for the following: operators of large-size power plants with a thermal furnace capacity in excess of 20 MW and also operators of power-intensive industrial plants. With this, ca. 55% of the CO_2 emissions potential directly participates in the trade. Currently, neither the traffic nor the building sectors are part of the trade in either a private or commercial manner. However, in Europe, efforts are already underway to extend emissions trading to all sectors in the long run. In other, smaller European nations like, for instance, Latvia and Slovenia, plants with a lower thermal output are already participating in the emissions trade. This is explicitly permitted in the Emissions Trade Bill as an opt-in rule. The evaluation and financing of buildings based on their CO_2 market value is something that, in the not-too-distant future, will reach the property sector as well. A possible platform for building-related emissions trade already exists with the EU directive on overall energy efficiency and with the mandatory energy passport. Our planet earth only has limited biocapacity in order to regenerate from harmful substances and consumption of its resources. Since the Nineties, global consumption levels exceed available biocapacity. In order to reinstate the ecological balance of the earth, the CO_2 footprint needs to be decreased. Target values that are suitable for sustainable development have been outlined in *Figure A7*.

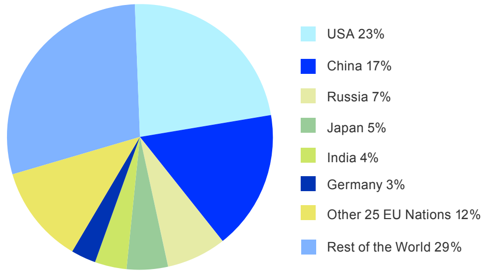


Fig. A8 Distribution of CO_2 Emissions by World Nations for the Year 2004

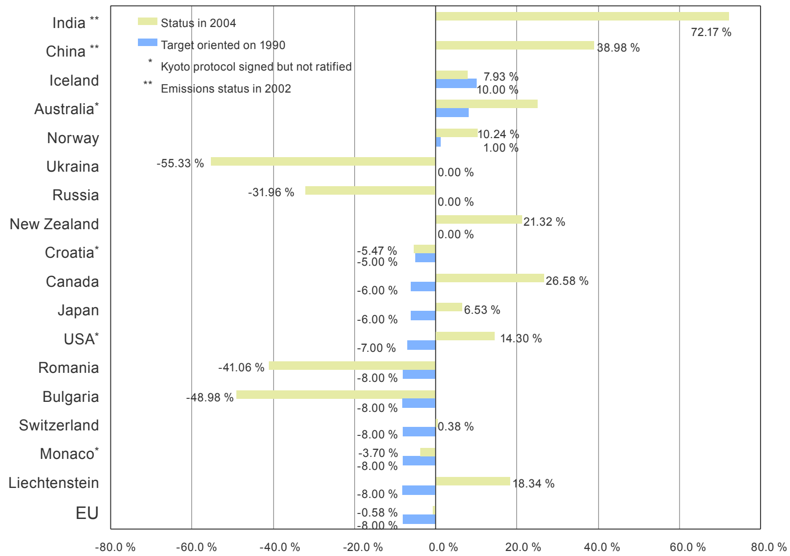


Fig. A6 Reduction Targets, as agreed in the Kyoto Protocol, and current Standing of CO_2 Emission Levels for the worldwide highest global Consumers

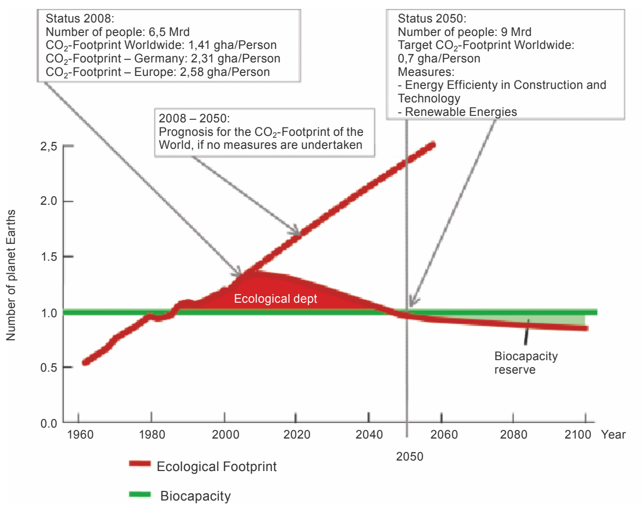


Fig. A7 Sustainability wedges and an end to overshoot

Rating Systems for Sustainable Buildings

Rating systems have been developed to measure the sustainability level of Green Buildings and provide best-practice experience in their highest certification level. With the given benchmarks, the design, construction and operation of sustainable buildings will be certified. Using several criteria compiled in guidelines and checklists, building owners and operators are given a comprehensive measurable impact on their buildings' performance. The criteria either only cover aspects of the building approach to sustainability, like energy efficiency, or they cover the

System (Country of origin)	DGNB (Germany)	BREEAM (Great Britain)	LEED (USA)	Green Star (Australia)	CASBEE (Japan)	Minergie (Switzerland)
Initiation	2007	1990	1998	2003	2001	1998
Key Aspects of Assessment & Versions	- Ecological Quality - Economical Quality - Social Quality - Technical Quality - Process Quality - Site Quality Purpose of the DGNB Certificate: Application for buildings of any kind (Office high-rises, detached residential homes, infrastructure buildings etc.) DGNB for: - Offices - Existing Buildings - Retail - Industrial - Portfolios - Schools	- Management - Health & Well-being - Energy - Water - Material - Site Ecology - Pollution - Transport - Land consumption BREEAM for: Courts, EcoHomes, Education, Industrial, Healthcare, Multi-Residential, Offices, Prisons, Retail	- Sustainable Sites - Water Efficiency - Energy & Atmosphere - Material & Resources - Indoor Air Quality - Innovation & Design LEED for: New Construction, Existing Buildings, Commercial Interiors, Core and Shell, Homes, Neighborhood Development, School, Retail	- Management - Indoor Comfort - Energy - Transport - Water - Material - Land Consumption & Ecology - Emissions - Innovations Green Star for: - Office – Existing Buildings - Office – Interior Design - Office – Design	Certification on the basis of "building-environment efficiency factor" BEE=Q/L Q … Quality (Ecological Quality of buildings) Q1 - Interior space Q2 - Operation Q3 - Environment L … Loadings (Ecological effects on buildings) L1 - Energy L2 - Resources L3 - Material Main Criteria: (1) Energy Efficiency (2) Resource Consumption Efficiency (3) Building Environment (4) Building Interior	4 Building standards are available: (1) Minergie - Dense building envelope - Efficient heating system - Comfort ventilation (2) Minergie-P additional criteria to (1): - Airtightness of building envelope - Efficiency of household applicances (3) Minergie-Eco additional criteria to (1): - Healthy ecological manner of construction (optimized daylight conditions, low emissions of noise and pollutants) (4) Minergie-P-Eco Adherence to criteria of Minergie-P and Minergie-Eco
Level of Certification	Bronze Silver Gold	Pass Good Very good Excellent Outstanding	LEED Certified LEED Silver LEED Gold LEED Platinum	4 Stars: ‚Best Practice' 5 Stars: ‚Australien Excellence' 6 Stars: ‚World Leadership'	C (poor) B B+ A S (excellent)	Minergie Minergie-P Minergie-Eco Minergie-P-Eco

Fig. A9 Comparison of different Rating Systems for Sustainable Buildings

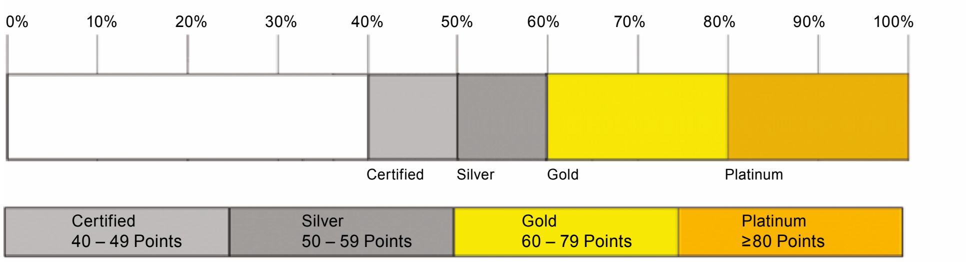


Fig. A12 LEED® Certification

whole building approach by identifying performance in key areas like sustainable site development, human and environmental health, water savings, materials selection, indoor environmental quality, social aspects and economical quality.

Furthermore, the purpose of rating systems is to certify the different aspects of sustainable development during the planning and construction stages. The certification process means quality assurance for building owners and users. Important criteria for successful assessments are convenience, usability and adequate effort during the different stages of the design process. The result of the assessment should be easy to communicate and should be showing transparent derivation and reliability.

Structure of Rating Systems

The different aspects are sorted in overall categories, like ›energy‹ or quality groups ›ecology‹, ›economy‹ and ›social‹ demands (triple bottom line). For each aspect, one or more benchmarks exist, which need to be verified in order to meet requirements or obtain points. Depending on the method used, individual points are either added up or initially weighted and then summed up to obtain the final result. The number of points is ranked in the rating scale, which is divided into different levels: The higher the number of points, the better the certification.

LEED® – Leadership in Energy and Environmental Design

The LEED® Green Building Rating System is a voluntary, consensus-based standard to support and certify successful Green Building design, construction and operations. It guides architects, engineers, building owners, designers and real estate professionals to transform the construction environment into one of sustainability. Green Building practices can substantially reduce or eliminate negative environmental impact and improve existing unsustainable design. As an added benefit, green design measures reduce operating costs, enhance building marketability, increase staff productivity and reduce potential liability resulting from indoor air quality problems.

The rating systems were developed for the different uses of buildings. The rating is always based on the same method, but the measures differentiate between the uses. Actually, new construction as well as modernization of homes and non-residential buildings are assessed. Beyond single and complete buildings, there are assessments for neighborhoods, commercial interiors and core and shell. The rating system is organized into five different environmental categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Material and Resources and Innovation.

Fig. A10 LEED® Structure

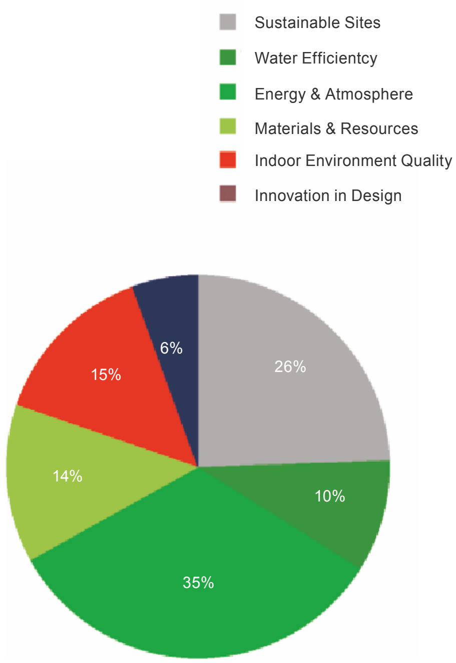


Fig. A11 LEED® Weighting

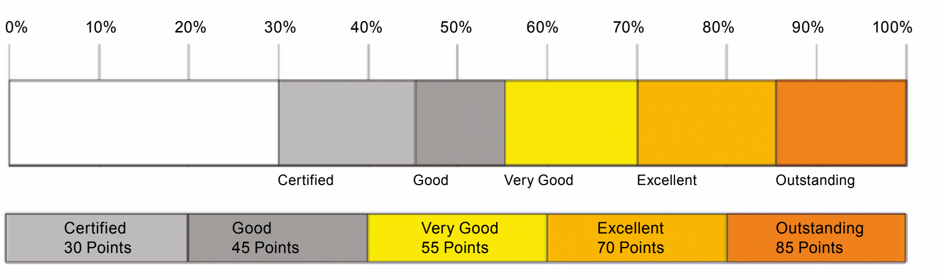


Fig. A15 BREEAM Certification

BREEAM – BRE Environmental Assessment Method

The assessment process BREEAM was created by BRE (Building Research Establishment) in 1990. BRE is the certification and quality assurance body for BREEAM ratings. The assessment methods and tools are all designed to help construction professionals understand and mitigate the environmental impacts of the developments they design and build. As BREEAM is predominately a design-stage assessment, it is important to incorporate details into the design as early as possible. By doing this, it will be easier to obtain a higher rating and a more cost-effective result. The methods and tools cover different scales of construction activity. BREEAM Development is useful at the master planning stage for large development sites like new settlements and communities.

Different building versions have been created since its launch, to assess the various building types. Currently, the evaluation program is available for offices, industry, schools, courts, prisons, multiple purpose dwellings, hospitals, private homes and neighborhoods. The versions of assessment essentially look at the same broad range of environmental impacts: Management, Health and Well-being, Energy, Transport, Water, Material and Waste, Land Use and Ecology and Pollution. Credits are awarded in each of the above, based on performance. A set of environmental weightings then enables the credits to be added together to produce a single overall score. The building is then rated on a scale of certified, good, very good, excellent or outstanding and a certificate awarded to the design or construction.

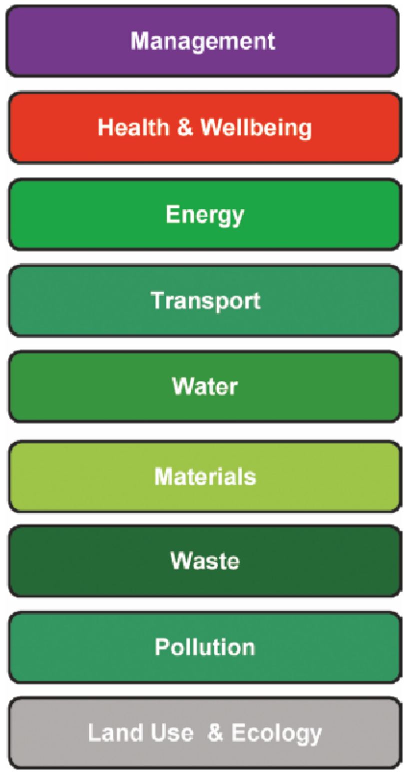


Fig. A13 BREEAM Structure

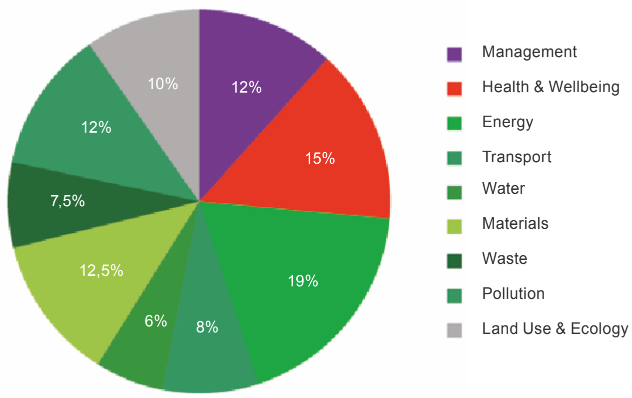


Fig. A14 BREEAM Weighting

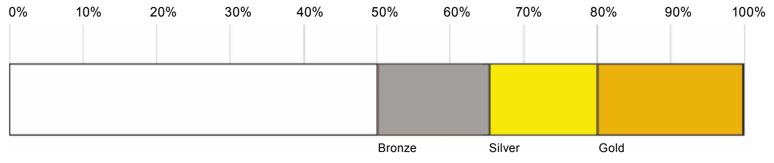


Fig. A18 DGNB Certification

Fig. A19 Certification medals with DGNB Gold, Silver, Bronze

DGNB – German Sustainable Building Certificate (GeSBC)
In contrast to comparable systems, the GeSBC label takes all three sustainability dimensions in account in its assessment structure, examining ecological, economic and socio-cultural aspects.

As the result of legislation, the German real estate industry already has a high standard of sustainability. In addition to the Energy Passport, the GeSBC addresses all items defining sustainability to meet the demands.

The German Sustainable Building Council (DGNB) was founded in June 2007 and created the German Sustainable Building Certificate together with the German Federal Ministry of Transport, Construction and Urban Development. The goal is »to create living environments that are environmentally compatible, resource-friendly and economical and that safeguard the health, comfort and performance of their users«.

The certification was introduced to the real estate market in January 2009. It is now possible to certify at three different levels, »Bronze«, »Silver« and »Gold«. As shown in Fig. A16, site quality will be addressed, but a separate mark will be given for this, since the boundary for the overall assessment is defined as the building itself.

MINERGIE ECO®
Minergie® is a sustainability brand for new and refurbished buildings. It is supported jointly by the Swiss Confederation and the Swiss Cantons along with Trade and Industry. Suppliers include architects and engineers as well as manufacturers of materials, components and systems.

The comfort of occupants living or working in the building is the heart of Minergie®. A comprehensive level of comfort is made possible by high-grade building envelopes and the continuous renewal of air.

The evaluation program is available for homes, multiple dwellings, offices, schools, retail buildings, restaurants, meeting halls, hospitals, industry and depots. Specific energy consumption is used as the main indicator of Minergie®, to quantify the required building quality. The aim of the Standard »Minergie-P®« is to qualify buildings that achieve lower energy consumption than the Minergie® standard. The Minergie and the Minergie-P® Standard are prerequisites for the Minergie ECO® assessment. The ECO® Standard complements Minergie with the categories of health and ecology. The criteria are assessed by addressing questions on different aspects of lighting, noise, ventilation, material, fabrication and deconstruction. The affirmation of the

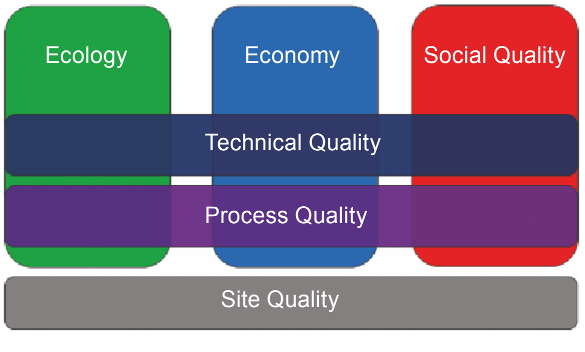


Fig. A16 DGNB Structure

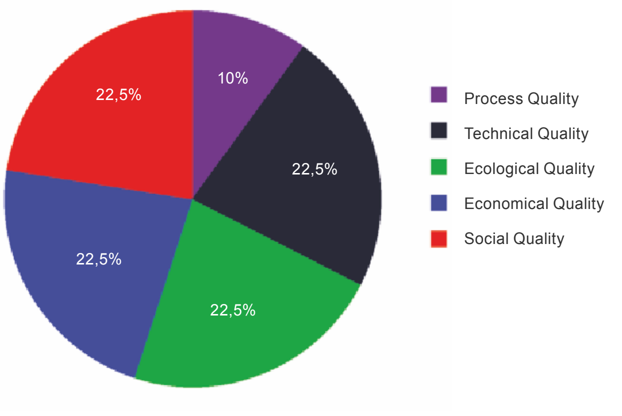


Fig. A17 DGNB Weighting

question must comprise at least 67% of all relevant questions. The assessment includes two different stages: the pre-assessment during the design stage (Fig. A20) and the assessement during the construction stage to verifiy the success of previously planned measures (Fig. A21).

Energy Performance Directive
An important building certification, incorporated by the EU, is the Energy Performance Certificate. They developed the prototype of the federally uniform Energy Performance Certificate. The certificate has been legally compulsory since 2007 as a result of the energy saving regulation, which is a part of the EU building laws. For Germany, Energy Saving Regulation defines maximum values for primary energy demand and the heat loss by transmission for residential and non-residential buildings. The maximum value depends on the type and use of the building. The maximum value for modernization in general lies 40% below the values of new construction. Energy balancing comprises beyond heat loss of transmission heat input of solar radiation, internal heat input, heat loss of distribution, storage and transfer inside the building as well as the energy loss by the energy source through primary production, transformation and transport. »Green Building« is an European program setting target values 25% or 50% below compulsory primary energy demands. Its focus is especially on buildings with non-residential use, like office buildings, schools, swimming pools and industrial buildings.

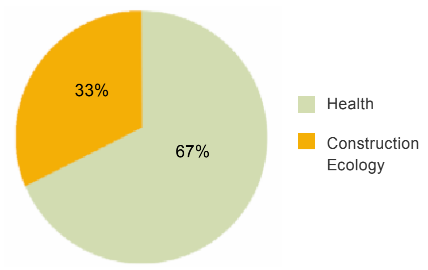


Fig. A20 Minergie ECO®
Weighting Pre-Assessment

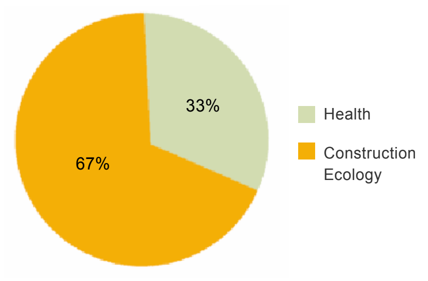


Fig. A21 Minergie ECO®
Weighting Construction Stage

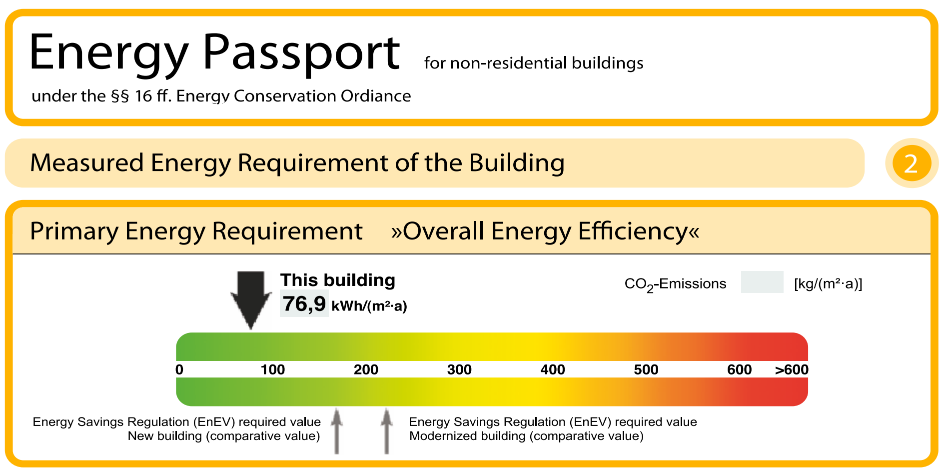


Fig. A22 Energy Passport

An integrated View of Green Buildings – Life Cycle Engineering

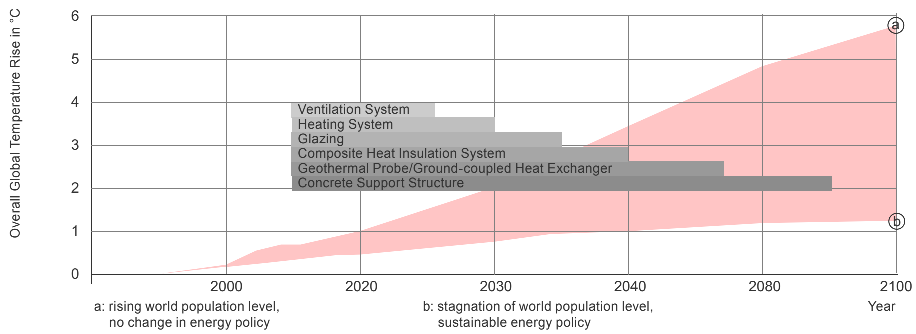
Green Buildings are buildings of any usage category that subscribe to the principle of a conscientious handling of natural resources. This means causing as little environmental interference as possible, the use of environmentally-friendly materials that do not constitute a health hazard, indoor solutions that facilitate communication, low energy requirements, renewable energy use, high-quality and longevity as a guideline for construction, and, last but not least, an economical operation. In order to achieve this, an integrated, cross-trade approach is required to allow for an interface-free, or as interface-free as possible, handling of the trades of architecture, support structure, façade, building physics, building technology and energy while taking into account both usage considerations and climatic conditions. To this end, innovative planning and simulation tools are employed, according to standards, during the design and planning stages for Green Buildings. They allow for new concepts since – by means of simulation of thermal, flow and energy behaviour – detailed calculations can be achieved already during the design stage. Attainable comfort levels and energy efficiency can thus be calculated in advance and this means that, already during the design stage, it is possible to achieve best possible security in regards to costs and cost efficiency. Equipped with these kinds of tools, Green Building designers and planners can safely tread new paths where they may develop novel concepts or products.

Aside from an integrated design and work approach, and the development and further development of products and tools, sustainability must be expanded so that the planners are able to gather valuable experience even during the operation of the buildings. This is the only way that a constructive back-flow of information into the building design process can be achieved, something that, until now, does not apply for contemporary building construction. This approach is to be expanded to encompass renaturation, in order to make allowances for the recycling capability of materials used even during the planning stage. In other industrial sectors, this is already required by law but, in the building sector, we are clearly lagging behind in this aspect. On account of consistent and rising environmental stress, however, it is to be expected that sustainability will also be demanded of buildings in the medium-term and thus not-too-distant future.

The path from sequential to integral planning, hence, needs to be developed on the basis of an integral approach to buildings and is to be extended in the direction of a **Life Cycle Engineering** approach. This term stands for integral design and consultation knowledge, which always evaluates a given concept or planning decision under the aspects of its effects on the entire life-cycle of a given building. This long-term evaluation, then, obliges a sustainable handling of all resources.

The authors consider Life Cycle Engineering to be an integral approach, which results in highest possible sustainability levels during construction. It unites positive factors from integral planning and/or design, the manifold possibilities of modern planning and calculation tools, ongoing optimisation processes during operation, and conscientious handling during renaturation of materials. All this results in a Green Building that, despite hampering nature as little as possible, can provide a comfortable living environment to meet the expectations of its inhabitants.

Fig. A23 Life expectancy of contemporary components when seen inside the time-frame of possible rises of global temperature levels



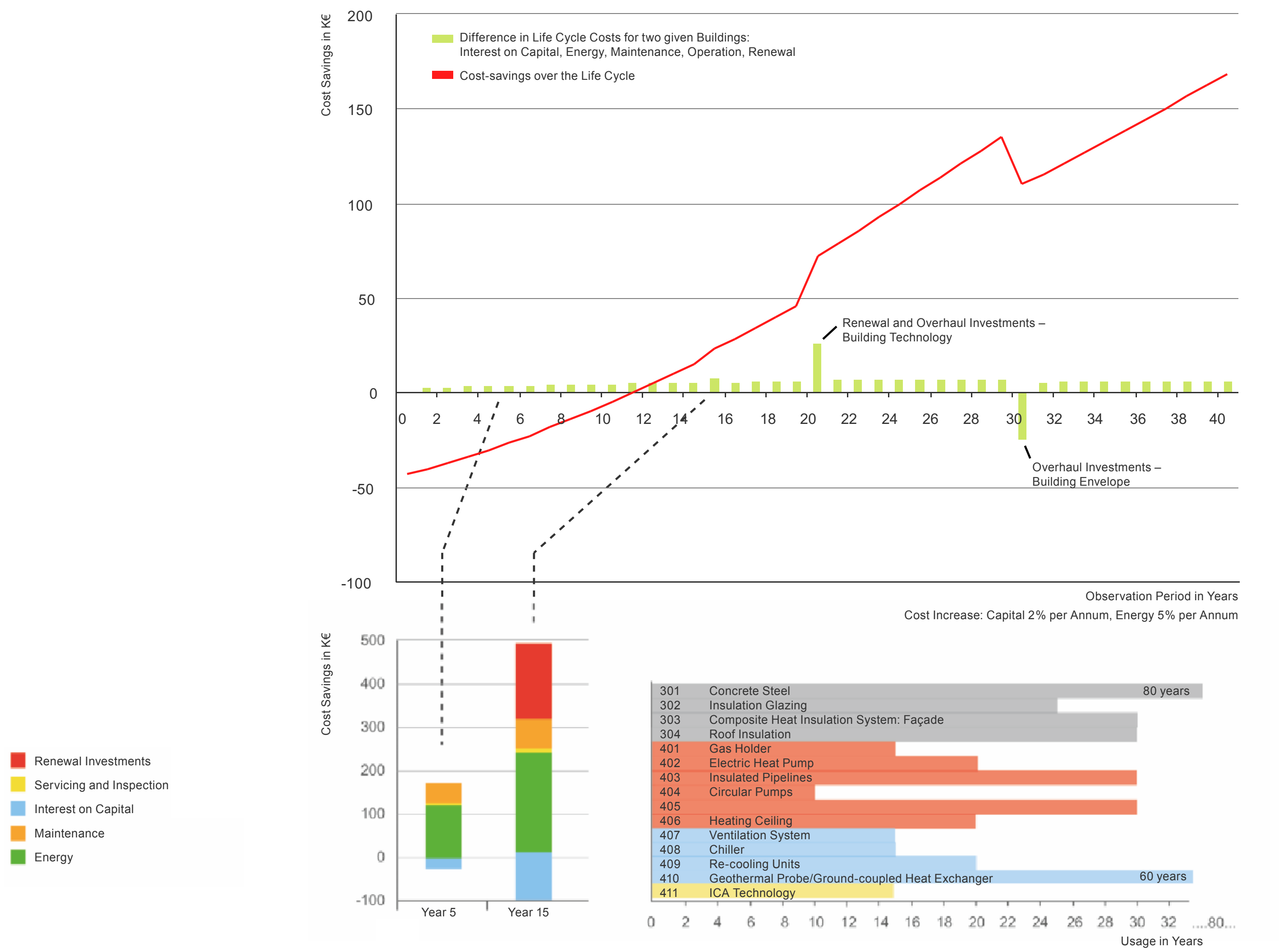


Fig. A24 Cost-savings Green Buildings vs. Standard Buildings – detailed observation over the entire Life Cycle

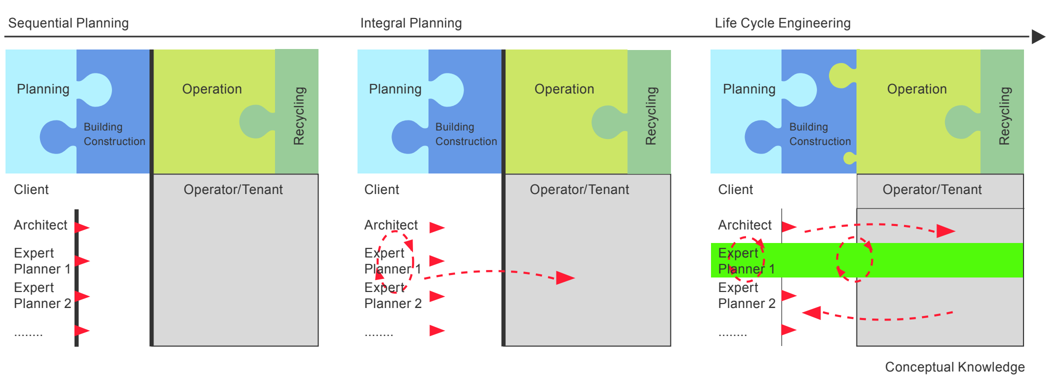


Fig. A25 Development of Planning Methods, from sequential Methodology to Life Cycle Engineering