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Sustainable building certification schemes - a comparison

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Sustainable Building Certification

1 Introduction

1.1 Background and objectives

The construction and operation of buildings today has a significant share of the environmental impact in the form of consumption of resources, energy and landscape. Not only because of the amount of material and energy used here, but also because of the long life of buildings. If errors are made at the beginning and buildings are built in such a way that they are associated with a high consumption of resources, then this has a very long-lasting effect.

Therefore, planners and builders also have a high impact on future environmental pressures and sustainable development. Assessing how a building can be planned and constructed to minimize resource consumption is not easy, since a variety of aspects play a role, which have different modes of action and sometimes even counteract each other.

In order to facilitate decisions here, a wealth of tools and indicators have been developed over time. Apart from the eco-labels, which refer to certain materials and products (sub-module environmental label), building certification systems should be mentioned at building level. Of these, there are now a large number of systems, some of which are limited to certain countries, but others are also used worldwide.

The project focuses on reducing greenhouse gas emissions related to the use and use of wood. Here, however, the main focus is on transports and the flow of goods. For planners and stakeholders, a toolkit is available that enables them to make a sustainable and climate-friendly planning and procurement decision and targeted control.

The comparison of different certification systems for sustainable construction presented here does not aim to assess which of the systems is better or worse. There are also no comprehensive explanations and introductions to the individual systems themselves.

With the present comparison of the selected relevant and known building assessment systems, the following key questions should rather be evaluated or answered, which are of importance to planners and building owners in the context of the project:

- What contribution do ecological aspects of sustainability have in the overall assessment?
- To what extent are (global) flows of goods recorded and evaluated?
- To what extent does the material (e.g., renewable resources) play a role in the assessment?
- What costs are associated with certification and for whom?
- What is the scope or scope of the certification systems?

1.2 Data basis

The task in the project was not an own detailed analysis of the different systems but an evaluation of existing studies and investigations. For this purpose, a preliminary search was carried out. The database and source of the system comparisons were ultimately based on the following studies and investigations:

- Project report of the Interreg project ENERBUILD from 2011: „Transnational comparison of instruments according to the ecological evaluation of public buildings“
- Final Report of a Research Project of the Federal Ministry of Transport and Building from 2009: Comparison of the System of the German Quality Seal Sustainable Building with International Systems (BBSR study)
- „Simply green“ - a comparison of 15 international certification systems of the swegon air academy from the year 2012.

- A study by the Ministry for a liveable Austria from 2016: „Building assessment systme in comparison“
- A 2013 study by Mittweida University of Applied Sciences: „Critical analysis of the certification systems used in Germany for sustainable real estate“
- A comparative analysis in the specialist book series DETAIL
- Own comparative evaluations of building certification systems from 2010
- as well as various web searches.

A total of 21 certification systems were recorded and described in the studies.

Table 1 shows an overview of the coverage of the different building certification systems by the individual studies.

Tab. 1: Overview of the analyzed building assessment systems and comparative studies.

	study /origin	simply green	BBSR-Studie	HS Mittweida	Klima: aktiv	ENER-BUILD	Detail	Holz von Hier
year		2012	2009	2013	2016	2011	2010	2010
BCA	SGP							x
BDM	F					x		
BREAM	UK	x	x	x	x	x	x	x
casaclima nature	I					x		
CASBEE	J	x					x	x
DGNB	D	x	x	x	x	x	x	x
Effinergie	F	x						
European Green Building Programme	EU	x			(x)		x	
German Passive House Standard	D	x						
Green Star	AUS	x						
GRIHA	IND							x
HQE	F	x				x	x	
IGBC	IND	x						x
Klima:aktiv	A				(x)			
LEED	USA	x	x	x	x			x
Miljöbyggnad system	S	x						
Minergie	CH	x					x	
protocollo Itaca Regione Piemonte	I					x		
TQB	A				(x)	x		
US ENERGY STAR	USA	x						

2) Results

Since the different studies followed different questions or based their assessment approaches, the results of the respective studies should first be reported separately.

Following this, in Chapter 3, a general synopsis of the various investigations will be made with regard to the central issues in the project.

Further comparison will exclude the system of the EU Green Building Program as it has a number of special features. So it is not a sustainability assessment system in the true sense, but rather an energy savings incentive program that aims at reducing energy consumption during the use phase. Other sustainability aspects are not taken into account. In addition, not concrete buildings are awarded, but the companies or builders are program partners. In the following, the EU Green Building Program will be briefly characterized.

EU Green Building Program

EU Green Building Program is a building standard of the European Commission applicable to different building types. The system was developed in an EU project and concentrates exclusively on the energy demand (from: „Building rating systems in comparison", 2016, study by the Ministry for a Livable Austria). In order to achieve the status of a European GreenBuilding, the maximum permissible energy values for national building regulations must be reduced by 25 percent. Evidence must be provided at the end (or primary) level of energy in those EU Member States that have already introduced appropriate parameters. For renovations, a 25% saving compared to the inventory must be proven.

In Germany, the German Energy Agency was responsible for the EU project. From the Internet, it is currently not clear whether this program is still active and is being driven forward. The impression from the Internet is rather no (see official website). Also on the page of the German Energy Agency you will find only website entries for the respective consultations and workshops of DENA in China with the search terms „EU Green Building Standard", „Green Building".

Fig.1: screen-shot of the current page www.eu-greenbuilding.org on January 2nd, 2018.

Fig. 2: screen-shot of the current page on January 2018.

The latest report available is the final report from 2006. According to the website, the project and the measures implemented cost around € 1.527 million, of which € 0.763 million was from the European Union. The report quantifies the energy savings through measures in the buildings involved in the project, totaling 90,000 MWh / year of primary energy. Extrapolated to 20 years (named as a brand in the project, for example for lifetime and / or depreciation?), The report claims 1.8 TWh of primary energy savings and a total avoidance of 435,000 tonnes of CO2 emissions. All in all, the EU green-building program would have cost every tonne of CO2 saved € 1,755 in taxpayers' money. Each year, the measures financed in this way avoided around 22,000 tonnes of CO2.

In comparison, a regional closure of process chains achieves significantly higher savings, which in addition are not costly to the public. By closing regional material cycles of overlapping flows of wood raw materials and wood products of the same product categories, the following CO2 savings could be achieved if only 5% of the material flows were closed regionally (data from WP1, EU CaSCo Report):

- Austria: total 370,000 t CO_2/year, at 5%: 18,500 t CO_2/year.
- France: total:> 500,000 t CO_2/year, at 5%: 25,000 t CO_2/year.
- Italy: total: 245,000 t CO_2/year, at 5%: 12,250 t CO_2/year.

- Germany: total:> 3,000,000 t CO_2/year, at 5%: 150,000 t CO_2/year.

According to the „final publishable report of the GreenBuilding project" (EIE / 04/057 / S07.38638, 2014, Tab. 1), „new buildings" with realized green building measures save on average 148 kWh / m2 * a and existing buildings, where energy saving measures have been implemented, about 110 kWh / m2 * a. The energy consumption of green buildings refurbished buildings was therefore 249 kWh / m2 * a in 2006 and 220 kWh / m2 * a for new buildings.

According to a study by the Institute for Housing and the Environment (IWU) of 1999, every office building by default had these values (standard of 1999 averaged 235 kWh / m² * a) and is now far surpassed by many new buildings.

The extent to which the buildings under the Green Building Program contributed to climate protection at that time and today or whether only the state of the art has been implemented here can not be inferred from the internet.

2.1) EU Project ENERBUILD

In the EU project ENERBUILD „Transnational comparison of instruments according to the ecological evaluation of public buildings", a new building assessment scheme was developed in the Alpine region (report February 2011) and compared selected existing building assessment systems. The following certification systems were analyzed:

- **Protocollo Itaca Regione Piemonte** (Italy)
- **Casaclima Nature** (Italy)
- **BDM** (France)
- **HQE** (France)
- **TQB - Total Quality Building** (Austria)
- **Minergie P-Eco** (Schwitzerland)
- **DGNB** (Germany, Austria)
- **LEED Italy** (Italy)

The study compares the investigated systems with regard to the following aspects:

- user
- Building
- considered lifecycle phases
- Structure (number of criteria, weighting, thematic assignment)
- certification process
- costs

In the study, the systems are briefly characterized and compared in terms of the mentioned aspects in tabular form. For the research question of the present project („Low Carbon Timber Construction"), the evaluation of the structure of the systems with regard to criteria and weighting is of particular importance.

However, the Enerbuild study does not make any quantitatively comparable statements, but gives a rather qualitative description.

Table 2 on the next page compares the results from the report. In doing so, the table was rearranged to delineate the more ecological aspects of social and economic aspects. Excluded in the table (as well as in the Enerbuild study) is the Minergie ECO system, since this follows a completely different scheme.

Weighting of environmental aspects

A certain quantification can be taken from the EnBuild study in the form of the number of environmental criteria or the proportion of the total number of criteria, although this makes it almost impossible to make an absolute statement due to weightings.

According to this, environmental criteria vary from a share of 39% (HQE) to 100% (Casa clima nature). The following list shows an overview.

- Protoc. Itaca: 65%
- LEED Italia: 72%
- Casa Clima Nature: 100%
- DGNB: 51%
- Total Quality: 44%
- BDM: 82%
- HQE: 39%
- Minergie Eco: 55%

According to the Enerbuild study, the focus of environmental aspects is on energy, followed by materials. However, the study makes no conclusive and comparative statements regarding the nature of the environmental reference.

A hard comparison between the systems is also difficult for the reason that they are oriented to different climatic requirements (cooling energy requirement is relevant only in the mediterranean area).

Meaning of the choice of material

Materials play a role in many rating systems, according to the Enerbuild study, this aspect comes second. However, it is in the foreground, whether it is recycled materials or healthy living materials etc. A weighting to the effect that the use of wood as a renewable material has a positive impact, is not apparent.

Importance of the prechains

The study makes no definite statements. Overall, however, it is clear that the emphasis in building assessment systems is on the use phase, both in terms of energy consumption and environmental

Tab. 2: Results of the Enerbuild project. Table restructured into three areas (a) environmental factors, (b) social factors and (c) economic factors.

	ENERBUILD	P. Itaca (Italy)	LEED Italia	DGNB	Casaclima Nature	Total Quality	BDM	HQE
öcologische Kriterien								
Klima	CO_2 Emissionen	CO_2 Emissionen	-	-	CO_2 Emissionen (Produktherstellung)	CO_2 Emissionen aus Energieverbrauch	thermal mass, Erneuerbare Energien, Sonneneinstrahlungskontrolle	-
Energie	Spezifischer Heizenergiebedarf Spezifischer Kühlenergiebedarf Primärenergiebedarf	U-Wert, Heizenergieverbrauch, sommerlicher Wärmeschutz thermal mass, Warmwasserenergieverbrauch	Optimierung Energieverbrauch, erneuerbare Energien, Moitoring Energieverbrauch, 3 weitere Kriterien	CO_2 Emissionen	Spezifischer Heizenergiebedarf, Primärenergiebedarf Produktherstellung	Primärenergiebedarf, Spezifischer Heizenergiebedarf sommerlicher Wärmeschutz	Monitoring Energieverbrauch	Primärenergiebedarf Monitoring Energieverbrauch
Umwelt	-	-	-	-	Versauerung (Produktherstellung)	-	-	-
Wasser	-	Trinkwasserverbrauch, -nutzung	-	Gebäudebezogene Lebenszykluskosten	-	-	Minimierung Wasserverbrauch	Wasserverbrauch, Abwasserrückgewinnung am Standort
Ressourcen (Material)	O13 Ökologischer Index	-	4 Kriterien zu Material	Sommerlicher Wärmeschutz	-	O13 Kalkulation als Leitlinie, Vermeidung von PVC	regionale Materialien Recycelte Materialien	Nachnutzbarkeit von Konstruktionsmaterialien
Abfall / Nachnutzung	-	-	Nachnutzung Gebäude	-	-	disposal indicators	construction sites waste disposal indicat.	construction material reuse
Soziale Kriterien								
Gesundheit	-	-	-	Innenaraumhygiene	-	Emissionsarmut der Konstruktion und der Materialien	Wohngesunde Materialien	Wohngesunde Materialien
Soziale Aspekte	-	-	-	-	-	-	-	-
Ökonomische Kriterien								
Ökonomie	Standardisierte Kalkulation der öconomischen Effizienz	-	-	Qualität der Projektvorbereitung	-	Life cycle cost calculation	-	-
Service und Komfort	information für die Nutzer, sommerlicher Wärmeschutz, Ventilation, Tageslichtnutzung	-	-	Integrale Planung	-	Barrierefreies Bauen	-	Tageslichtnutzung
Prozessqualität	Entscheidungsfindung und Zielfestlegung, Formulierung von prüfbaren Zielen für energetische und ökologische Maßnahmen, Produktmanagement, Nutzung von Emissionsarmen Produkten, Planungshilfen für energetische Optimierung	Technische Dokumentation	-	Optimierung und Qualität des Planungsprozesses	-	-	-	Gebäude-anpassungsfähigkeit
Standort	Zugang zu öffentl. Nahverkehr Ökologische Standortqualität	-	öff. Nahverkehr, Entwicklungsdichte		-	-	Anbindung an öff. Nahverkehr, Nähe zu Dienstleistungen	Optimierung Transport / Anfahrt

impact. Only at Casa Clima Nature do the environmental aspects seem to relate primarily to the manufacturing process of the materials, although this is not described in more detail.

Importance of regionality

The aspect of origin or regionality of materials is only discussed in the BDM system. However, this seems to be more based on consideration of regional know-how and manufacturing methods.

2.2) BBSR Study

On behalf of the Federal Ministry of Transport, Building and Urban Development (BMVBS) and the Federal Institute for Building, Urban and Spatial Research (BBSR) in the Federal Office for Building and Regional Development (BBR), an in-depth analysis of the three building assessment systems BREEAM, LEED and DGNB was carried out. The focus was on the basic structure of the systems, system variants, evaluation methods, main criteria groups, individual criteria, basic requirements and the certification process.

The study compares the weighting of the three dimensions of sustainability or other parameters in the comparative chapter. Here too, as in the case of the study by HS Mittweida, the result is that the weighting of the ecological criteria for LEED (62.3%) and BREEAM (56.3%) is considerably higher than for the DGNB with 22.5%. , At the same time, it is emphasized that LEED, in particular, does not require a life cycle assessment of building materials. BREEAM calls for an LCA for the building materials, DGNB an LCA for the entire building.

Weighting of environmental aspects

Like other studies, the BBSR study concludes that the LEED and BREEAM systems place greater emphasis on the environmental aspects of sustainabili-

ty. A positive certification would therefore suggest a clearer message of reduced environmental impact. However, reference is made to the more comprehensive life cycle assessment at DGNB, which refers to the entire building. Of course, the environmental effects of the materials used can also be included here. It can be assumed, however, that their overall influence in the system of DGNB tends to be lost because it can easily be compensated by other parameters. The BBSR study does not score here.

Meaning of the choice of material

The criteria have been broken down into local and global impacts. The latter are summarized in the table below for shares in the valuation. Again, the greater weighting of global environmental impacts, e.g. Climate in LEED and BREEAM, where BREEAM more evaluates the LCA of products, LEED, however, specific requirements for the materials such. Reuse or other.

	DGNB	LEED	BREEAM
Emissions (LCA)	6,92 %	1,45 %	11,73 %
sutainable materials	1,15 %	15,94 %	6,06 %
Sum	**8,07 %**	**17,39 %**	**17,79 %**

Importance of the prechains

As shown in the table above, the global impact of the materials and their upstream chains at DGNB is much less significant. They are still highest rated at BREEAM, with standardized life cycle assessments of building materials with respect to certain aspects of upstream chains, such as the effects of transport have systemic weaknesses (see EPD subproject).

Importance of regionality

The BBSR study also shows that with the exception of LEED, with a blanket perimeter definition criterion, the ‚regionality' of materials plays no role in building rating systems.

2.3) Study of the University of applied science Mittweida

Within the framework of a bachelor thesis, the German building rating systems DGNB, BREEAM and LEED were analyzed and compared. The system variants, the application areas according to building types, the structure (criteria, indicators) of the certification process and the fees are examined.

Weighting of environmental aspects

The key message is that the system of the DGNB as a „second generation" system would cover the sustainability aspects in a more comprehensive sense. In contrast, the other two systems would be considered as the „first generation".

Conversely, this means that BREEAM and LEED are much more concerned about the environmental dimension of sustainability. This is positive in the sense of the project CaSCo, the study of the HS Mittweida regards this as a defect. The cause is the different background or objective. The bachelor thesis was conducted at the chair for real estate and facility management, so that here clearly the focus is on the „value" of the building in terms of the market value.

Meaning of the choice of material, Importance of the prechains and regionality

The study has not made any statements.

2.4) Study „Klimaaktiv"

The Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) has examined various building certification systems in a study published in October 2016. In addition to the own standard of the Ministry (Klimaaktiv) the following systems were examined:

- TQB (Total Quality Building) der ÖGNB (Österreichische Gesellschaft für Nachhaltiges Bauen)
- DGNB
- EU Green Building
- BREEAM
- LEED

However, the study does not subject the systems (at least as far as the publication is concerned) to a systematic comparison but rather describes them side by side, with Green Building, BREEAM and LEED being only briefly characterized.

Weighting of environmental aspects

With the standard Klimaaktiv the area of the energy supply occupies the highest weight with 60%. The entire area of construction materials and construction accounts for only 15%. In contrast, both domains each occupy 20% of the TQB system.

However, both systems are still well below the high weight of the environmental aspects of LEED and BREEAM.

Meaning of the choice of material, Importance of the prechains and regionality

The study has not made any statements.

2.5) DETAIL study

This study is one of the most detailed comparisons of rating systems and, in a sense, one of the most systematic. The following systems are characterized in detail:

- BREEAM
- LEED
- DGNB
- CASBEE
- HQE
- MINERGIE
- EU Greenbuildung Programm

In the later comparison and comparison, however, only the first three systems are included.

The study pays special attention to the description of the planning and certification process as well as a description of the structure of the systems. It is therefore mainly aimed at planners. These aspects are not relevant to the issues in the project.

But also in terms of weighting e.g. From environmental aspects in the evaluation result, the DETAIL study does not make any comparative or judgmental statements. Only the relevant criteria are mentioned.

The EU Greenbuilding Program includes, according to the analyzes of the study, e.g. No material related criteria or environmental aspects other than energy efficiency.

Energy efficiency is also a priority at Minergie, although aspects of building materials choice (subsystem Minergie-ECO) seem to play a role here (well-available building materials, recycled building materials, building materials with low environmental impact). A closer description of the influence these aspects have on the result is missing.

In the case of the HQE system, only one out of 42 criteria seems to address the issues in the ‚Low Carbon Timber Construction' project, namely the ‚Reduction of environmental impacts through the targeted selection of construction products'. However, it remains unclear what exactly is meant by that and what weighting this has.

Although the CASBEE system has environmental criteria in its portfolio, there is a great emphasis on the reuse of materials or the use of recycled materials. A targeted evaluation of environmental effects through the production of materials or the process chain is not recognizable. From the in-depth comparison of the BREEAM, LEED and DGNB systems in the study, the following summarized statements can be made with regard to the project-relevant issues.

Weighting of environmental aspects

A clear statement goes in the direction of the proportion of ecological criteria in the overall result. Here BREEAM with 33.6% and LEED with 31.1% are well ahead of the DGNB system with 16.3%. If one adds the energy sector, the result is the following ranking: LEED with 63.3% before BREEAM with 57.1% and DGNB with 30.7%. The DGNB system stands out particularly clearly and presents itself more as a system that assesses the market value and resale value of the building, because its direct environmental impact.

Meaning of the choice of material

The DGNB system has not defined any specific requirements or criteria here. At BREEAM, material influences are taken into account via a general life cycle analysis. LEED is the only one of the investigated systems that defines specific material requirements in terms of using low-emission and recycled materials, renewable raw materials or certified wood.

Importance of prechains

For BREEAM, the upstream chains seem to have a specific focus, as the life-cycle considerations are limited to building materials according to the DETAIL study and do not refer to the use or re-use phase of the building. At DGNB, the upstream chains are not subject to any specific criteria or considerations. At LEED, too, the environmental impact of the production of building materials obviously does not matter.

Importance of regionality

Only the LEED system rates the use of regional building materials (radius of 800 km) as a criterion. (The study was published before the DGNB system reintroduced a corresponding subcriterion (2018)).

2.6) Study „Simply Green"

The ‚Simply Green' study was conducted by the Swegon Air Academie in Sweden and published in 2012. The purpose of the study was to give an overview of the main building certification systems in the market for orientation as to the objectives and structure. It comprises the largest number of considered certification systems of all evaluated studies.

The publication points out that the different systems are very different and there is hardly any systematic and well-founded comparability. This starts with the fact that some systems are more likely to be environmental assessment systems, while others are purely energy efficiency instruments. In addition, not only the subdivision and structure such as e.g. Criteria vary widely, aggravating that the same terminology may have different meanings in the different systems. Notwithstanding the limiting difficul-

ties, however, the study conclusively compares the different systems studied. Figure 3 shows the final comparison from the Simply Green study.

Weighting of environmental aspects

Again, because the Simply Green study has grouped and categorized the different evaluation criteria, a direct comparison with the results of the other studies is again not possible. Simply Green has not explicitly summarized „environmental" or „ecological" aspects. But summarizing the areas of energy, water, materials and waste, this is probably in line with the categorization of the other studies of BBSR or DETAIL. It is therefore noticeable that the DGNB system has small proportions here. But also the other systems Green Star, HQE, CASBEE and IGBC rank behind the systems BREEAM and LEED.

Meaning of the choice of material

A decided interpretation of the influence that material selection has on the evaluation result can not be inferred from the study.

Importance of prechains

In the study Simply Green, the results of the analyzes of the systems are only summarized in an overview. Concrete information about the weighting or consideration of the upstream chains, e.g. can not be removed there.

However, the description of the structure of the systems suggests that, as a rule, the upstream chains are given little attention. These aspects are directly related to requirements or considerations of the material. However, the material itself has a comparatively low weighting for all systems, which is 0% for the energy-based systems (EU Greenbuilding Program, Minergie, German Passive House Standard, Energy star, effinergie) and 1% for the environmental systems (DGNB). and 13% (LEED, Miljöbygnad) varies. In addition, in some of the systems, the aspect of materiality is limited to questions of recycled content and reusability.

Importance of regionality

A definite statement on requirements of a regional origin in the systems can not be taken from the study. It notes only the following systems that the origin or origin of the materials is a criterion: BREEAM, LEED, BDM, CASBEE and IGBC. However, it remains unclear whether this is regionality or e.g. Sustainable raw material extraction goes. With regard to LEED, it is already known from the studies described above that regional origin is considered positive, and at BDM we know that the focus is on the aspect of regional traditions and know-how.

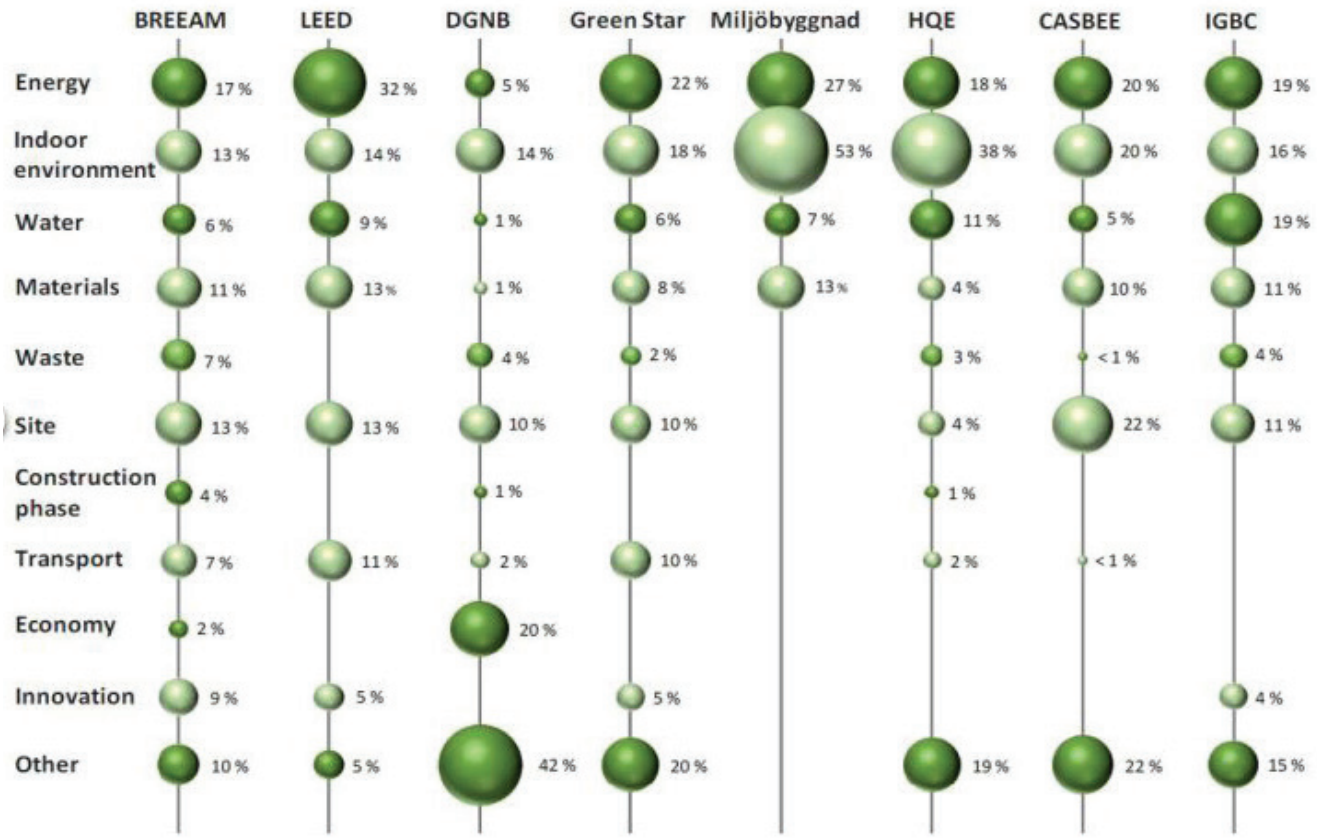

Abb. 3: Comparison of the criteria weighting of (some of) the examined building rating systems. (From: Simply Green, 2012)

2.7) Analyses Holz von Hier

Other worldwide building rating systems that have been compared by HOLZ VON HERE are

- **BCA** (Singapur)
- **BREEAM** (UK)
- **CASBEE** (Japan)
- **DGNB** (Deutschland)
- **E.E.W.H.** (Taiwan)
- **Green Star** (Australien)
- **GRIHA** (Indien)
- **HK BEAM** (Hong Kong)
- **LEED** (USA)

The results are summarized in the profiles of the rating systems.

3) Synopsis

The different building assessment systems have very different histories and backgrounds, often take into account specific country-specific or regional characteristics and framework conditions, some pursue different objectives and have a very different structure with regard to the criteria and indicators. The weighting of the different factors is also very different. In addition, certain criteria can sometimes be assigned to different areas (CO2 emission reduction, for example, either in the material area or in the energy sector, etc.).

They can therefore hardly be compared directly with each other. Early on, with the development and establishment of such building rating systems in different countries, there were also efforts and initiatives to harmonize them, in Europe e.g. the ISBEE initiative or the Sustainable Building Alliance (SB Alliance). The aim was to create a framework that makes the evaluation results comparable among the different systems. However, this has ultimately failed so far, because a uniform framework catalog of key indicators was found or defined, which can then be adapted regionally. But with this regional adjustment, comparability was lost again, as stated in the DETAIL study.

Against this background, the synopsis sought here does not constitute a „rating" of the rating systems, but rather summarizes the impressions from the studies examined and its own research with regard to the issues relevant to the CaSCo project. The classifications are summarized in Table 3 and largely expressed in terms of points awarded. Strokes symbolize lack of relevance, few points of little importance and many points of high importance or consideration. The background to this is the question as to how far the respective evaluation system gives a planner information about the environmental impact of a building or helps it to plan and build a building with the least possible environmental impact and, above all, climate impacts.

Weighting of environmental aspects

It asks how far a planner can use a particular certification system to minimize the impact on the environment. Here, once all rating systems come out, which are in principle aimed at an energy efficiency building, so Effinergie, the passive house standard, US Energy Star, Minergie, and the Green Building Program, but also the Asian systems CASBEE, GRIHA, IGBC and Greenstar and the Austrian TQB and Climate: active. The modern system of the DGNB also devotes a rather subordinate space to the actual ecological parameters. The French systems BDM and HQE, as well as the Italian protocollo Itaca, and above all BREEAM and LEED, as well as the local Italian casaclima nature, are geared more towards the environment.

Meaning of the choice of material

Here the question is in the foreground, which system can be used or is suitable, in order to give the special characteristics and advantages of renewable raw materials and here in particular wood validity. All systems that are more energy-efficient are also eliminated. Although a number of systems have defined criteria for the materials, the focus here is usually on the issue of reusability or recycling. The systems LEED, casaclima nature, the Swedish Miljöbygnad and BREEAM are most likely to show differences in the result of which materials are used.

Importance of prechains

Here, the question is whether the respective system takes into account (adequately) the aspect of the environmental effects of the upstream chains, especially from the point of view of the importance of the flow of goods. Here, the circle of suitable systems is limited even further, since many systems map the environmental effects primarily over the usage phase. Hardly any system devotes special importance to the question of environmental impact through the production of building materials. This expresses the tendency to look at the buildings „holistically" and to see the construction materials rather in their arrangement in the building context. This is certainly legitimate on the one hand, since a good material can also be installed unfavorably. However, the share of upstream chains in the environmental impact is underestimated, and this increasingly as the buildings themselves become more energy efficient in operation. The casaclima nature system is most likely to take this aspect into account, as the environmental criteria seem to refer explicitly to the manufacturing process of the materials.

Importance of regionality

Here, the question is discussed as to whether and to what extent demonstrably regionally produced materials are taken into account within the framework of the corresponding system. Since usually the importance of the flow of goods along the entire processing chain for the environmental footprint, in particular of building materials, is systematically underestimated, it is not surprising that hardly any evaluation system covers this aspect at all. Only three systems also score points when building materials of regional origin are TQB, BDM and LEED.

Only LEED explicitly requires a certain perimeter. Since 2018, a subcriterion has also been set up at DGNB, which rewards the use of construction products from a radius of 500 km from the place of origin, albeit only slightly. As far as the use of climate-friendly regional building materials is concerned, most systems therefore do not provide information to planners or are not usable to specifically support this.

Importance of demonstrably climate-optimized wood products from regional production for the building rating system

Evidence for climate-friendly produced short-distance timber is an important aspect of sustainability. It would therefore be desirable if you also played a corresponding role in the overarching building rating systems. Unfortunately, this is only the case in exceptional cases.

The effectiveness as proof of a criterion of regionality is unclear at BDM.

For LEED this should be usable on the basis of the km radius criterion.

At the DGNB, the introduction of the criterion for regional construction products also recognizes the environmental label HOLZ VON HIER as proof here.

Holz von Hier is also recognized in the sustainability standard of the Federal Ministry for Small Housing (BNK) as proof of the requirements for wood products. This would also be conceivable for the Austrian TQB.

Tab. 3: Relevance of the rating systems for the questions in the project Low Carbon Timber Construction.

Aspect / **System**	weight of ecological aspects	conside-ration of prechains	meaning of the material	regionality of materials	costs	importance in Europe
BCA	++	-	+	-	?	-
BDM	++	+	+	+	€	+
BREAM	+++	+	+	-	€€€	+++
casaclima nature	+++	++	++	-	€	+
CASBEE	+	+	+	-	free/€€	-
DGNB	+	+	-	+	€€€	+++
Effinergie	+	-	-	-	?	+
European Greenbuilding Progr.	+	-	-	-	free ?	+++
German Passive House Standard	+	-	-	-	?	+
Green Star	+	-	-	-	?	-
GRIHA	+	-	-	-	?	-
HQE	++	+	+	-	€€	++
IGBC	+	-	++	-	?	-
Klima:aktiv	+	-	+	-	free ?	+
LEED	+++	-	++	+	€€€	+++
Miljöbyggnad system	++	+	++	-	?	-
Minergie (-ECO)	+	-	-	-	€€	+
protocollo Itaca Regione Piemonte	++	-	+	-	free	+
TQB	+	+	+	+	€€	+
US ENERGY STAR	+	-	-	-	?	-

4) Profiles of Building Certification Systems

In the following, the examined building evaluation systems, which are relevant for the European area, are described in more detail. Other investigated systems, which will hardly be used in Europe, are briefly characterized below. The information comes from the various studies, partially supplemented by views of the respective websites as of January 2018.

However, a direct comparison is difficult, both in terms of the number and type of each area and criteria, and in terms of their assessment and weightings. Each of the mentioned criteria can be evaluated once or several times. This was not covered here, which would make comparability even more limited. Here, therefore, only (1) the number of areas and (2) criteria, (3) the actual ranking and if present (4) selected material aspects and (5) information on transports in the upstream chains are displayed if available. Information on (6) cost structures and (7) number of certified buildings are sometimes difficult to find on the websites, or sometimes very complex, so that only a rough first and, above all, non-binding overview can be given.

4.1) BNB

www.bnb-nachhaltigesbauen.de. *January 2018*

Bereiche: 6

- (1) Ecological quality
- (2) Economic quality
- (3) Socio-cultural and functional quality
- (4) Technical quality
- (5) process quality
- (6) Location quality

Critaria: 50

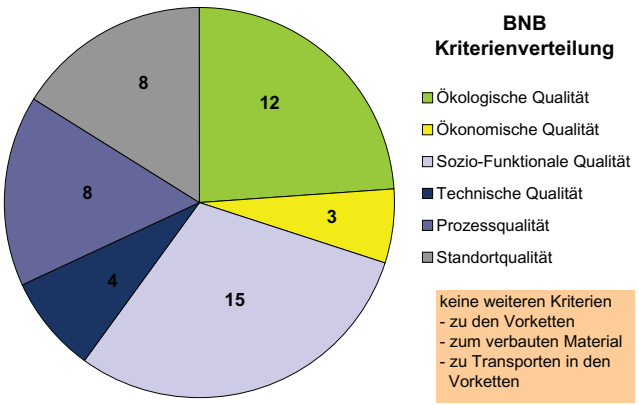

Abb. 4: BNB - Criteria distribution original.

(1) Ecological quality: 2 aspects, 12 criteria

(a) effects on the global and local environment

- Global Warming Potential (GWP)
- Ozone Depletion Potential (ODP)
- Ozone formation potential (POCP)
- Acidification potential (AP)
- Overfertilisation potential (EP)
- Risks to the local environment - optional
- Sustainable material extraction / wood

(b) resource use

- Primary energy demand, non-renewable (PEne)
- Total primary energy demand u. Share (PEernew.)
- Drinking water requirement and waste water volume
- Calculation aid drinking water
- land use

(2) Economic quality: 2 aspects, 3 criteria

(a) life cycle costs

- Building-related costs in the life cycle
- Instruments Estimation v. Life cycle costs

(b) performance

- Use capacity

(3) Socioec. quality: 3 aspects, 15 criteria

(a) health, comfort, user satisfaction

- Thermal comfort in winter
- Thermal comfort in summer
- Indoor air quality
- Acoustic comfort
- Visual comfort
- Influence of the user
- Accommodation features in the outdoor area
- Safety and accident risks

(b) functionality

- Accessibility
- space efficiency
- conversion feasibility
- accessibility
- bike comfort

(c) assurance of design quality

- Creative and urban design quality
- architectural art

(4) Technical quality: 1 aspect, 4 criteria

(a) Technical design

- soundproofing
- Heat and condensation protection
- Cleaning and maintenance
- Dismantling, separation and recovery
- (unclear): technical building equipment, resistance to natural hazards.

(5) Process quality: 2 aspects, 8 criteria

(a) planning

- project preparation
- Integral planning
- Complexity and optimization of planning
- Tender and award
- Requirements f. optimal management

(b) Construction
- Construction site / construction process
- Quality assurance of the construction
- Systematic commissioning

(6) Location quality: 1 aspect, 8 criteria

(a) Location characteristics
- Risks at the micro location
- Relationships at the Micro Location
- Quartier features
- road access
- Proximity to use-relevant facilities
- Attached media / development

Selected material aspects

No other criteria in the sense of specific consideration of the upstream chains of building materials.

Transporte in den Vorketten (LCp A2, A4)

no criteria.

certification levels:

- Bronze: > 50%
- Silver: > 65%
- Gold > 80%

Costs (according to website)

No information on costs found. In Germany a must for federal buildings.

Certified buildings (according to website)

- Number: 25 (Januar 2018)

4.2) BREEAM

www.breeam.com

The worldwide BREAM standards are different for each country (e.g., United Kingdom, USA, Netherlands, Norway, Sweden, Germany, Austria).

Sectors: 9 (+1) bei BREEAM

(1) Management
(2) health and comfort
(3) energy
(4) Transportation (use phase)
(5) water
(6) materials
(7) waste
(8) Land use, ecology
(9) Environmental impact
(10) Innovations (additional)

Criteria: 57 according to BREEAM

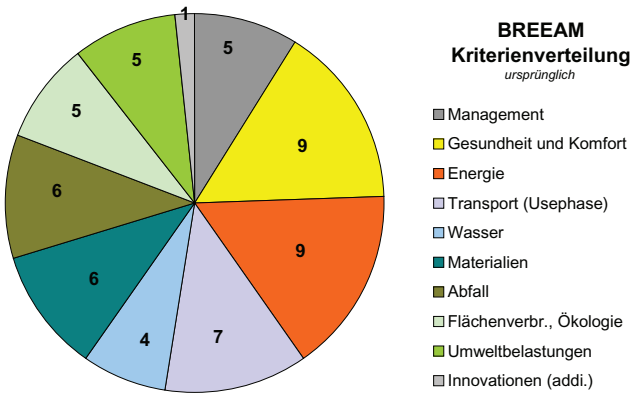

Abb. 5: BREEAM - Criteria distribution original.

(1) Management. Criteria: 5
- Project design.
- Life cycle cost analysis.
- Responsible construction
- Commissioning and transfer.
- Re-use.

(2) health and well-being. Criteria: 9
- Visual comfort
- Indoor air quality
- Safe working in laboratories
- Thermal comfort
- acoustics
- accessibility
- accidents
- Private space
- water quality

(3) energy. Criteria: 9
- Reduction of energy consumption and CO_2 emissions
- energy monitoring
- outdoor lighting
- Low carbon design
- Energy efficient cooling
- Energy-efficient transport systems
- Energy-efficient laboratory systems
- Energy efficient device
- drying rooms

(4) transportation. Criteria: 7
- Access to public. transport
- Nearby recreational opportunities

- Alternative transport options
- Alternative means of transport
- maxim. Parking capacity
- timetables
- Possibility for home office

(5) water. Criteria: 4
- water consumption
- water monitoring
- Water loss detection and avoidance
- efficient water use

(6) material. Criteria: 6
- environmental effects
- Conservation measures
- Responsible extraction of raw materials
- insulation
- Design for durability and reusability
- material efficiency

(7) waste. Criteria: 6
- Bauaballmanagement
- Recycled aggregates
- Operational waste
- Speculative finishes (?)
- Adaptation to climate change
- Functional adaptability

(8) Land Use and Ecology. Criteria: 5
- site selection
- Ecological value of the site and protection of ecological characteristics
- Minimization of impacts on site ecology
- Improvement of the site ecology
- Long-term influence on biodiversity

(9) pollution. Criteria: 5
- Effects of Coolants
- NOx emissions
- Surface water runoff
- Reduction of nightlight pollution
- Reduction of noise pollution

(10) Innovation. Criteria: 1
- innovation

Criteria: 57 resorted to comparability

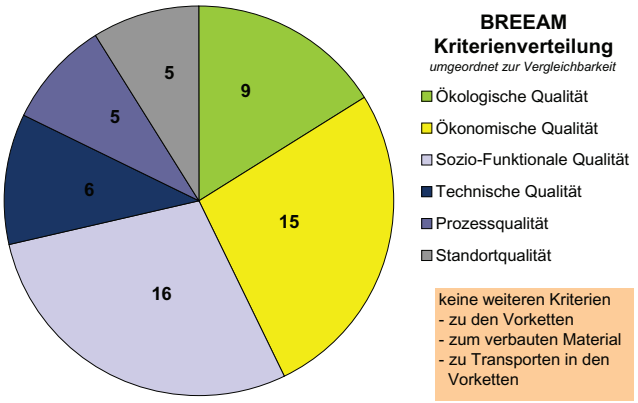

Abb. 6: BREEAM criteria resortet oto comparability.

(1) Ecological quality. Criteria: 9
- Reduction of energy use and carbon emissions.
- Water consumption
- Construction waste management
- Recycled aggregates
- Impact of refrigerants
- NOx emissions
- Surface water run-off
- Reduction of night time light pollution
- Reduction of noise pollution

(2) Economic quality. Criteria: 15
- Energy monitoring
- External lighting
- Low carbon design
- Energy efficient cold storage
- Energy efficient transport systems
- Energy efficient laboratory systems
- Energy efficient equipment
- Drying space
- Water monitoring
- Water leak detection and prevention
- Water efficient equipment
- Operational waste
- Speculative finishes
- Adaptation to climate change
- Functional adaptability

(3) socio-cultural, function. Quality. Criteria: 16
- Visual comfort
- Indoor air quality
- Safe containment in laboratories
- Thermal comfort
- Acoustic performance
- Accessibility
- Hazards
- Private space
- Water quality

- Public transport accessibility
- Proximity to amenities
- Alternative modes of transport
- Alternative modes of transport
- Maximum car parking capacity
- Travel plan
- Home office

(4) Technical quality. Criteria: 6

- Life cycle impacts
- Hard landscaping and boundary protection
- Responsible sourcing of construction products
- Insulation
- Designing for durability and resilience
- Material efficiency

(5) process quality. Criteria: 5

- Project letter and design.
- Life cycle cost and service life planning.
- Responsible construction practices
- Commissioning and handover.
- After Care.

(6) Location quality. Criteria: 5

- Site selection
- Ecological value of site and protection of ecological features
- Minimizing impact on existing site ecology
- Enhancing site ecology
- Long term impact on biodiversity

Certification ranking

- up to 6 stars.

Selected material aspects

No other criteria in the sense of the upstream chains.

Transports in the prechains (LCph A2, A4)

keine Kriterien

Costs (according to website)

- Flat fee for registration with BREEAM: approx. 3.500 €
- Plus the cost of the actual auditing. These are to be expected depending on the time required. There are no details. However, these are likely to move within the range of several thousand euros per building.

Certified buildings

BREEAM is available in principle for the following systems

- BREEAM inventory (in-use)
- BREEAM modernization (Refurbishm., Fit-out)
- BREEAM New Construction
- BREEAM City Quarters (Communities)
- BREEAM Customized Systems

According to the website, 563,419 projects are certified in 77 countries worldwide. It can not be easily tracked on the website of what kind these projects are and where they are located.

4.3) DGNB (Germany)

www.dgnb.de *(infos website January 2018)*

Sectors: 6

- (1) Ecological quality.
- (2) Economic quality.
- (3) Socio-cultural and functional quality.
- (4) Technical quality.
- (5) process quality.
- (6) Location quality.

Criteria: 37 according to DGNB

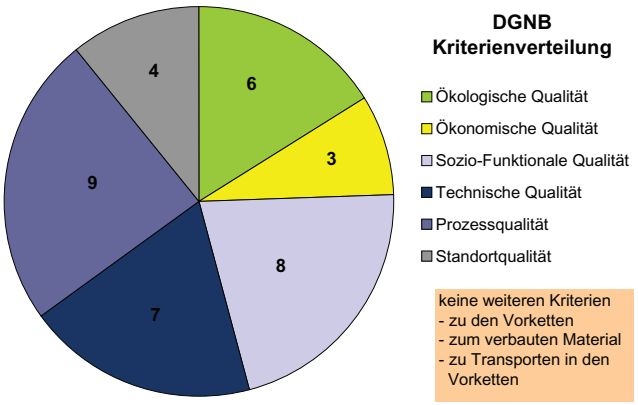

Abb. x: DGNB - Criteria distribution original.

(1) Ecological quality. Criteria: 6

- Life cycle assessment of the building
- Risks to the local environment
- Verantwortungsbew. resource extraction
- Drinking water requirement and waste water volume
- land use
- Biodiversity at the site

(2) Economic quality. Criteria: 3

- Building-related costs in the life cycle
- Flexibility and Reusability
- marketability

(3) Sociology. & functional quality. Criteria: 8

- Thermal comfort
- Indoor air quality
- Acoustic comfort

- Visual comfort
- Influence of the user
- Staying qualities inside and out
- safety
- Accessibility

(4) Technical quality. Criteria: 7

- soundproofing
- Quality of the building envelope
- Use and integration of building technology
- Cleaning friendliness of the building
- Dismantling and recycling friendliness
- Immissionsschutz
- mobility infrastructure

(5) process quality. Criteria: 9

- Quality of project preparation
- Fuse afterh. in tender and award
- Docs. for sustainable management
- Method z. städtebaul. u. gestalter. conception
- Construction site / construction process
- Quality assurance of the construction
- Orderly commissioning
- user communication
- FM-compliant planning

(6) Location quality. Criteria: 4

- micro location
- Radiance and influence on the neighborhood
- road access
- Proximity to use rel. Objects, facilities

Selected environmental aspects

„Life Cycle Assessment of the building". Indicators for the assessment are: LCA planning, LCA optimization, LCA comparative calculation, Agenda 2030 bonus (climate protection targets of the municipality), circular economy bonus, halogenated hydrocarbons in refrigerants.

„Risks to the environment". Indicators for evaluation are: Environmentally friendly materials.

„Responsible resource extraction". Indicators for evaluation are: Responsible raw materials, Secondary raw materials.

Annotation:

The climate and environmental label HOLZ VON HIER is rated in the DGNB new version in this area as proof Responsible production of raw materials or as proof of wood from sustainable forestry.

„Drinking water requirement and wastewater volume". Indicators for the evaluation are: drinking water demand and waste water, outdoor facilities, integration into the neighborhood infrastructure.

„Land use". Indicators for assessment are: land take, degree of sealing and / or compensatory measures.

„Biodiversity at the site". Indicators for assessment are: habitat quality, diversity of outdoor species, diversity of species directly adjacent to the building, invasive plant species, biotope networking, development / maintenance management, biodiversity strategy.

Certification ranking

- Bronze: > 50%
- Silver: > 65%
- Gold > 80% xxx

Selected material aspects

No other criteria in the sense of the upstream chains.

Transports in the prechains (LCph A2, A4)

Only about general LCA of the building, but without consideration of A4. Responsible rust extraction has introduced a subcriterion of regional raw material procurement since 2018.

Costs

The total certification costs comprise the (1) certification costs for the DGNB and (2) the auditor's fees. The DGNB costs are fixed costs and are based on the gross floor area, the usage profile and whether the client is a member of the DGNB network (separate regulations apply here). The fees for the auditor are negotiable.

Certification Costs Non-DGBN members:

- New buildings and redevelopment buildings: € 6,600 to € 73,500 depending on the floor area of the building
- Interior work: 3,000 € to 15,000 € depending on the floor space.
- plus fee fees auditor.
- „Training for the exclusively consulting DGNB consultant covers 100 lessons, costs 3000 € for DGNB and 5000 € for non-members. The training of auditors, on the other hand, takes twice as long and amounts to 6000 € for DGNB and 8000 € for non-members. A membership is 60 € per year for students and 120 € for individuals; Offices pay between 500 and 5,000 €". („Sustainability in Comparison" db 09 | 2009).
- „In addition to the certification fees depending on the size of the project (on average, costs for built-up buildings of between € 15,000 and € 40,000 are specified here) and the auditor's fee, the

builder usually has to expect higher construction costs. But owners, users and investors benefit in return from lower operating costs and higher rental income. „ (Article Dt Bauzeitung: „Sustainability in Comparison", db 09 | 2009).

Certified buildings

Details according to the website, January 2018.

- 910 certified buildings (since 2009).
- 27 of them in Austria
- of which 826 in Germany
- none of them in France, Italy, Slovenia
- without a registered building.

4.4) „Klimaaktiv"

www.klimaaktiv.at. Januay 2018. Information also from building rating systems Comparison (2016).

Sectors: 6

Sectors (in total 1000 points):

- (A) location and quality assurance (130 points)
- (B) Energy and Supply (500 points)
- (C) building materials, constructions (150 points)
- (D) Comfort and indoor air quality (175 points)

Criteria: 34 according to Klimaaktiv

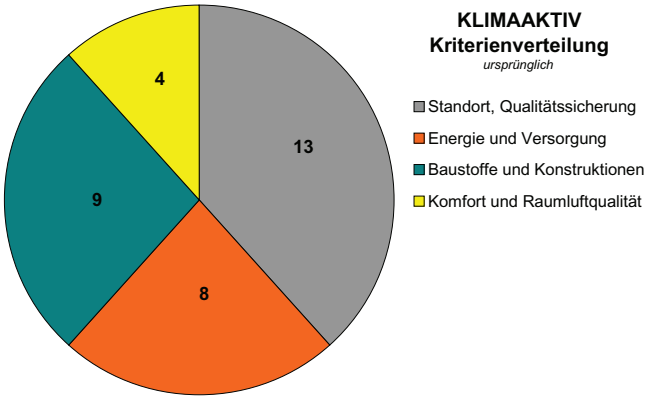

Abb. x: Klimaaktiv - Criteria distribution original.

(A) location and quality assurance. Criteria: 13

- Infrastructure and green mobility
- Infrastructure near the location
- Environmentally friendly mobility
- Bicycle traffic
- Transportation
- electromobility
- concepts
- Proof of quality for planning and execution
- economics
- Quality assurance energy requirement calculat.
- consumption forecast
- Building shell airtight
- Energy consumption monitoring

(B) energy and supply. Criteria: 8

- Heating requirement OIB
- Primary energy requirement OIB
- CO2 emissions OIB
- Energy Performance Factor
- Heating demand PHPP
- Primary energy requirement PHPP
- CO2 emissions PHPP
- Generation of PV power PHPP

(C) building materials and constructions. Criteria: 9

- building materials
- Exclusion of harmful substances
- Exclusion of special worries. substances
- Avoidance of PVC and oth. halogenorg. connect.
- Use of products with environmental labels
- Constructions and buildings
- Eco index of the entire building BG3
- Eco index of thermal building shell BG1
- Disposal indicator E1 / E10

(D) comfort and indoor air quality. Criteria: 4

- Thermal comfort
- Comfort ventilation with heat recovery
- Use of low-emission and low-emission products / in remediation including pollutant testing
- Measurement of indoor air quality

Criteria: 34 rearranged (comparability)

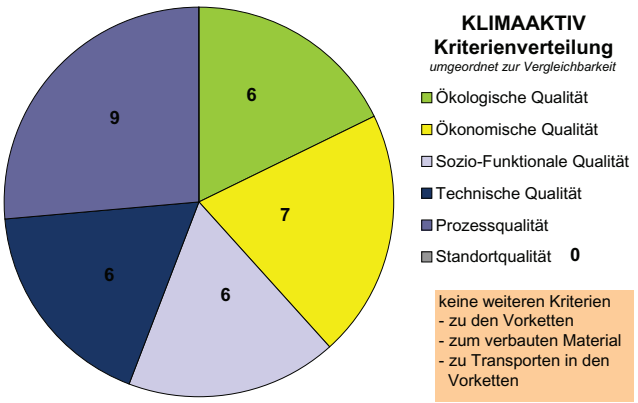

Abb. x: Klimaaktiv - Criteria re-sorted for comparability.

(1) Ecological quality: 6 criteria

- Exclusion of harmful substances
- Use of products with environmental labels
- Eco index of the entire building BG3
- Eco index of thermal building shell BG1
- CO_2 emissions OIB
- CO_2 emissions PHPP

(2) Economic quality: 7 criteria

- building materials
- Heating requirement OIB
- Primary energy requirement OIB
- Energy Performance Factor
- Heating demand PHPP
- Primary energy requirement PHPP
- Generation of PV power PHPP

(3) Sociology. & functional quality: 6 criteria.

- Thermal comfort
- Comfort ventilation with heat recovery
- Use of low-emission and low-emission products / in remediation including pollutant testing
- Measurement of indoor air quality
- Exclusion of special worries. substances
- Prevention of PVC and other organohalogen compounds

(4) Technical quality: 6 criteria

- Infrastructure and green mobility
- Infrastructure near the location
- Environmentally friendly mobility
- Bicycle traffic
- Transportation
- electromobility

(5) Process quality: 9 criteria

- Constructions and buildings
- concepts
- Proof of quality for planning and execution
- economics
- Quality assurance energy requirement calculat.
- consumption forecast
- Building shell airtight
- Energy consumption monitoring
- Disposal indicator E1 / E10

(6) Location quality: 0 criteria

- no

Certification ranking

- Bronze: Mindestkriterien
- Silver: > 750 Punkte
- Gold: > 900 Punkte

Selected material aspects

No other criteria in the sense of upstream chains of building materials.

Transports in the perchains (LCph A2, A4)

No criteria.

Costs

Basically, any planner can declare a building for free on the platform. According to the website, the entries are checked for plausibility by the team Klimaktiv and released after a successful check.

Certified Buildings

According to website:

- 573 objects in the klimaaktiv database
- of which 423 residential buildings
- including 150 service buildings.
- thereof 41 state prize buildings.

4.5) LEED/USGBC (USA)

www.usgbc.org

„The independent body of the Green Building Certification Institute (GBCI) awards ... a total of 100 points and 10 additional points (German Bauzeitung:" Sustainability in Comparison „db-Archiv - db 09 | 2009).

Sectors: 6

- (1) location and transportation
- (2) Sustainable sites
- (3) water efficiency
- (4) energy and atmosphere
- (5) material and resources
- (6) Indoor environmental quality
- continue with (for the authors) unclear evaluation innovations and planning process and regional characteristics

Criteria: 47 original

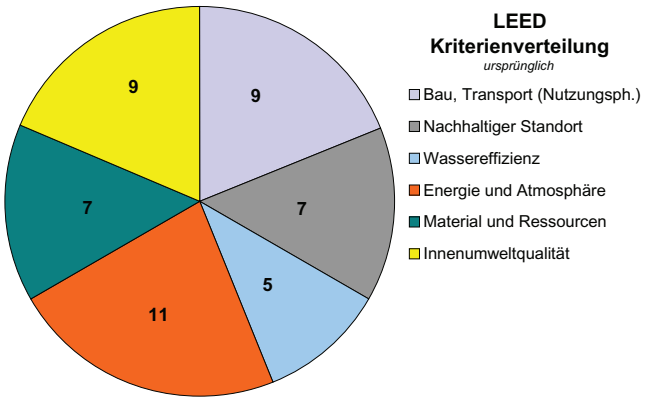

Abb. x: LEED - Criteria distribution original.

(1) Place and Transport (Nutzugsph.) Criteria: 9

- Integrative process
- LEED for the location of the neighborhood
- Protection of sensitive landscapes
- Place with high priority

- Surrounding building density and diverse uses.
- Access to high quality transit
- Bike facilities at the building
- Reduced footprint (space) for parking
- Green vehicles

(2) Sustainable location. Criteria: 7
- Construction activity Pollution prevention
- site evaluation
- Location development - protection or restoration of the habitat
- open space
- Rainwater Management
- Reduction of „heat islands“
- Reduction of light pollution

(3) water efficiency. Criteria: 5
- Reduction of water consumption in the open air
- Reduction of indoor water consumption
- Building water measurement
- Cooling tower use water
- water metering

(4) energy and atmosphere. Criteria: 10
- Commissioning and verification
- Minimal energy performance
- Building levels related energy measurement
- Refrigerant Management
- Advanced commissioning
- Optimized energy efficiency
- Advanced energy measurement
- Demand Response
- Renewable energy
- Green electricity and CO2 compensation

(5) Material resources. Criteria: 7
- Storage and collection of recyclables
- Construction planning, demolition planning
- Reduction of life cycle costs of buildings
- Disclosure / opti. EPD
- Disclosure / opti. Procurement of raw materials.
- Disclosure / opti. Material components
- Construction, demolition waste econom. docum.

(6) indoor environmental quality. Criteria: 9
- Indoor air quality standards
- Tobacco smoke control
- Strategies for improved indoor air quality
- Low-emission materials
- Construction / indoor air quality managem. plan
- Assessment of indoor air quality
- thermal comfort
- interior lighting and
- daylight

Criteria: 47 rearranged (comparability)

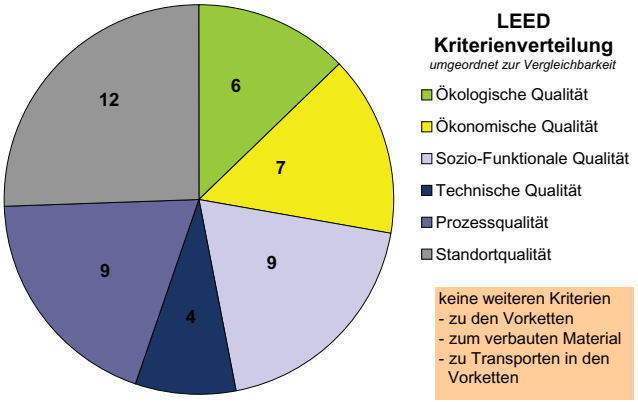

Abb. x: LEED - Criteria reorganized for comparability.

(1) Ecological quality. Criteria: 6
- Reduction of water consumption in the open air
- Reduction of indoor water consumption
- Optimized energy efficiency
- Renewable energy
- Green electricity and CO2 compensation
- Storage and collection of recyclables

(2) Economic quality. Criteria: 7
- Building water measurement
- Cooling tower use water
- water metering
- Minimal energy performance
- Building levels related energy measurement
- Refrigerant Management
- Reduction of life cycle costs of buildings

(3) Sociology. & functional quality. Criteria: 9
- Indoor air quality standards
- Tobacco smoke control
- Strategies for improved indoor air quality
- Low-emission materials
- Construction / indoor air quality managem. plan
- Assessment of indoor air quality
- thermal comfort
- interior lighting
- daylight

(4) Technical quality. Criteria: 4
- Access to high quality transit
- Bike facilities at the building
- Reduced footprint (space) for parking
- Green vehicles

(5) process quality. Criteria: 9
- Commissioning and verification
- Construction planning, demolition planning
- Construction, demolition waste economy documentation

- Disclosure / opti. EPD
- Disclosure / opti. Procurement of raw materials.
- Disclosure / opti. Material components
- Advanced commissioning
- Advanced energy measurement
- Demand Response

(6) Location quality. Criteria: 12

- Integrative process
- LEED for the location of the neighborhood
- Protection of sensitive landscapes
- Place with high priority
- Surrounding building density and diverse uses.
- Construction activity Pollution prevention
- site evaluation
- Location develop.. protection, restoration habitat
- open space
- Rainwater Management
- Reduction of „heat islands"
- Reduction of light pollution

Sectors

LEEDS is available for various sectors

- „Green Building for New Buildings „(Core & Shell, Schools, Retail, Healthcare).
- Interior design for commercial interiors, retail, commercial interiors.
- „Operation, maintenance" for existing buildings.
- Green „neighborhood development".
- Green Home for „private homes".

Certification ranking

- Basis certification (40-49 credits)
- Silber (50-59 credits)
- Gold (60-79 credits)
- Platin (> 80 credits)

Selected material aspects

- Materials and resources. includes 1 credit for using certified wood and 1-2 credits for using regional material (500 miles of the project side).
- No other criteria in the sense of upstream chains of building materials.

Transports perchains (LCph A2, A4)

No criteria.

Costs

Certification costs for buildings:

- Registration plus flat fee per building: $ 1,500- $ 5,000 to LEED organization.
- Certification Fee: $ 3,420 to $ 33,000 per building.
- Review: $ 10,000 for review per building.
- plus the negotiable Auditorenhonorar (certainly in 4/5-digit magnitude to set).
- „In addition to the ... certification fees ... and the ... Auditor's fee, the developer ... must expect higher construction costs." (Article Dt. Bauzeitung 2009: „Sustainability in Comparison" db-Archiv - db 09 | 2009, fees have risen since then).

Certified Buildings

According to the website (January 2018) there are 110,075 certifications in 165 countries worldwide

- 431 of them in Germany
- of which 91 in Italy
- of it unclear in Austria
- of it unclear in France
- of which unclear in Slovenia

4.6) CASBEE (Japan)

www.ibec.or.jp/CASBEE. (CASBEE = Comprehensive Assessment System for Building Environmental Efficiency).

On the one hand, CASBEE exists as a self-assessment by planners, which must be accompanied by building applications. On the other hand, it is also a certification system in which an independent third party on the basis of an assessment body checks buildings and issues certificates.

CASBEE subdivides 6 areas, which are grouped into the ecological quality of the building (Q) and the impact on the environment (LR).

Sectors: 6

- (Q1) Interior quality (e.g., sound / heat comfort, lighting, air quality). 40%
- (Q2) Service quality (e.g., service, adaptability, durability, reliability, flexibility). 30%
- (Q3) Outdoor quality (e.g., protection / creation of biotopes, urban-rural environment, local features and outdoor / recreational area). 30%
- (LR1) energy (e.g., thermal load, EE energy usage, efficiency in service / operation). 40%
- (LR2) resources and materials (water resources, reducing the use of nonrenewable resources, avoiding the use of pollutant materials). 30%
- (LR3) environment (e.g., consideration): 30%.

The evaluation matrix results from an environmental factor BEE (Q: LR). The higher the quotient, the better the evaluation result.

Criteria: 52 original

(1) LR1 - Energy: (9)

- heating load
- Use of renewable energies
- Systems for heating and air conditioning
- ventilation systems
- lighting
- Water heating
- transport systems
- Observation (efficient operation)
- Plant operation and control

(2) LR2 - resources and materials: (10)

- water saving
- Rainwater and gray water use
- Reduction of material requirements
- Reuse exist. building structures
- Use of reused materials (2)
- Lumber from sustainable. forestry
- Improvement of reusability
- Use of pollutant-free materials
- Avoidance of CFCs

(3) LR3 - Environment: (7)

- global warming potential
- air pollution
- Heat island effect
- Burden on the local infrastructure
- Noise, smells
- wind impairment
- light pollution

(4) Q1 - Indoor Quality: (13)

- noise
- soundproofing
- Schallabsortption
- Room temperature control
- Humidity control
- Type of room ventilation. Systems
- daylight
- antiglare
- lighting level
- Controllability of the lighting
- pollution sources
- Ventilation
- work schedule

(5) Q2 - quality of use: (9)

- Function & usage
- Comfort
- maintenance
- earthquake resistance
- maintenance cycles
- reliability
- spatial design option
- Floor, ceiling load rating
- Adaptability of the building

(6) Q3 - Outdoor space quality on the property: (4)

- Conservation and creation of biotopes
- Urban and landscape planning
- Attention to local characteristics
- Improvement of the thermal environment

certification levels

There are 5 certification levels related to the determined quotient:

- BEE> = 3 Excellent (*****)
- BEE = 1.5 - 3 Very good (****)
- BEE = 1 - 1.5 Good (***)
- BEE = 0.5 - 1 Pretty bad (**) (!)
- BEE <0.5 Bad (*)

Selected material aspects

The material is of great importance, but with a focus on the use or reuse of existing structures and materials. There are no other criteria in the sense of upstream chains of building materials. These are only - similar to DGNB - affected in the form of a building-based life cycle assessment on construction, use phase and reuse.

Transports in the prechains (LCph A2, A4)

No ciriteria.

Costs

As a mandatory self-assessment in the course of building applications CASBEE is free of charge.

If a certificate, created by an auditor, is requested, costs will be charged at the amount of:

- Registration: unknown
- Certification fee: € 5,400 to € 14,260 per building.

5) Further considered Building Rating Systems

Other globally relevant building rating systems include BCA Green Mark, E.E.W.H, Green Star, GRIHA, HK BEAM and others. These systems are characterized but not described in more detail, since they are not or not known to be used in the project area.

(1) BCA Green Mark (Singapur)

www.bca.gov.sg. (BCA = Building and Construction Authority)

The building system looks at a total of 5 sectors or categories, which are listed below with the percentage weightings:

- Smart and Healthy Building (21%)
- Climate adapted design (21%)
- Resource accountability. (21%)
- Building energy performance (21%)
- Other green characteristics, innovation (6%)

The 5 sections are divided into 15 basic requirements and 16 evaluation criteria. The evaluation can be done in three stages:

- Gold at 50 - 60 out of 100 points
- Gold Plus at 60 - 70 out of 100 points and
- Platinum at> 70 points.

(2) E.E.W.H. (Taiwan)

http://twgbqanda.com/english/

EEWH, as the building certification system of Taiwan, comprises 9 indicators from 4 categories: Ecology, Energy Saving, Waste Reduction and Health.

Sectors: 9

- (1) Biodiversity indicator.
- (2) Green indicator.
- (3) indicator soil water (infiltration, retention).
- (4) Energy Saving Indicator.
- (5) CO_2 emission reduction indicator.
- (6) Indicator for reduction of construction waste.
- (7) Water resource indicator.
- (8) Waste and wastewater improvements.
- (9) Interior quality indicator.

The system is very much geared to the specific conditions in the country. Therefore, it can not be compared to the European systems. The importance of the precursors and the material selection on the evaluation result is minimal

(3) Green Star (Australien, Neuseel.)

www.gbca.org.au (Australia)
www.nzgbc.org.nz (New Zealand)

Sectors: 9

- (1) Management (16 points).
- (2) Quality of the indoor environment (28 points).
- (3) Energy (31 points).
- (4) Transport (users in the use phase, not transportation of the material forequality) (11 points).
- (5) water (12 points).
- (6) Materials (27 points, 3 points are considered for the use of wood from sustainably managed forests).
- (7) Land use and ecology (8 points).
- (8) Emissions (13 points).
- (9) Innovation (5 points).

(4) GRIHA (India)

www.grihaindia.org.

Sectors: 4 (Criteria 31)

- (1) site selection, planning, construction. (e.g., preserving the landscape, soil protection, design, shaded hard surfaces, improving exterior lighting, efficient energy supply, minimum worker safety equipment, reducing air pollution in the building).
- (2) building design / construction. Environment, water, energy. (e.g. reduction of landscape water demand, water consumption in the building, efficient use of water during construction, optimization of building design, energy efficiency of the building within the specified comfort limits, use of fly ash in construction, structure and material (e.g. reduction of volume, weight, time of construction by high-performance technology, use of low-energy indoor materials, use of renewable energy, EE boosted hot water system, recycling, re-charging and reuse of water, wastewater treatment, water recycling, re-use.Waste management (e.g., reducing waste during construction, efficient waste separation, storage and disposal of waste, recovery of resources from waste. Health, wellbeing (e.g. use of low VOC paint, adhesives, sealants, minimization of ozone depleting substances, water quality assurance, indoor, outdoor noise reduction, tobacco, smoke control, minimum standards for people with disabilities)
- (3) Building operation and maintenance (e.g., energy audit, validation, building operation, maintenance).
- (4) Innovation (innovation points). The system is very much geared to the specific conditions in the country (climatic, water availability, etc.).

Therefore, it can not be compared to the European systems. However, the importance of the precursors and the material selection on the evaluation result is minimal.

The rating is based on stars. This means at maximum achievable 100 points:

- 25-40 points - 1 star
- 41-55 points - 2 stars
- 56-70 points - 3 stars
- 71-85 points - 4 stars
- > 86 points - 5 stars

(5) HK BEAM (Hong Kong)

www.beamsociety.org.hk

Sectors: 6

- (1) location / environment (25%).
- (2) material aspects (8%, just 1 point to show that (only) 50% of all wood / composite products used in the project come from sustainable sources or from recycled wood).
- (3) energy use / efficiency (35%).
- (4) Water use / efficiency (12%).
- (5) interior quality (20%).
- (6) Innovations and additional aspects (BEAM professional)

The evaluation is done via the ‚medals' scheme:

- Bronze: at 40% of the credits
- Silver: 55% of the credits
- Gold: 65% of the credits and
- Platinum: at> 75% of the credits.