AAR4817 Use and Operation of Zero Emission Buildings

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Building Environmental Assessments and Low Energy Architecture

A Comparative Analysis of three Methods:

The BRE Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED) and the German Sustainable Building Certificate (DGNB)

Summary

The main direction of the essay is building sustainability assessments. This Essay compares three different building assessment methods, BREEAM, LEED and DGNB in sustainability point of view and specifically focuses on energy performance criteria in LEED and BREEAM. This essay raise the following questions: Do building certification methods promote energy conscious architecture?

The essay consist of three parts; sustainable development, building assessment methods, Review of energy criteria and case study.

Keywords: Environmental Assessment, Sustainability, BREEAM, LEED, DGNB, Energy Saving Buildings, Green Buildings, Bio-climatic Architecture

Introduction

Due to the growing debates on sustainability and climate change green or sustainable building is on the rise. In all sectors efficiency in energy use and resources are crucial to deal with growing resources demand and increasing emissions and environmental impacts. (Dirlich, 2011) Building sector accounts 40% of total energy consumption and similar proportion of greenhouse gases emissions in the world. To reduce the environmental impact of buildings, new buildings need to use less energy in both their construction and operation than previous buildings of similar size and shape, while still providing a satisfactory indoor condition for their occupants. (Newshman, G.R.; Mancini, S.; Birt, B., 2009)

Many countries have developed green building certifications aimed at promoting more sustainable buildings. The assessment techniques vary in their overall intention, approach and field of application. (Münch, 2009) Three of them will be discussed in this essay; LEED, BREEAM and DGNB. In North America **LEED** (Leadership in Energy and Environmental Design), administered by the US Building Councils (USGBC) and in Europe **BREEM** by British Building Research Establishment (BRE) are international and well-known schemes. German Sustainable Building Certificate (**DGNB**) is second generation of building assessment methods and its criteria are based on European standards.

The focus of this essay is on energy use. In this study I compare three building assessment methods in sustainability point of view (BREEAM Europe commercial 2009, LEED 2009 for new construction, DGNB 2009 for office and administration buildings). Then bring up few critical questions on two certification systems (LEED and BREEAM) and energy saving approach in the buildings. The main questions which formed the initial concept of the essay are:

- How three building assessment methods comply with sustainability concerns? (Which one is more following sustainable development issues)
- Do assessment methods promote energy saving building?

The essay consists of three parts_ "*sustainable development", "building assessments methods"* and *"short review on energy criteria"*. First part describes theoretical background of this essay and focuses on sustainable development and environmental building assessments. Second part has look at three assessment methods and compare their overall intention and criteria together. Third chapter focuses on energy criteria in two assessment methods; LEED and BREEM, and brings a case study for LEED.

Methods and limits:

This essay is based on literature studies of relevant books and articles on three assessment methods (LEED, BREEAM, DGNB) and thematic comparison of their criteria. Then, in the next step, the research contents narrow down to analysis and evaluation the energy performance credits in BREEAM and LEED and at the end provide one case study for LEED certified building.

This study has faced several challenges. First was difficulty to get manual and guideline for DGNB. While BREEAM and LEED are easy to access, free and online, DGNB is very complex in this process. It is private building certification which the getting detail of criteria requires to buy software and full manual which was the not planned for this essay. Beside that the software is available only in German and English version is under way.

The second challenge was limitation in time and content of this course which limited analysis different case studies (certified and not certified buildings) for these assessment methods in larger scope. Although this essay benefits one case study of LEED certified building, providing more examples to refer would make this study more reliable and real.

PART 1: Sustainable Development

Sustainable development is a difficult notion to define; it is also continually evolving, which makes it more difficult to define. (Strange, T.; Bayley, A., 2008, p. 24) The concept of sustainable development emerged in 1987 in "our common future" report which also known as Brundtlandd Report. [1] In that report the term defines as:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

According to definition, sustainable development has three components: environment, society, and economy. Tracey Strange in her book "Sustainable development, Linking economy, society, environment" states that the interconnection of these three aspects considers sustainability and the center of this overlapping in human well-being. (Strange, T.; Bayley, A., 2008, p. 25)

This integrated view reflects a "triple bottom line" (TBL) approach to sustainability and at the same time brings three dimensions: the ecological, the economic and the social. This concept is often states that embracing and balancing all three issues of sustainability are critical and necessarily. In other words, there is no doubt that solutions which address only environmental, only social or only economic concerns are completely insufficient. (Robinson, 2004, p. 378)

In addition, the more overlap of these three quality fields the higher human well-being and quality.

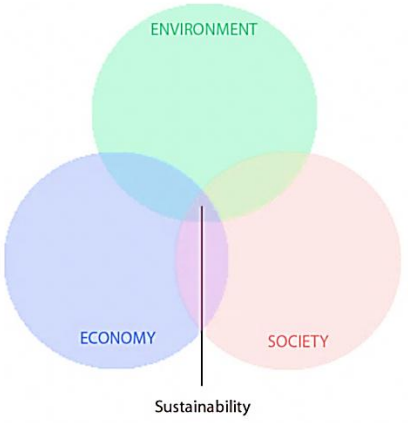

Figure 1. triple bottom line of sustainability

[1] Conference was organized by *World Commission on Environment and Development* (WCED)
See http://upload.wikimedia.org/wikisource/en/d/d7/Our-common-future.pdf for whole report.

Sustainable development in building construction

The building and construction industry has a significant role in supporting sustainable development. It consumes considerable amount of energy resources (about 40 percent of total energy consumption) and associated 30% of greenhouse gas emissions among all sectors in the whole world. (Fowle, K.M.; Rauch, E.M., 2006, p. 5)
In 1999, the International Council for Research and Innovation in Building and Construction (CIB) published the "Agenda 21" on Sustainable Construction (CIB, 1999), which has clarified the main concepts, aspects and challenges that sustainable development presents to civil construction.

To realize sustainable development in the construction industry, building environmental assessment methods have been considered as an effective tool. They are designed to promote environmental awareness among building professionals. (Braganca, R., & H., 2010) In other words, these assessment methods have emerged to evaluate building performance across a wide range of environmental considerations.

There are many assessment systems in different countries. The assessment techniques vary in their overall plan, approach and field of application. They are designed for different kinds of decision makers, developed for regional or national employments and some of them have international schemes and are used in other countries. (Münch, 2009) The European research project PETUS, Practical Evaluation Tools for Urban Sustainability, gives a comprehensive overview of more than 180 sustainability tools, including case studies. (Jensen, M.E.; Elle, M., 2007) Without doubt, it is hard to say one system is better than the others because they are all designed based on a national background, which is somehow limiting.

The output of assessment systems is a label by a third party certification. The third party, the responsible organization behind the label, presents a set of criteria and standards for a "sustainable building". The techniques make useful framework for the design team and also supports the decision making in the planning and constructing process. So, Sustainability techniques include sustainability tools and sustainability methods. (Münch, 2009)

This essay focuses in detail only on three assessment techniques: the BREEAM, the LEED and the DGNB.
In the following chapter three assessment systems will explain in detail in their scopes, categories and labeling system.

PART 2: Building Assessments Method

LEED

"Leadership in Energy and Environmental Design" (LEED) was developed by The U.S. Green Building Council (USGBC) in 1998. The aim of building assessment system was to develop a method to measure and compare "green buildings". Meanwhile the USGBC has over 20,000 members and more than 125,000 LEED Accredited Professionals (LEED AP). The assessment system has been published in 1998 as LEED Version 1.0, followed by Version 2.0 in 2000, Version 2.1 in 2002, Version 2.2 in 2005 and the actually valid Version 3.0 in 2009.

Scope of buildings

The LEED certification system has been adopted for many building types: LEED Core & Shell, LEED New Construction, LEED Schools, LEED Retail, LEED Healthcare, LEED Commercial Interiors, LEED Homes, LEED Existing Buildings and LEED Neighborhood Development. (What LEED Is, 2011)

Categorization

In this essay, all the information and materials are based on the LEED 2009 for new construction. In LEED 2009 there are 110 possible points. The points included: (LEED 2009 for New Construction and Major Renovations Rating System, 2008)

- SS- Sustainable Sites: (26 Possible Points) Construction activity pollution prevention, site selection, Development Density and Community Connectivity, Brownfield redevelopment, alternative transportation, site Development, Storm water Design, heat island Effect, Light pollution reduction
- WE- Water Efficiency: (10 Possible Points) Water Use Reduction, Water Efficient Landscaping, Innovative Wastewater Technologies, Water Use Reduction
- EA- Energy & Atmosphere: (35 Possible Points) Fundamental Commissioning of Building Energy Systems, Minimum Energy Performance, Fundamental Refrigerant Management, Optimize Energy Performance, On-site Renewable Energy, Enhanced commissioning , Enhanced Refrigerant Management , Measurement and Verification, Green Power
- MR- Materials & Resources: (14 Possible Points) Storage and Collection of Recyclables, Building Reuse, Construction Waste Management, Materials Reuse, Recycled Content

- EQ- Indoor Environmental Quality: (15 Possible Points) Regional Materials, Rapidly Renewable Materials, Certified Wood
- ID- Innovation & Design Process: (6 Possible Points) Innovation in Design, LEED Accredited Professional
- RP- Regional Priority: (4 Possible Points)

Project Totals: 110 Possible Points

Evaluation

Buildings can qualify for four levels of certification: Certified: 40–49 points, Silver 50–59 points, Gold 60–79 points, Platinum 80 points and above.

BREEAM:

BREEAM is the British Building Research Establishment (BRE) Environmental Assessment Method and was created in 1990. In that time it was the first commercially available environmental assessment tool for buildings. It has been used by many other rating systems as their development basis. (Rivera, 2009) BREEAM is a widely used method and has over 116,000 buildings certified and nearly 714,000 registered all around the world. (BREEAM Europe Commercial 2009 Assessor, 2008)
In this context the aims of BREEAM are: (BREEAM Europe Commercial 2009 Assessor, 2008, p. 9)

- To mitigate the impacts of buildings on the environment
- To enable buildings to be recognized according to their environmental benefits
- To provide a credible, environmental label for buildings
- To stimulate demand for sustainable buildings

Scope of buildings

BREEAM is used for a wide range of formats from country specific scheme, for example UK, Netherland, Spain, Sweden and Norway, to international schemes which designed for the certification of individual projects anywhere in the world.

Categorization

In this essay my study is based on BREEAM Europe Commercial 2009. BREEAM Europe Commercial covers BREEAM Europe offices, retail and industrial buildings. The manual consist of 10 categories and 59 criteria.

Each category has certain weighting for the overall rating and finally the performance of the whole building can be defined. These categories are: (BREEAM Europe Commercial 2009 Assessor, 2008)

- MAN- Management: (10 possible point) Commissioning, Construction site impacts, Building User Guide
- HEA- Health and Wellbeing: (14 possible point) Daylight, Occupant thermal comfort, Acoustics, Indoor air and water quality, Lighting
- ENE- Energy: (21 possible point) CO2 emissions, Low or zero carbon technologies, Energy sub metering, Energy efficient building
- TRA- Transport: (10 possible point) Public transport network connectivity, Pedestrian and Cyclist facilities, Access to amenities, Travel plans and information
- WAT- Water: (6 possible point) Water consumption, Leak detection, Water re-use and recycling
- MAT- Material: (12 possible point) Embodied life cycle impact of materials, Materials re-use, Responsible sourcing, Robustness
- WST- Waste: (7 possible point) Construction waste, Recycled aggregates Recycling facilities
- LE- Land Use and Ecology: (10 possible point) Site selection, Protection of ecological features, Mitigation/enhancement of ecological value
- POL- Pollution: (12 possible point) Refrigerant use and leakage, Flood risk, NOx emissions, Watercourse pollution, External light and noise pollution
- Innovation: (10 possible point) Exemplary performance levels, Use of BREEAM Accredited Professionals

Each section has its own weighting.

Evaluation

The rating benchmarks for the 2009 version of BREEAM Europe include:

Unclassified <30 %, Pass ≥30 %, Good ≥45 %, Very good ≥55 %, Excellent ≥70 %, Outstanding ≥85 %

DGNB:

The German Sustainable Building Council, DNGB, is a non-profit organization founded in 2007. Like other national building rating system organizations it is member of the World Green Building Council.
The DGNB considers itself to be the central German organization for exchange of knowledge, professional training and for raising public awareness for sustainable building. (DGNB, 2009)
The mission of the DNGB is the advancement of sustainable buildings and the development of the German Certificate for Sustainable Buildings.
The DNGB presents the GSBC as a label of the second generation. Its criteria include actual standards on ISO and CEN level, certification for construction products and EPD, based on ISO 14025. (DGN08)
The GSBC is remarkably much more based on quantitative measures and making use of the life-cycle approach, than other assessment methods under study. Certification process requires considerable effort to verify. Therefore opponents accuse this assessment method as being way too complex. Their argument is that this method can only be applied on highlight and high-budget projects where external expertise can be afforded. (Münch, 2009)

Scope of building

Today, the GSBC is only available for new construction of office and administration buildings. The system is still under development and other building types, like existing buildings, and an international version are under development. (DGN08)

Categorization:

An assessment relies on 63 criteria distributed into six categories and each category is weighted in the overall score of the building. (Ebert, T.; Hauser, G.; Ebig, N., 2011)

- Ecological Quality: 22,5 % (ecological impacts on global and local environment of the building's construction including its systems engineering, other risks and impacts on global and local environment, utilization of renewable resources, waste, water and land use)
- Economical Quality: 22,5 % (life cycle cost and monetary values)
- Socio-cultural and Functional quality: 22,5 % (health, comfort, user satisfaction, cultural backgrounds, functionality and assurance of design quality)
- Technical Quality: 22,5 % (fire and noise protection, quality of the building shell and ease of maintenance)

- Process Quality: 10 % (quality of planning and design, construction process, building use and maintenance and quality of the construction activities)
- Quality of the Location: rated independently (transport related topics, risks and image of location)

Fig2. Topics of DGNB

Evaluation

This scheme provides category weighting like the BREEAM but it is additionally based on a weighting for each criterion. Each criterion can receive a maximum of 10 points. At the same time it is possible to increase the weighting of each criterion. Buildings can be qualified in 3 categories:

50% bronze, 65% silver, 80% gold

Sustainable development and three assessments

The clear fact about building certification systems is that the aim of all them is promoting sustainability. As it discussed in previous chapter, it is difficult to say which one of these assessment is better and more comprehensive. The obvious point is that a good assessment should fulfill and comply with issues concern in sustainability. Figure below shows how 3 assessments, LEED, BREEAM, DGNB, deal with that.

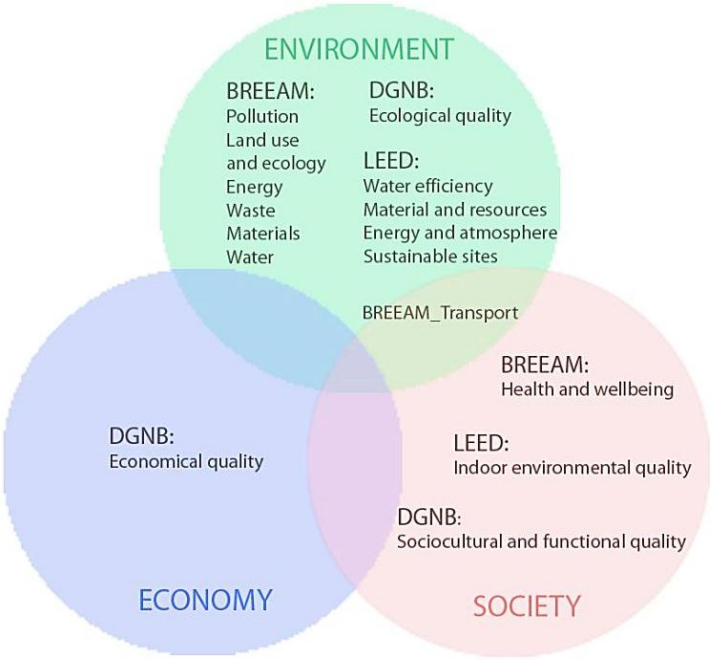

Fig 3. Sustainable development and three assessments (My own illustration)

The figure illustrates that most of the criteria and points in three assessments are related to environmental aspects. Environmental impacts to surrounding include pollution, land use, Energy, water, waste and material. Most of credits in bream and LEED go for environmental issues.

Building assessment methods in terms of society point of view concentrate on indoor environmental quality and health and well-being. In DGNB functional quality has been taken into account as a separate section in this chapter. As it can be seen DGNB is the only one which puts specific credits for economical quality.

PART 2: Comparison of systems

The categorization and criteria catalogue of the three assessment methods are radically different. Different sustainability topics are allocated under different categories with different weightings. This section compares thematic differences of the assessment methods.

The three methods under study have been introduced as systems that offer a label and third party certification. All three methods rely on criteria, but they are allocated in different ways. (Münch, 2009) In the BREEAM there are 59 criteria in nine sections or categories, in the DGNB, 49 criteria are allocated into six performance or quality categories and the LEED distributes 58 criteria requirements, presented into five chapters.

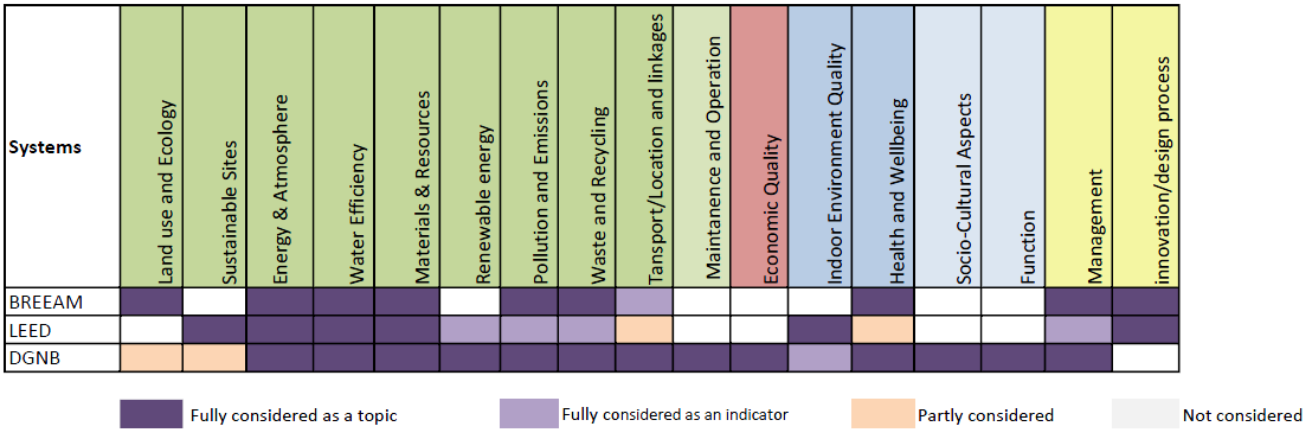

Fig4. Criteria in BREEAM, LEED and DGNB

This picture shows different topics and their importance in each scheme. Result of evaluation has been show by different colors and divided to high request, moderate request, low request and not request chapter. In this classification, environmental aspects include: Land use and ecology, sustainable sites, water efficiency, material and resources, renewable energy, pollution and emissions, waste and recycling and transportation. As it can be seen in the illustration, in DGNB, most of them except land use and ecology and sustainable sites, fully considered as a topic. In LEED renewable energy, pollution and emissions and waste are moderate request.

Economical quality in DGNB consists of “building life cycle cost” and “suitability for conversion” which both of them are fully considered as a topic and are high requested. *Building life cycle cost* is moderate

request in BREEAM while it is low request in LEED. In both assessments it measured as an indicator. (Münch, 2009)

In sociality point of view, beside indoor environmental quality and health and well-being, DGNB covers sociocultural and functional qualities which are not taken into account in BREEAM and LEED. While innovation and design process have certain credit in LEED and BREEAM, DGNB does not allocate points for that.

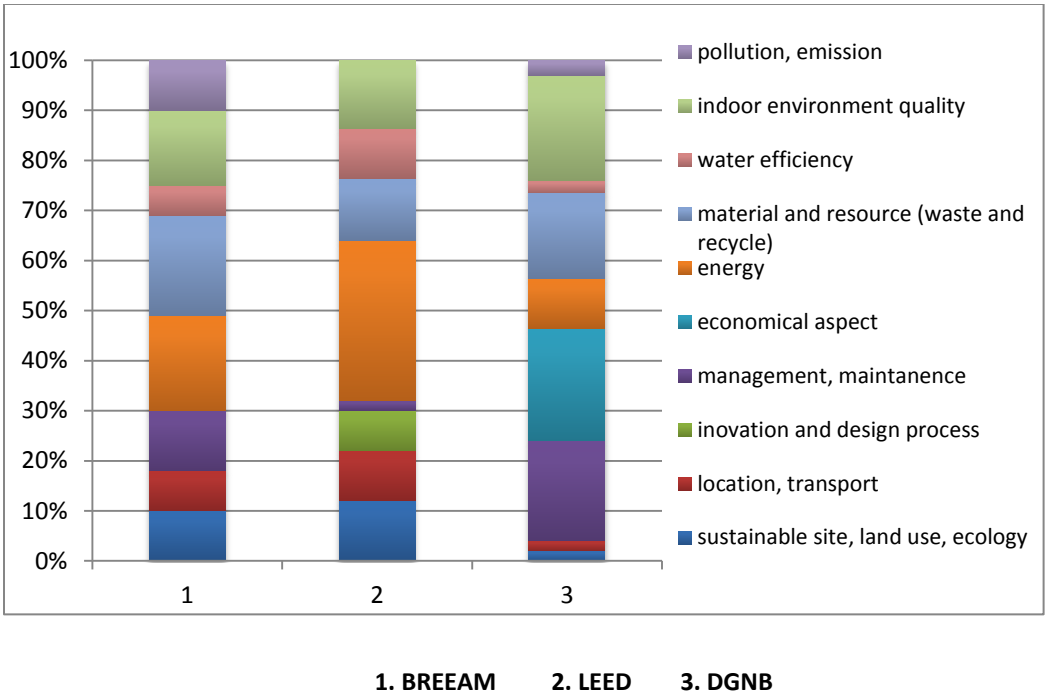

Fig 5. Thematic comparison of systems (my own illustration)

This illustration display thematic comparison of assessment methods. The main differences in systems are in energy section, management and economical aspects.

The importance of Energy section differs from 10% in DGNB, 32% in LEED and 19% in BREEAM. The management section shows a big difference in among certification systems. Meanwhile LEED gives only 2% of points to this section, DGNB gives 20 %. Economical aspect is other section which has different weighting among systems. (Liu, G.; Nolte, I.; Michel, S., 2010) While DGNB dedicates 22.5% of weighting to this section, BREEAM and LEED do not have priority for that. BREEAM has 2 points for Life cycle analysis under management section. (Man 12).

PART 3: Short Review of ENERGY Criteria

BREEAM

The energy assessment in BREEAM Europe Commercial 2009, is referred to Energy efficiency in buildings. Although it is voluntary standards, the energy performance assessment adopts the U.K building regulation as a benchmark to rate the level of performance improvement. (Roderick, Y.; McEwan D.; Wheatley C.; Alonso C, 2009)

It allows up to 15 credits to be achieved when the building demonstrates an improvement in the energy efficiency in building fabric and services. For each category, there are a minimum number of credits that must be achieved. To get excellent 6 points, and outstanding 10 points is requirement. (BREEAM Europe Commercial 2009 Assessor, 2008)

No. of credits available	Issue Title	Minimum Standards				
		P	G	VG	E	O
15	Ene 1 - Energy Efficiency	-	-	-	6	10
1	Ene 2 - Sub-metering of Substantial Energy Uses	-	-	-	1	1
1	Ene 3 - Sub-metering of High Energy Load and Tenancy Areas	-	-	-	-	-
1	Ene 4 - External Lighting	-	-	-	-	-
3	Ene 5 - Low or Zero Carbon Technologies	-	-	-	1	1
1	Ene 6 - Building fabric performance and avoidance of air infiltration	-	-	-	-	-
1	Ene 7 - Cold Storage	-	-	-	-	-
2	Ene 8 - Lifts	-	-	-	-	-
1	Ene 9 - Escalators and travelling walkways	-	-	-	-	-

Table 1. Ene 1 - Energy Efficiency (BREEAM manual)

There are three options demonstrate energy performance of building. (BREEAM Europe Commercial 2009 Assessor, 2008)

Option 1: **Determination of the energy performance of the building using the National Calculation Methodology** (maximum 15 credits)

Where there is a National Calculation Methodology in place in the country of assessment, the number of credits achieved is based on the percentage improvement in the assessed designs predicted Building Energy Performance Index (BEPI) over the Current Standards Building Energy Performance Index (CSBEPI)[2].

BREEAM Credits	New buildings	Refurbishments
1	1%	-50%
2	3%	-32%
3	5%	-20%
4	7%	-9%
5	11%	0%
6	15%	8%
7	19%	15%
8	25%	21%
9	31%	28%
10	37%	36%
11	45%	45%
12	55%	55%
13	70%	70%
14	85%	85%
15	100%	100%
Exemplar credit 1	*Carbon neutral building*	
Exemplar credit 2	*True zero carbon building*	

Table 2. Percentage improvement over the requirements of local Building Regulations (BREEAM manual)

As it can be seen it the table, minimum requirement for getting outstanding requires 10 points which is equal to 37% improvement in energy performance of building.

Option 2: **Determination of the energy performance of the building using a Dynamic Simulation Modeling tool** (maximum 15 credits)

Option 2 is available for design teams where there is no operational National Calculation Methodology in place or where the National Calculation Methodology does not require a dynamic simulation model but the design team wants to undertake a more in-depth analysis of the building as part of the design and for the purposes of assessing BREEAM.

A maximum of 15 credits will be available under this option and the rating scale is the same as option 1.

Option3: **Energy Design Features** (maximum 10 credits)

[2] Current Standards Building Energy Performance Index (CSBEPI) = 66 kWh/m2

Option 3 is available for design teams who cannot carry out an energy modeling of their building and where there is no operational National Calculation Methodology in place. However, because energy modeling is the only acceptable way to demonstrate that a building is a truly energy efficient building, a maximum of 10 credits will be available under option 3.

LEED

In energy criteria in LEED, there are 35 possible points and 3 Prerequisite requirements. These are:

1. Fundamental Commissioning of Building Energy Systems
2. Minimum Energy Performance
3. Fundamental Refrigerant Management

The document states that the minimum energy performance in Prerequisite 2 is 10% improvement in the proposed building performance rating for new buildings, or a 5% improvement in the proposed building performance rating for major renovations to existing buildings, compared with the baseline building performance rating.

Other credits have been shown in below table:

	Energy and Atmosphere	Possible points
Credit 1	Optimize Energy Performance	1-19
Credit 2	on-site Renewable Energy	1-7
Credit 3	Enhanced Commissioning	2
Credit 4	Enhanced Refrigerant Management	2
Credit 5	Measurement and Verification	3
Credit 6	Green Power	2

Table 3. Energy and Atmosphere credits (LEED,2008)

Table 3 shows the optional energy credits available under LEED for New Construction (LEED 2009 for New Construction and Major Renovations Rating System, 2008) also shows the total credits available.

In LEED assessment, there are three approaches to assess building energy performance.

Option 1. **Whole Building Energy Simulation** (1–19 points)

The first approach is whole Building Energy Simulation, which allows up to 19 points when the building demonstrates a percentage improvement in the proposed building performance rating compared with

the baseline building performance rating. The minimum energy savings percentage for each point is shown in below: (LEED 2009 for New Construction and Major Renovations Rating System, 2008)

New Buildings	Existing Building Renovations	Points
12%	8%	1
14%	10%	2
16%	12%	3
18%	14%	4
20%	16%	5
22%	18%	6
24%	20%	7
26%	22%	8
28%	24%	9
30%	26%	10
32%	28%	11
34%	30%	12
36%	32%	13
38%	34%	14
40%	36%	15
42%	38%	16
44%	40%	17
46%	42%	18
48%	44%	19

Table 4. minimum energy cost savings percentage and available points (LEED,2008)

Option 2. **Prescriptive Compliance Path: ASHRAE Advanced Energy Design Guide** (1 point)

The second is the *perspective compliance path* which allows the specific project to achieve 1 point when they meet ASHRAE[3] Advanced Energy Design Guide.

Option 3. **Prescriptive Compliance Path: Advanced Buildings™ Core Performance™ Guide** (1–3 points)

Another option is Prescriptive Compliance Path which allows specific projects to gain up to 3 points when they comply with Advanced Buildings™ Core Performance™ Guide developed by the New Buildings Institute.

Option 2 and 3 are not available to projects outside U.S.

In all approaches, the assessed building needs to meet minimum performance level, which is Energy and Atmosphere (EA) Prerequisite. This is equivalent to 10% improvement in building performance for new buildings compared with the baseline building performance rating.[4]

[3] American Society of Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE)

In addition, the document states that On-site Renewable Energy is nonpolluting and renewable energy sources including solar, wind, geothermal, low impact hydro, biomass and bio-gas strategies. Maximum possible credit for this chapter is 7 points, which can be gained by using 13% renewable energy. (LEED 2009 for New Construction and Major Renovations Rating System, 2008) It can be seen that passive solar energy is not considered as On-site Renewable Energy.

Case Study:

LBNL Molecular Foundry Laboratory_ LEED Gold certification

The Molecular Foundry, a nanotechnology research facility located at the U.S. Department of Energy's Lawrence Berkeley National Laboratory, designed by the Smith group of San Francisco, and completed in 2006. It is the first building in Berkeley which has received a LEED gold certification. (Krotz, 2007)

Fig 6. Berkeley Lab's Molecular Foundry- West and North elevation (Smith group)

Fig 7. East and South elevation

According to their report the Molecular Foundry consumes 28 percent less energy than California building efficiency standard, also consumes 35 percent less energy than the national energy standard, as prescribed by the ASHRAE standard 90.1. In addition, the facility produces 85% fewer greenhouse-gas emissions than a conventional facility. use of materials that have low VOC (volatile organic compound) content and low VOC emissions. (Krotz, 2007)

About 85 percent of all building construction waste was recycled. Almost all wood used was sustainably harvested as well as rapidly growing renewable materials, such as bamboo flooring. The building has a

[4] (the baseline building performance rating is according to the building performance rating method in ANSI/ASHRAE/IESNA Standard 90.1-2007)

compact volume and its six stories minimize the footprint and more than 50 percent of the site is landscaped with native plants. There exist good access to public transportation, and Berkeley Lab's biodiesel-powered shuttle system minimizes car travel around the 100-building campus. (Shaviv, 2008)

An electromagnetic water treatment system on the cooling towers reduces total water consumption and the amount of chemicals released to the atmosphere and the sewer. Wind tunnel modeling of the building was used to determine air exhaust and intake locations. Indoor air quality elements include carbon dioxide monitoring and control of outside air for ventila-tion. In the building use of materials that have low VOC (volatile organic compound) content and low VOC emissions. (Molecular Foundry) All these efforts made the Molecular Foundry one of only three Department of Energy Office of Science facilities which received LEED gold certification.

Energy performance of building has been improved by Sun-Shades, high-performance thermal products, (such as double gazed or triple glazed windows), light shelf and operable windows. Other strategies they used in the building is optimized electrical and HVAC (space heating and cooling) systems, an energy-efficient chiller and boiler plant, and new arrangement of energy-intensive areas such as labs, a cleanroom, and a computer server room. (Smith Group/JJR)

Deeply study on what exactly has been done in order to achieve energy efficiency in the building, one can find that it has to do mainly with the right sizing of the mechanical and electrical systems in the labs, which were originally designed for 25 W/ft2 and was reduced to 15 W/ft2. The electrical system was reduced by 38%, by using efficient T- 5 bulbs in lighting systems with bi level switching and occupancy-based controls. The HVAC system was reduced by about 50%, by limiting the number of air handlers, downsizing the boilers and chillers and by using an energy efficient elevator. Therefore, 35% less energy consumption than the national energy standard. (Shaviv, 2008)

Actually not much effort has been accomplished for passive and bio-climatic architecture. There are no special elements to achieve passive cooling or heating. There are no sunshades to protect the large West facing windows and hardly any shading to protect the Eastern and Southern windows. (Shaviv, 2008)

Now this question rise up that "Do green building certifications enhance bioclimatic and energy conscious architecture?"

Discussion

The research process and the findings can be discussed in two parts; First, in terms of comparing systems and second one in evaluating energy section in assessment methods and energy saving architecture approach.

The review of three green building assessments (BREEAM, LEED, DGNB) and analysis of thematic rules and criteria demonstrate that the general structure of the systems is relatively similar, and main topics considered for the assessment are nearly the same. Among all three assessments, the German system (DGNB) provides some particular characteristic which can not be found in other systems, such as economical quality and functional aspect which are high required criteria. **It can be said that that DGNB is more comply with three sustainable concern; environment, economy and society.**

The importance of energy section differs in assessment methods. Among three assessment methods, the lowest amount can be found in DGNB. It's only 10% of all possible points. The possible declaration can be the German energy saving regulation which has to be fulfilled by any new construction apart from any certification. BREEAM gives 19% of total point to energy while this proportion in LEED is 32%.

In chapter 3 Energy criteria in LEED and BREEAM discussed. This part explained how different assessment calculates energy performance of the building and how a building can get possible credits. Shaviv (2008) states that LEED is simple 'point hunting' approach. In LEED 2009, although about 32% of possible points are given as a requirement to energy efficiency one can get LEED silver without any saving energy, except what is demanded by the prerequisite. Only when the goal is to gain LEED gold or platinum, improvement the energy performance of the building gets necessary.

Making reference to published work at National research council Canada (Newshman, G.R.; Mancini, S.; Birt, B., 2009) appears that from 100 LEED certified commercial and institutional buildings in US, on average, LEED buildings used 18-39% less energy per floor area than their conventional counterparts. However, 28-35% of LEED buildings used more energy than their conventional counterparts.

Similar approach exists in BREEAM. Energy efficiency in building is required rule when the aim of certification was excellent or outstanding. Minimum requirement for getting outstanding requires 10 points which is equal to 37% improvement in energy performance of building.
Another debate on the energy regulation in assessment methods is that, not in BREEAM, nor in LEED, passive solar energy is not considered as on-site renewable energy. Therefore in these assessments

there is no encouragement to passive solar design. Analysis the case study on Molecular Foundry Laboratory in Berkeley which has received LEED gold certification appears that only improving mechanical system make it possible to have high grade certified building.

Although there is this expectation that passive and low energy architecture be essential part of Green Architecture movement, examining carefully the criteria of certifications and mentioned buildings, do not confirm that completely. Actually, certified building does not ensure that they are well in energy performance point of view and passive solar architecture.

According to the LEED, and also BREEAM, energy efficiency in building can be achieved only by improving mechanical, electrical and hot water system. So, there is no encouragement for bio-climatic and passive design.

Now, this this question raise again: *"Do assessment methods promote energy saving building"*

At a societal level, green buildings can cause considerable energy savings and promote sustainability and environmental concerns, but further work needs to be done to define green building rating schemes to ensure more success at bioclimatic architecture.

What can be done in this matter is, treating passive solar design as any other renewable energy feature. In fact dedicating specific credits for that could be one of the solutions and promote good passive architecture designs.

Conclusion

This essay provides a view to environmental assessment methods and specifically energy criteria. It also discusses relation between bio-climatic passive design and energy credits in two green building assessments (LEED and BREEAM). For criticizing certification methods more documents and case studies are required.

This essay demonstrates that environmental assessment methods promote sustainability and in following low energy architecture, while more attempts in this regard is required.

This essay can be used as a starting point for further research in detail on green building certifications and enhancing their performance in society.

Further work for this matter would be formed around this question:

How passive architectural design can be assigned in green certification rating?

Beside that providing more case studies_ successful and not successful designs_ and analyzing their energy performance would very useful make the research more valid.

References:

(2008). *BREEAM Europe Commercial 2009 Assessor.* BRE Global Ltd.

(2008, November). *LEED 2009 for New Construction and Major Renovations Rating System.* USGBC.

What LEED Is. (2011, 11 20). *U.S. Green Building Council*. U.S. Retrieved from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1988

Braganca, L., R., M., & H., K. (2010, 2). Building Sustainability Assessments. *Sustainability*.

Chew, M.; Das, S. (2008). Building Grading Systems: A review of the State- of- the- Art. *Architectural Science Review, 51*.

CIB. (1999). *Agenda 21 for sustainable constructure.*

Dirlich, S. (2011). A Comparison of Assessment and Certification Schemes for Sustainable Building and Suggestions for an International Standard System. *IMRE*, 1.

Ebert, T.; Hauser, G.; Ebig, N. (2011). *GREEN BUILDING CERTIFICATION SYSTEMS.* Munich, Germany: Detail Green Book.

Fowle, K.M.; Rauch, E.M. (2006). *Sustainable Building Rating Systems.* U.S. Department of Energy by Battelle. Pacific Northwest National Laboratory.

Jensen, M.E.; Elle, M. (2007). Tools for Urban Sustainability.

Krotz, D. (2007, October 5). *Molecular Foundry Receives LEED Gold Certification*. Retrieved 11 25, 2011, from Research News: http://www.lbl.gov/Science-Articles/Archive/MSD-Foundry-rating.html

Liu, G.; Nolte, I.; Michel, S. (2010). longlife comparison of worldwide certification system for sustainable buildings. *SET2010- 9th international conferece on Sustaiable Energy Technologies.* Shanghai, China.

Molecular Foundry. (n.d.). Retrieved from Smith group, JJR.

Münch, J. (2009). *Sustainability Assessment of Buildings.* Master-Thesis, Technical University of Denmark.

Newshman, G.R.; Mancini, S.; Birt, B. (2009, August). *Do LEED- certified buildig save energy? yes, but...*

Reed, R.; Bilos, A.; Wilkinson, S.; Schulte K. (2009). International Comparison of Sustainable Rating Tools. *JOSRE, 1*.

Rivera, A. (2009). International Application of Building Certification Methods: A Comparison of BREEAM and LEED. *PLEA2009- 26th Conference on Passive and Low Energy Architecture.* Quebec, Canada.

Robinson, J. (2004). *Sustainable Development.*

Roderick, Y.; McEwan D.; Wheatley C.; Alonso C. (2009). Comparison of energy performance assessmnet between LEED, BREEAM and GREEN STAR. *Building Simulation 2009- Eleventh International IBPSA Conference*, (pp. 1167-1176). Glasgow, Scotland.

Shaviv, E. (2008). Passive and Low Energy Architecture (PLEA) VS Green Architecture (LEED). *PLEA 2008-25th Conference on Passive and Low energy Architecture.* Dublin.

Smith Group/JJR. (n.d.). Retrieved 12 2011, 10, from Molecular foundry: http://www.smithgroup.com/index.aspx?id=392&section=34

Strange, T.; Bayley, A. (2008). *Sustainable development; Linking economy, society, environment.* OECD.

WEB SOURCES:

(n.d.). (D. brochure, Producer, & DGNB) Retrieved 11 2011, 08, from http://issuu.com/manufaktur/docs/dgnb_excellence_defined_sustainable_building_with_?mode=embed&layout=http%3A%2F%2Fskin.issuu.com%2Fv%2Flighticons%2Flayout.xml&showFlipBtn=true&proShowMenu=true

DGNB. (2009). *DGNB Borouchor. http://www.dgnb.de/_en/index.php*

APPENDIX:

LEED	possible points	%	minimum reqiurement
Sustainable Sites	26	23.63636364	
Water Efficiency	10	9.090909091	
Energy & Atmosphere	35	31.81818182	
Materials & Resources	14	12.72727273	
Indoor Environmental Quality	15	13.63636364	
Innovation & Design Process	6	5.454545455	
regional priority	4	3.636363636	
TOTAL	110	100	

BREEAM	credit available	Wighting %	%
management	10	12	10.90909091
health and well-being	14	15	13.63636364
Energy	21	19	17.27272727
Transport	10	8	7.272727273
water	6	6	5.454545455
materials	12	12.5	11.36363636
waste	7	7.5	6.818181818
land use and ecology	10	10	9.090909091
pollution	12	10	9.090909091
innovation	10	10	9.090909091
TOTAL	112	110	

DGNB	credit available	%
Ecological quality		22.5
Economic quality		22.5
Sociocultural and functional quality		22.5
Technical quality		22.5
Process quality		10
Total		100

Quality of buildings			
	BREEAM	LEED	DGNB
sustainable site, land use, ecology	10	12	2
location, transport	8	10	2
inovation and design process	0	8	0
management, maintanence	12	2	20
economical aspect	0	0	22.5
energy	19	32	10
material and resource (waste and recycle)	20	12.4	17
water efficiency	6	10	2.5
indoor environment quality	15	13.6	21
pollution, emission	10	0	3
total	100	100	100