The International Journal Of Engineering And Science (IJES)
||Volume||2 ||Issue|| 7 ||Pages|| 31-38||2013||
ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805

A Comprehensive Comparison between LEED and BCA Green Mark as Green Building Assessment Tools

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----------***ABSTRACT***----------
Remarkable growth in the advanced construction techniques has intensified significantly the needs for having sustainable buildings. Many countries have taken notable steps in this area. These steps have led to introducing sustainable assessment tools. Leadership in Energy and Environmental Design (LEED) is a program launched by the U.S. Green Building Council for certifying, designing and constructing sustainable buildings. Other countries around the world have also applied sustainable programs to measure their revenue in terms of sustainability. In the Asian region, BCA Green Mark has been developed by Singapore as one of the initiatives in the issues pertaining to green buildings. This paper will examine and compare two international tools: LEED of United States of America and Green Mark of Singapore to specify the scope of the work for each of these standard programs. The findings show that there are some differences in the classified criteria due to functional specifications. It was observed that the LEED green scheme had a wider sustainable scope than BCA green index through all areas of green concepts in new construction projects. These sustainable scopes have been described in detail by relevant tables.

KEYWORDS: *Assessment tools, Criteria, Green building, and Sustainability.*

Date of Submission: Date, 13 July.2013 ⟺ Date of Publication: Date 20 July.2013

I. INTRODUCTION

Undoubtedly, the building industry is known as a high resource consumption user of raw material, energy and usage of land [1]. Excessive use of resources such as water, materials, energy and fossil fuels on a global scale has obliged countries to consider the implementation of sustainable assessment tools. In addition, designing and construction energy efficient building not only aims to reduce carbon dioxide (CO2) and other GHG emissions but also involves cost effective measures for end users [2], [3]. One of the most common negative impacts of CO2 is the participation in the production of Greenhouse Gas that is contributing to global warming. These gases absorb the sun's energy re-radiated by the earth's surface and reflect this heat back to the earth. In fact, this function likes an insulator, transmitting and holding sunlight energy in the form of heat. This process is called "Green House Gas emission".

In this regard, many countries have provided appropriate strategies to prevent the situation from getting worse. The first steps were taken in 1990 by BREEAM in England and continued by LEED in 1996 [4]. LEED is a third party certification and approved as a benchmark in the world. This program provides a clear direction for various phases in a project including design, construction and operation of buildings. LEED is considered as a tool for all types and sizes of building to verify that it meets exactly all requirements of a high performance green building. After that different countries started to introduce their solutions in the context of environmental sustainability. Among the countries that have carried out unwavering efforts we can point to:

Australia (GBAS), Brazil (AQUA/LEED Brasil), Canada (Green Globes), New Zealand (Green Star NZ), Finland (PromisE), France (HQE), Germany (DGNB), United states (LEED), Switzerland (Minergie), Singapore (Green Mark), Netherland (BREEAM Netherland), England (BREEAM), Malaysia (GBI), Japan (CASBEE), Jordan (EDAMA). The policies may be either compulsory or voluntary or a mix of both for building sectors in these countries. Each of these programs ultimately lead to a certification which requires precise fulfillment of all terms and processes stipulated in the program's documents. This study focuses on the LEED (US) and Green Mark (Singapore) to provide a comparison between them and a better understanding of assessment criteria and the scope of these two guidelines.

II. LITERATURE REVIEW

The concept of green building refers to a structure that tries to consume zero energy and has a minimum negative impact on the environment. Jerry [5], in "The Green Building Revolution," defines a green building as, "a high-performance property that considers and reduces its impact on the environment and human health." The Massachusetts Technology Collaborative describes a green building as "a building that has been constructed or renovated to incorporate design techniques, technologies, and materials that minimize its overall environmental impacts." Increasing concern on environmental issues and the shocking statistics of the amount of available resources have led to a movement that has come to be known as "Green Building". In the early 1990, sustainable construction was considered as a great interest and formally incorporated in the construction industry.

A few years later the Agenda 21 was published in 1999 by the International Council for Research and Innovation in Building and Construction [6], which has highlighted the main challenges that sustainable development presents to the construction industry. It can be stated that this Agenda had an important role in the creation of green assessment tools in building industry. Cole et al. [7] expresses green building assessment programs as tools for measuring building performance with respect to environmental considerations. Richard Hill [8] conducted research to answer the question whether building assessment tools originated from developed countries could satisfy the different environmental focus and socio-economic needs of South Africa.

Assessment tools in the past were primarily used to measure specific concepts of green methodology. The focus area was selected to address key aspects of inefficiencies in buildings. Most tools focused on three main areas: energy, material and water use in the building. In recent years, the authors applied new sustainable practices such as: day lighting analysis, native plants, material reuse, recycle and densification. In fact, although green building subjects recognized over 15 years ago but they were basically accomplished by academics to study building behavior. The two main tools as initiatives in this field are the UK BREEAM model and the green building challenge process (GBTool). It is notable that many today's assessment systems has been designed on the basis of BREEAM and GB Tool. There are various assessment systems in different countries around the world and is difficult to say that which one is the best due to the fact that they are all designed based on a national classification. LEED program like similar tools were created to promote integration, increase awareness, Stimulate green competition, save the environment and institutionalize green buildings.

Recently, there have been many studies to understand the key role aspects of construction methods in the LEED certification process. O'Toole [9] conducted a research in the form of case study. He focused on the LEED certification process of an office renovation project in which general contractor was monitored during getting the LEED certification. In another study Eichholtz, [10] found 3% rental and 19% sales price premium for ES rated office buildings albeit no statistically significant rental-price premium for LEED rated office buildings. Other studies that replicate similar results are Eichholtz, Kok, and Quigley [11], Fuerst and McAllister [12] and Reichardt, Fuerst, Rottke, and Zietz [13]. Dozens of research studies have been conducted which link various green building and LEED attributes to improvements in occupant performance and productivity as well as reductions in absenteeism [14, 15, 16, and 18].In Singapore, the Green Mark Program launched by Building and Construction Authority (BCA) in January 2005 to develop sustainability issues in the construction industry and promote environmental awareness among contractors, designers and builders to eventually deliver healthier buildings to end-users. In fact, Singapore is the first Asian country that has embraced and conducted eco-building assessment system. Singapore is a cosmopolitan country with good financial standing placed in Southeast Asia. This country was considered by many investors and is known as one of the most significant economic centers. Therefore, any movement to the impact of eco-labeling on property value may have a cosmopolitan flavor that appeals to a wide audience.

It is necessary to bear in mind that the green movement in Asian perception may differ from the western Perception. While the Asian lauds the ideals of the green revolution, there is a lingering fear that a full commitment to the green revolution may scuttle the Asian economic revolution, which has firmly put Asia on the geopolitical landscape of the world [18]. Economics takes precedence over sustainability ideals. As noted by Addae-Dapaah, [19], location and accessibility are the primary consideration of Singaporeans in the choice of commercial buildings; green features are of secondary importance.

III. DETAILED DESCRIPTION OF EACH ASSESSMENT TOOL

In this section the features and details of each scheme will be reviewed and then different categories and classifications of each technique will be discussed to obtain the desired results.

3-1. GM rating system

The GM assessment program was developed by the Building and Construction Authority (BCA) of Singapore in January 2005 to promote sustainability in the construction industry and raise environmental awareness among stakeholders of a project. Several incentive programs have been allocated to developers or projects that meet the requirements of GM certification such as monetary and additional floors in each project. According to amendment Act 2008, all buildings with a gross floor area higher than 2000 m^2 must meet the GM gold rating. The scoring method is as follows:

- Green Mark Certificate (GMC-50 to75<)
- Green Mark Gold (GMG-75 to 85<)
- Green Mark Gold Plus (GMGP-84 to 90<)
- Green Mark Platinum (GMP-90 and above)

Buildings are awarded a maximum of 140 points for residential and 190 points for non-residential buildings based on a range of criteria defined for incorporating environment-friendly features. The BCA Program evaluates both residential and non-residential buildings (new or existing) to measure their performance in terms of sustainability and identify the impact of building on the environment. The building will be assessed based on the following five criteria:

1. Energy Efficiency
2. Water Efficiency
3. Environmental Protection
4. Indoor Environmental quality
5. Other green features

Certified Green Mark buildings are required to be re-assessed every three years to maintain the Green Mark status. New buildings certified will subsequently be re-assessed under the existing buildings criteria. Existing buildings will be re-assessed under the existing building criteria. Before beginning the assessment process, developers and government agencies would have to submit an application form to BCA. After that BCA team provides a meeting with the project team to specify the criteria and request for documentary proofs to substantiate the submissions. Actual assessment includes design and documentary reviews as well as site verification. Documentary evidences should be submitted at the end of the assessment. When assessment is fully completed a letter of award (Certification) will be sent to the team.

3-2. LEED Green Scheme

The LEED approach provides a comprehensive program for designing sustainable plans and implementing green constructions to award green certification for buildings that have implemented these guidelines properly. LEED covers a wide range of criteria in the construction field. The following major categories are presented by the LEED scheme:

1. Water Efficiency
2. Energy and Atmosphere
3. Materials and Resources
4. Innovation and Design Process

5. Indoor Environmental Quality
6. Sustainable sites

This standard is applicable for different types of projects such as: new construction, major renovations, tenant build-out, operations and maintenance. However, the rating system for new construction is the most popular grading guidelines in LEED certification. According to the last revision of LEED guideline the possible points for new construction are 69 which shall be obtained through evaluation of building performance in the six major fields listed above. The LEED possible rating for new construction is as follows:

- Water Efficiency (5 possible points)
- Energy and Atmosphere (17 possible points)
- Materials and Resources (13 possible points)
- Innovation and Design Process (5 possible points)
- Indoor Environmental Quality (15 possible points)
- Sustainable sites (14 possible points)

At first, to commence the process of certification review, the required documents shall be submitted to the relevant regional Green Building Council. Thereafter, six or eight credits will be selected to perform the audit. The council then asks for submission of a report with special information on the selected credits. The final decision will be made by the council to award the LEED certification. Depending on the number of points achieved, four rating levels of LEED certification can be awarded to a project: certified (26-32 points), silver (33-38 points), gold (39-51 points) and platinum (52-69 points). Existing buildings are ranked completely different according to the following ranges:

- Certified (34-42 points)
- Silver (43-50 points)
- Gold (51-67 points)
- Platinum (68-92 points)

To achieve sustainability concepts, efficient teamwork among stakeholders is crucial. The other words, implementing integrated efforts from design stage to the construction and operation phase shall be taken into consideration. In the following, these two blueprints will be evaluated on the credits discussed above.

IV. COMPARISON OF GREEN INDEXES IN VARIOUS ASSESSMENT CRITERIA

In this part, these two general sustainable plans are investigated based on the main assessment criteria.

4-1. WATER EFFICIENCY

LEED SCHEME: This criterion covers different areas of sustainability in new construction and existing building such as indoor water use reduction, landscaping water use reduction and wastewater strategies. LEED focuses on the three main sustainable factors in new construction:

- The main purpose is to raise the water efficiency within buildings to decrease the burden on wastewater systems. (USGBC, 2005)
- To eliminate the use of potable water near the project site for landscape irrigation. (USGBC, 2005)
- To decrease the generation of wastewater while raising the local aquifer recharge.

The scheme for existing building involves (USGBS, 2008):

- Minimizing indoor plumbing fixture as prerequisite.
- Measuring of water performance.
- Additional indoor plumbing fixture and fitting efficiency.
- Water efficient landscaping.
- Cooling tower water management.

GREEN MARK SCHEME: this plan ponders further on the following cases (BCA Green Mark Version ERB/1.0):

- Provision and monthly monitoring of main water meter readings for the whole development.
- Display of posters on water conservation.
- Water Efficiency Improvement Plans.
- Use of water efficient cleaning equipment.

Table 1: Water Efficiency Comparison

GREEN POLICIES	LEED	GREEN MARK
Water Conservation	√	√
Cooling Tower Water Management	√	√
Monitoring Regularly and Leak Detection		√
Water Efficient Landscaping	√	√
Innovation for Reducing Water Use	√	
Application of Water Efficient Fittings	√	√
Leading in applying Advanced Wastewater Technologies	√	
Minimizing indoor plumbing	√	

4-2. ENERGY EFFICIENCY

LEED SCHEME: there are three main prerequisites. The first one is to make sure that energy-efficient systems are installed, calibrated and customer's desired results are provided by producing following items [20]:

- Reduced energy use
- Lower operating costs
- Fewer contractor callbacks
- Better building documentations
- Improved occupant productivity

To meet these requirements, the following energy-related systems shall be taken into consideration [20]:

- Heating, Ventilating, air conditioning and refrigeration (HVAC & R) systems with associated controls.
- Lighting and day lighting controls.
- Domestic hot water system.
- Renewable energy systems such as wind, solar.

The second intent is to register the minimum level of energy consumption to reduce environmental and economic impacts resulted from excessive energy use. The third one is refrigerant management to reduce stratospheric ozone depletion [20].LEED scheme has provided six additional credits to enhance levels of energy performance in new construction. These credits include:

1) Optimize energy performance
2) On-site renewable energy
3) Enhanced commissioning
4) Enhanced refrigerant management
5) Measurement and verification
6) Green power

GREEN MARK SCHEME: in comparing to LEED, BCA provides less detailed plans in terms of energy efficiency for new construction. The major policies include the following actions:

1) Monthly monitoring of main electrical meter readings.
2) Thermal Performance of Building Envelope – ETTV.
3) Building Envelope – Design/Thermal Parameter.
4) Air-conditioning System.
5) Lighting density.
6) Lifts with energy efficient features (variable voltage and variable frequency motor drive).
7) Energy management.
8) Natural ventilation for parks and common areas.
9) Renewable energy efficient features.
10) Artificial Lighting

Table 2: Energy Efficiency Comparison

GREEN POLICIES	LEED	GREEN MARK
Monitoring And Measuring Performance	√	√
Providing Renewable Energy	√	√
Enhanced Commissioning	√	
Refrigerant Management	√	√
Reduced Energy Use	√	√
Emissions Reduction Reporting	√	
Energy Efficient Lighting Systems	√	√
Electrical Sub-Metering		√
Artificial Lighting		√

4-3. Material and Resources

LEED SCHEME: two prerequisites and nine additional credits are considered in this part. Sustainable purchasing policy and solid waste management policy as prerequisites are followed by more sustainable factors. The main objective is to purchase durable goods and materials to reduce the environmental impacts of materials acquired for use in the operations, maintenance of buildings. Reducing the amount of toxic waste

that is disposed of in landfills is another goal in this context. The following credits are provided to collect points in new constructions:

- Construction Waste Management.
- Materials Reuse
- Recycled Content
- Regional Materials
- Rapidly Renewable Materials
- Waste stream audit
- Certified Wood

GREEN MARK SCHEME: Waste management improvement plan, Sustainable Construction, Sustainable Products and promotional materials on recycling are the main criteria supported by green mark in new construction. Environmental Management Practice, Green Transport, Refrigerants and Storm water Management are other essential cases.

Table 3: Material and Resources Comparison

GREEN POLICIES	LEED	GREEN MARK
Waste Management	√	√
Durable Goods and Materials	√	√
Road accessibility and Green Transport		√
Storm-water Management	√	√
Reducing water in construction phase		√
Recyclable Materials	√	√
Materials Reuse	√	
Renewable Materials	√	

4-4. Indoor Environmental Quality

LEED SCHEME: Minimum Indoor Air Quality Performance, environmental tobacco smoke (ETS) control are two main prerequisites. The main aim is to enhance indoor air quality in buildings in order to provide the health and well-being of the occupants (USGBC, 2008). Minimize exposure of building occupants and maintenance personnel to potentially hazardous material, biological and contaminated ingredients which have negative effects on human health, air quality and the environment are other essential priorities. This approach in new construction focuses more on the following items:

- Indoor air quality (IAQ) development
- Outdoor air delivery monitoring
- Increased ventilation
- Construction Indoor Air Quality Management Plan (during construction – before occupancy)
- Low-Emitting Materials
- Indoor Chemical and Pollutant Source Control
- Controllability of Systems (lighting – thermal comfort)
- Thermal comfort monitoring
- Day light and views

GREEN MARK SCHEME: this plan emphasizes more on the cases mentioned below in new construction:

- Thermal Comfort: this credit provides comfortable internal temperature for occupants.
- Noise Level: the main aim is to maintain an internal noise level with good ambient sound level.
- Indoor Air Pollutants: control the internal pollutions in order to develop indoor air quality.
- Indoor Air Quality (IAQ) Management: focuses on strategies for controlling indoor air quality in the long-term.
- High Frequency Ballasts.

Table 4: Indoor Environmental Quality Comparison

GREEN POLICIES	LEED	GREEN MARK
Indoor air quality development	√	√
Outdoor air delivery monitoring	√	√
Low-Emitting Materials	√	√
Indoor Chemical and Pollutant Source Control	√	

Controllability of Systems	√	
Thermal comfort monitoring	√	√
Daylight and views	√	√
Thermal Comfort	√	√
Noise Level	√	√
Increased ventilation	√	
Construction Indoor Air Quality Management Plan	√	

V. CONCLUSION

This study has been implemented to compare two green index plans from two different continents. These regulatory plans cover the requirements that try to improve energy efficient concepts. This can include a combination of different methods and technologies such as: more efficient lifts, escalators, bulbs and air-conditioned building. However, many residents concern with the primary costs of green technology in construction. They often neglect of reducing costs of energy use in the long-term. Beside life cycle management, government incentives can also have an important role in removing these challenges.

In short, moving towards sustainable building makes the integration between different communities to create a stable environment. This would encourage countries to recruit legislations which run similar to other countries.

ACKNOWLEDGEMENTS

We appreciate the pioneering work of those people who provided us with the sufficient information to accomplish this study.

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