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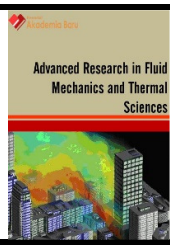

Comparative Study on Energy Management and Efficiency Category in Sustainable Building Rating Schemes

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ABSTRACT

The paper aims to provide comparative study on energy management and efficiency category in sustainable building rating schemes. Eleven sustainable rating schemes have been considered in the present papers which consist of forty three tools. All the tools have been reviewed in terms of credits allocation, parameters allocation, and its credits requirement associated with energy management and efficiency category. In terms of credits allocation, all considered schemes have allocated at least ninety eight credits for parameters in energy management and efficiency category with minimum of twenty nine parameters. In addition to the credit and parameters allocation, the present work also provides specific requirement on the credits for each of the schemes. Eighty six parameters have been recognized from the tools associated to be associated with energy management and efficiency. All these parameters have been consolidated into eighteen parameters and would be very useful for the future development of the sustainable tools.

1. Introduction

Sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The main aim of sustainable development is to improve quality of life and at the same time safe-guard the environment [1] which includes social, economic and environmental issues. Buildings have long been acknowledged as one of the most significant artificial structures imposing reasonable impacts on the global environment. Nduka and Ogunsanmi [2] reported that buildings have been accounted for being responsible for about 25 to 40% of energy usage in the world, 30 to 40% of materials resources consumption in the world, 30 to 40% of waste production in the world and 30 to 40% of GHGs released to the atmosphere globally. In

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addition to these, the report also stated that about 30% of recently built or reactivated buildings are associated with sick building syndrome which in turn exposes occupants to unhealthy environmental conditions. Therefore, several old and recent reports including UNSD Report [3], United Nation Report [4], Hoornweg and Gomez [5] and Leggett and Carter [6], among others highly recommended the implementation of sustainable building construction concept as a means of conserving cost and resources, mitigate global warming and climate change.

The concept of sustainable building pays at using less water, optimizing energy consumption, conserving natural resources, generating less waste and provides healthier spaces for occupants. A large number of rating systems or schemes have been developed to facilitate the efficient and consistent evaluation of building impact on the environment. Among the pioneers are BREEAM UK (1990) [7-9], LEED USA (1996) [7, 10, 11]and BEAM HK (1996) [12]. Similar effort has been done in other countries like CASBEE in Japan (2002) [13], Green Star Australia (2002) [14] and the most recent around Asia Pacific are the Green Mark Singapore (2005) [15, 16] followed by the GBI Malaysia (2009) [16-19], Green Ship Indonesia (2010) [16, 20] and GreenRE Malaysia (2013) [21].

All these SBRS consist of several tools which usually focus on the nature of the building such as residential building, non-residential building, industrial building and many more. Due to geographical and country-bound-interest, all the tools have their own unique way in evaluating the sustainability of a buildings. Despite the uniqueness of each tool, they all share some common evaluation categories such as energy, water, land use, waste and innovation and also share similar parameters.

The present paper aims to compare the energy management and energy efficiency category among the rating tools by providing comprehensive discussion on the parameters and associated credits allocation given by each rating tools.

1.2 Rating Systems Review

Several studies have shown and explore the benefit of different assessment tools through comparing different rating schemes and/or their assessment categories to either determining the appropriete rating system for certain region around the world or the importance of various categories in the rating tools. Fowler and Rauch [10] considered several rating schemes and tools to determine the suitable rating tool/tools for use by United States General Service Administration (GSA). The report provides comprehensive methdology for selecting the schemes for comparison and evaluate the rating schemes on the basis of their applicability, development, usability, schemes maturity, technical contents, measurability and verification and communicability to the GSA. On the other hand, Fenner and Ryce [9] compares BREEAM and LEED schemes as implemented by Canada Green Building Council. They determining the effectiveness of these rating systems and propose improvements to their methods. Sawatzky [22], research focus on comparing LEED New Construction (NC) and Built Green multi-storey and residential tower (MS & RT) rating systems for suitability of the city of Vancouber green building goals. On top of the aforementioned work, Waidyasekara *et al.,* [23], focuses on water efficiency and conservation consideration eleven rating scheme's new construction rating tools. They discuss water category as an important factor of sustainability of built environment.

Although all the rating schemes aimed at single objective of assessing the sustainability of built environment, but it is difficult to specifically find similarity between the existing tools. Each scheme has a different way of classifying the buildings life cycle performance make it nearly impossible to find a similar tool across the rating schemes. For example BREEAM classify buildings into community, new construction, in-use, refurbishment and redevelopment [8], while LEED classify based on building design and construction (residential and non-residential building), interior design and development, existing building operation and maintenance, and neighbourhood and development [11]. Some other schemes simply classify building as residential and non-residential building consisting of stages (new construction, interior design, existing building, and operation and maintenance). Among them are Indian GBC [24], GreenRE [21] as well as GreenShip rating schemes [25]. On the other hand, BEAM [12] classify the buildings into new and existing building covering different types of building (residential, non-residential and industrial). In comparison with the other schemes, GBI [19] and Green Mark [15] also include tools for township assessment together with new and existing for both residential, non-residential and industrial buildings.

Given the wide range of existing rating tools introduce by several rating schemes, it is necessary to have a consistent evaluation of categories and parameters across the schemes and availability to ensure wider global acceptability and easier rating tool comparison across the rating schemes. Eventually, the parameters might be different from one scheme to another depending on the organizational, building, government and other stakeholder's needs but it is necessary that the categories should be consistent across the rating schemes.

Therefore, the present study focusses on reviewing the new and existing for both residential and non-residential buildings rating tools from eleven rating schemes around the world. The study will further determine the energy management and efficiency consideration and extent of coverage by these rating schemes. Such information will help to understand the significance of the energy management and efficiency category in the existing rating schemes and generating new set of harmonise categories and parameters as well as their importance.

2. Methodology

2.1 Rating Tools

Although all the rating tools aimed at single objective of assessing the sustainability of the building, it is difficult to specifically find similarity between the existing tools. Given the wide range of the rating tools, it is necessary to have a consistent evaluation of categories, parameters and availability across the schemes to ensure proper comparison across the rating schemes. Overall, total of 11 (eleven) SRBS has been considered in the present study as shown in Table 1. Out of 95 (ninety five) rating tools made available by all the considered SRBS, only 43 (forty three) are considered in the present study focusing on new and existing for both residential and non-residential buildings. Table 2 shows the list of considered tools in the present study.

2.2 Categories and Parameters

Table 3 shows the categories involve in all considered tools in the present study. Overall, there are 16 (sixteen) categories that has been covered by all the tools. 8 (eight) out of these sixteen have been covered in more than 50% of the considered rating tools; Sustainable

Management (SMN), Indoor Environmental Quality (IEQ), Energy Management and Efficiency (EME), Water Management and Efficiency (WME), Sustainable Material and Waste management (SMW), Sustainable Ecology Protection (SEP), Sustainable Innovation (SIN) and Sustainable Sites Planning (SSP).

Table 1
Summary of the Reviewed SBRS

SBRS	Country	Available RT	No of Categories	Certification Level
BREEAM	UK	5	10	5Star, 4Star, 3Star, 2Star, 1Star, Unclassified [8]
Green Mark	Singapore	15	7	Platinum, Gold^{PLUS}, Gold, Certified [15]
Green Star A	Australia	4	9	world Leadership, Australian Excellence, Best Practice [14]
Green Star NZ	New Zealand	4	9	world Leadership, New Zealand Excellence, Best Practice [26]
Green Star SA	South Africa	6	9	6Star, 5Star, 4Star, 3Star, 2Star, 1Star [27]
BEAM	Hong Kong	3	7	Excellent, Very Good, Good, Satisfactory [12]
India GBC	India	11	10	Platinum, Gold, Silver, Certified [24]
LEED US	United State	21	8	Platinum, Gold, Silver, Certified [11]
GBI	Malaysia	17	6	Platinum, Gold, Silver, Certified [19]
GreenRE	Malaysia	4	7	Platinum, Gold, Silver, Bronze [21]
GreenShip	Indonesia	5	6	Platinum, Gold, Silver, Bronze [25]

Table 2
Summary of Reviewed Rating Tools in the SBRS

SBRS	Reviewed RT	Reviewed Rating Tools
BREEAM	3 - Tools	Breeam's New Construction, In-Use and Refurbishment RT [8]
Green Mark	4 - Tools	Green Mark's Residential New and Existing Building and Non Residential New and Existing Buildings RT [15]
Green Star A	3 - Tools	Green Star Australia's Design as Built, Building Performance and Interior Decoration RT [14]
Green Star NZ	3 - Tools	Green Star New Zealand's Office, Industrial and Education Buildings RT [26]
Green Star SA	3 - Tools	Green Star South Africa's Multi-Residential, Office and Public and Education Buildings RT [27]
BEAM	3 - Tools	BEAM's Existing Selective and Comprehensive Building and New Buildings RT [12]
India GBC	6 - Tools	Indian GBC's Existing, Owner Occupied New, tenant Occupied New, Green Residential Societies, Individual Residential Unit and Multi-Dwelling Residential Units Buildings RT [24]]
LEED US	6 - Tools	LEED's New Construction, Existing Building, Core and Shell, Hotel, Hospital, School Buildings RT [11]
GBI	5 - Tools	GBI's Non Residential New and Existing, Residential, Industrial new and Existing Buildings RT [19]
GreenRE	3 - Tools	GreenRE's Non Residential New and Existing Building and Residential Building and Landed Homes RT [21]
GreenShip	4 - Tools	Green Ship's Non Residential New and Existing and Residential New and Existing Buildings RT [25]

On top of the aforementioned categories, only two categories have been covered by all the tools which are Energy Management and Efficiency (EME) and Water Management and Efficiency (WME). As been shown in Table III, the consideration of EME category comes with different names depending on the SRBS. For example, Green Mark originated from Singapore make used of energy efficiency terms while Indian GBC make use of energy conservation and management terms representing energy related aspects of the evaluation. All related parameters considered on energy aspect of the building will be consolidated under the name of EME.

3. Results and Discussion

3.1 Overall Credits and Parameters Allocation

Table 4 shows the list of considered SRBS together with numbers of categories, credits allocation and parameters allocation. BREEM and Indian GBC offer more categories in comparison with other SRBS at 10 categories. Meanwhile, GBI and GreenShip offer the lowest number of categories at 6 categories among considered SRBS. Details of the categories can be found in Table III. The number of credits and parameters allocation as shown in Table IV are the average credits and parameters value of the SRBS taking into the consideration tools for new non-residential buildings.

In terms of credits allocation, Green Mark has allocated the highest credits at 230 credits followed by BEAM HK and GreenRE with all other considered SRBS allocated less than 200 credits for their associated tools. GreenShip has once again allocated lowest credits at 98 credits in comparison with other SRBS. Meanwhile, in terms of parameters allocation, BEAM HK allocated highest parameters at 83 parameters making it credits-to-parameters-ratio at 2.8. The next highest allocation of credits is Green Star SA with 66 parameters thus recorded much lower credits-to-parameters-ratio at 2.4 in comparison with BEAM HK. The lowest allocation of credits offered is by GreenShip at 98 credits thus recorded lowest credits-to-parameters-ratio at 2.1.

The highest credits-to-parameters-ratio offered by the SRBS is 6.06 by GreenRE, followed by Green Mark at 5.89 and Green Star A at 4.03. High credits-to-parameters-ratio represent higher credits secured by the building once full-filling the required parameters and vice versa.

3.2 Credits and Parameters Allocation

Figure 1-2 shows the variation credits and parameters allocation of each SBRS associated with EME category. Generally, all SRBS have allocated more than 15% of the credits on EME category. The highest percentage of credits on EME allocated is by 44% for Green Mark and Green RE associated to 93 and 101 parameters respectively. The high value shows that all of these schemes put high priority on energy management and efficiency on determining the sustainability of a building.

The second tier on acknowledge the important of energy management and efficiency in building sustainability has a range between 20% to 40% credits allocation on the categories. SRBS that fall into this tier are BREEAM, Green Star NZ, LEED US, GBI and GreenShip with 20%, 21%, 31%, 33% and 27% respectively. The lowest tier consists of Green Star A, Green Star SA, BEAM HK, and India BC. The last two mentioned SRBS recorded the lowest percentage of credits allocation for EME at 19% which is equivalent to 40 credits and 26 credits respectively.

Table 3
Assessment Categories Matrix in the Reviewed SBRS

BREEAM	GreenMark	GreenStar A,	GreenStar NZ	GreenStar SA	BEAM HK	Indian GBC	US LEED	GBI	GreenRE	GreenShip Indonesia
Management	Sustainable Operation and Management	Management	Management	Management	Management	Facility Management	-----		Sustainable Operation and Management	-----
Health and Wellbeing	Community and Well Being	-----	-----	-----	-----	Health and Comfort	-----			Indoor Health and Comfort
-----	Indoor Environmental Quality	Indoor Environmental Quality	Indoor Environmental Quality	Indoor Environmental Quality	Indoor Environmental Quality	Indoor Environmental Quality	Indoor Environmental Quality	Indoor Environmental Quality	Indoor Environmental Quality	-----
Carbon & Energy	Energy Efficiency	Energy	Energy	Energy	Energy Use	Energy Conservation and Efficiency	Energy and Atmosphere	Energy Efficiency	Energy Efficiency	Energy Efficiency and Conversation
Transport	-----	Transport	Transport	Transport	------	-----	Location and Transport	-----	-----	-----
Water	Water Efficiency	Water	Water	Water	Water Use	Sustainable Water Practices	Water Efficiency	Water Efficiency	Water Efficiency	Water Conservation
Material		Material	Material	Material	Material and Waste Aspect	Building Material and Resources	Material and Resources	Material and Resources		Material Resources and Cycle
Waste	-----	-----	-----	-----		Waste Management	-----	-----	-----	-----
Land Use & Ecology	Environmental Protection	Land Use and Ecology	Land Use and Ecology	Land Use and Ecology	-----	-----	-----		Environmental Protection	Building Environmental Management
-----	-----	Emission	Emission	Emission	-----	-----	-----	-----	-----	-----
Pollution	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Innovation	Other Green Features	Innovation	Innovation	Innovation	Innovation and Addition	Innovation and Practices	Innovation	Innovation	Other Green Features	-----
-----	-----	-----	-----	-----	-----	Sustainable Architecture and Design	-----	-----	-----	-----
-----	-----	-----	-----	-----	-----	-----	Regional Priority	-----	-----	-----
-----		-----	-----	-----	Site Aspect	Site Selection and Planning	Sustainable Sites	Sustainable Site Planning and Management		Appropriate Site Development
-----		-----	-----	-----	-----	-----	-----		Carbon Emission of Development	-----

Source: Individual sustainable building rating scheme

Table 4
Categories Average Credits and Parameters Allocation by each Rating Scheme

Rating Scheme	BREEAM	Green Mark	Green Star A	Green Star NZ	Green Star SA	BEAM HK	India GBC	LEED US	GBI	GreenRE	GreenShip
Categories	10	7	9	9	9	7	10	8	6	7	6
Credits	171	230	117	145	155	229	153	110	100	212	98
Parameters	57	39	29	54	66	83	57	56	46	35	46
Parameters-To-Credit-Ratio	3.00	5.90	4.03	2.69	2.35	2.76	2.68	1.96	2.17	6.06	2.13

Source: Individual sustainable building rating systems

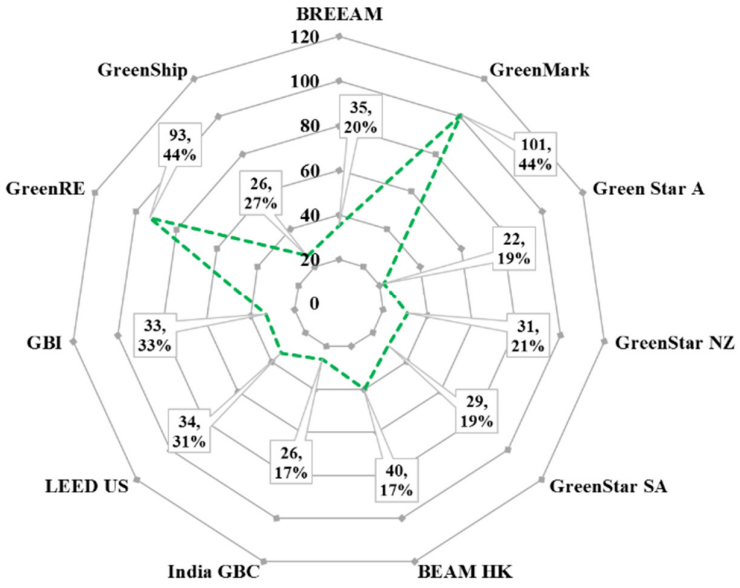

Fig. 1. Average Credits Distribution on Energy Management and Efficiency. Source: Individual sustainable building rating systems

Figure 2 shows the average parameters allocation in EME category by all considered SBRS. The highest parameters allocated by LEED US with 12 parameters constitute of 21% of total parameters considered by the scheme. This is followed by GreenRE with 10 parameters representing 29% of the total parameters. In terms of percentage of parameters on EME, only Green Mark belongs in the first tier with the aforementioned scheme. Green Mark recorded 23% of the total parameters are associated with EME.

In the second tier which allocates 10% to 20% of the total parameters on EME are BREEAM, Green Star NZ, BEAM HK, GBI and GreenShip. All these SRBS allocate 16%, 15%, 11%, 17% and 17% of the parameters on EME categories respectively. All other SBRS allocate less than 10% of the total parameters in EME. The lowest allocation of parameters associated with EME is the one of Green Star A with only 7% parameters allocation constitutes for only 2 parameters.

Each SRBS has its own method in distributing the credits and parameters. In terms of EME categories, minimum of 19% of the overall credits have been allocated representing nearly one fifth

of the evaluation. The maximum credits allocation has been as high 44% of the total credits. In terms of parameters, the highest credits-to-parameter ratio has been allocated by Green Mark and Green Star with both of the SRBS recorded as high as 11 credits for each parameter evaluated by the scheme. This is followed by GreenRE with 9.3 credits for each EME parameters. All other SRBS allocate relatively low credits-to-parameter ratio with the overall average value of 5.8 credits for each EME parameter.

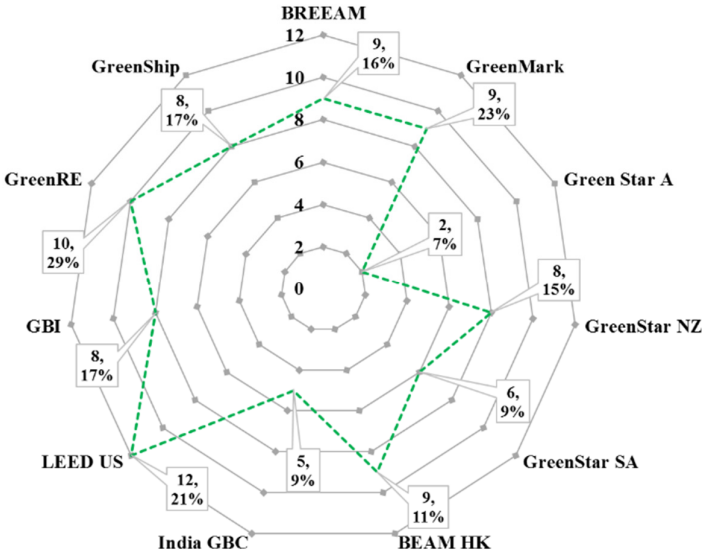

Fig. 2. Average Number of Parameters on Management and Efficiency. Source: Individual sustainable building rating systems

Table 5 shows requirement made by each SRBS on EME category. Out of 11 considered SRBS, only 4 of them have not made EME category as prerequisite in the evaluation. These 4 SRBS include Green Star A, Green Star SA, Indian GBC and GBI. Although the others have made EME category as their prerequisite, the requirement are varied throughout the SRBS. BREEAM, Green Mark Green Star SA and GreenRE have set a minimum requirement in terms of EME credits to be achieved during the evaluation. Incapability of the evaluated building to achieve such requirement will hinder their ratings awarded by the SRBS. Other prerequisite of EME category includes energy monitoring, natural ventilation consideration, building energy performance, and passive design analysis and policy and energy management plan. By having the prerequisite, the SRBS can ensures all rated building will have minimum characteristics of a sustainable building.

Table 5
Prerequisite and their Credits Allocation

S/No	Rating Schemes	Prerequisite	Credits	Description
1	BREEAM	Yes	Inclusive *	Energy consumption recording and monitoring Minimum credits for EME for BREEAM rating (average of 25.8%) Evidence requirement for each assessment type Minimum building energy monitoring and usage
2	Green Mark	Yes	Inclusive *	Minimum credits for EME for each Green Mark rating Minimum thermal performance of building Minimum system efficiency for different cooling system in a building Chiller Plant M&V Instrumentation Natural Ventilation area applicable to only occupied area
3	Green Star A	No	No	Nil
4	Green Star NZ	Yes	No	Minimum credits for EME for Green Star NZ rating (average 25%) Minimum energy consumption Minimum credit from EME parameters
5	Green Star SA	No	No	Nil
6	BEAM	Yes	No	Compulsory compliance with Building Energy Code (BEC) Minimum energy performance
7	India GBC	No	No	Nil
8	LEED US	Yes	No	Energy efficiency best management practices Fundamental commissioning and verification Minimum energy performance Building-level energy metering Fundamental refrigerant management
9	GBI	No	No	Nil
10	GreenRE	Yes	Inclusive *	Minimum credits for EME for each Green Mark rating Minimum thermal performance of building Minimum system efficiency for different cooling system in a building Chiller Plant M&V Instrumentation Natural Ventilation area applicable to only occupied area
11	GreenShip	Yes	No	Policy and energy management plan Minimum building energy performance Passive design analysis Minimum building energy monitoring and usage Minimum thermal performance of building

Source: Individual sustainable building rating systems

4. Conclusion

Comparative study on energy management and efficiency category in sustainable building rating schemes has been conducted. Based on the study, the listed conclusions can be made are:

1. Energy management and efficiency is one of the major categories considered in sustainable rating schemes.
2. Although the credits and parameters allocation are varied between the schemes, significant amount of the credits and parameters have been allocated for energy management and efficiency category.

3. Given the diversity of parameters for energy management and efficiency category across the tools, it is necessary to consolidate the parameters to represent general parameters that should be considered in future development of sustainability tools.

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