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Comparative Study on the Malaysian Sustainable Building Rating Systems

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Abstract: Sustainable building are buildings which have less impact on the environment and are assess with suitable assessment tools from rating systems. Hence many countries struggle to have these rating systems that suite the need of its stakeholders. The study compares the two widely accepted rating systems in Malaysia. These are Green Building Index (GBI) and Green Real Estate (GreenRE) are specifically design and developed for Malaysian tropical weather, environmental and development context, cultural and social needs. GBI rating system developed 15 assessment tools and GreenRE have 4 assessment tools therefore, only four assessment tools were compared. The total credits allocation are 100/154Cr, 100/183Cr and 100/184Cr and total parameters of 39Pr/24Pr, 51Pr/29Pr and 44Pr/30Pr for RNB, NRNB, NREB assessment tools for GBI/GreenRE respectively. Among the criteria, energy, water, indoor and outdoor environmental qualities were given high priority with high credit and parameters allocation. GreenRE give more priority in EEF and WEF category as compared to GBI with putting more priority over GreenRE in the remaining as it consider more categories of buildings, parameters in the remaining criteria and higher rating grade. It is easier to score credits and attain high ratings in the GreenRE assessment tools than GBI assessment tools even though in both the sustainability issues considered are similar. The results from GBI and GreenRE assessment exercise are solely dependent on the personality, quality and experience of the assessor. All the tools are pointing to a single similar objective that is the implementing the principle of sustainability in the Malaysian build environment and hence they are both suitable for assessing Malaysian buildings. The review will help in understanding the ratings systems and useful for countries developing rating systems for their built environment.

Keywords: Assessment, Building, Credit, Environment, GBI, GreenRE, Parameters, Residential and sustainability

1. Introduction

Global concern over the growing of climate change, Greenhouse Gases (GHGs) emission and control, has been the agenda of discussion for both developed and developing countries. Despite the fact that achieving sufficient understanding of international climate negotiation is facing great difficulty. Individual countries, cities and communities have realized that they can actually move faster than the international community with more flexible ways of corporation. Hence actions are taken at national, sub-national and local levels to account for GHG emission, hence mitigate climate change [1, 2] and other sustainable development issues [3].

Climate change and urbanization are two of the most important phenomena facing the world today; and they are inextricably linked. Poverty reduction and sustainable development remain core global priorities but, as the World Development Report 2010 emphasizes, climate change now threatens to undermine the progress achieved by low and middle-income countries with poorest populations are most vulnerable [4,5].

Several old and recent reports including Mohamed and Dalimin, [3]; Hoornweg and Gomez, [5]; United Nation Sustainable Development Report, [6]; United Nation Report, [7, 8]; Leggett and Carter, [9] and Wijeyesekera, [10] among several others recommended on the construction of sustainable building as a means to mitigate global warming and climate change. These lead to the establishment of Sustainable Building Rating Systems (SBRS) around the world with BREEAM UK developed in 1992, LEED USA and BEAM Hong Kong developed in 1996 and the Japan CASBEE in 2001 being the pioneers.

2. Literature Review

Several works were carryout by researchers around the world to explore the benefit of different assessment tools through comparing different rating systems and/or their assessment categories which include research by Driedger, [11] whose study focus on carbon neutral campus for University of British Columbia for a life span of 20years and review the most prominent rating systems around the environment for recommending a green

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building rating system that would form part of this strategy. The rating systems includes BOMA Go Green (Canada and the US), BREEAM (UK), Green Star (Australia), Passive House (Germany and the US), The Living Building Challenge (Canada and the US) and LEED (Canada and the US). While Fenner and Ryce, [12] compares the two most widely adopted Systems; the UK BREEAM and the LEED as implemented by the Canada Green Building Council. Their study aim at determining the effectiveness of these rating systems and to propose improvements to their methods. Sawatzky, [13] research focus on comparing LEED New Construction and Built Green rating systems for suitability of the city of Vancouber green building goals. Amamata, et al, [14] reports on the comparison between smarts building and green certified building through comparing BREEAM, LEED and GBI. Hedaoo and Khese, [15] presents the comparative analysis of four prominent sustainable green building rating systems namely BREEAM, LEED, GREEN STAR and GRIHA. The major goal of these studies is to consider all aspect of the rating systems in order to ascertain of best one(s) and to provide a deep insight into sustainable green building rating systems [16, 17].

Other researches include Bahaudin, et al, [18]; Kshirsagar, et al, [19] and Bhortake and More, [20] compare some existing and notable rating tools from rating systems around the world for either suitability for some countries or reviewing their assessment criteria and parameters in relation to their marks or credits allocation. This study specifically aimed at considering the variation and suitability of widely accepted rating systems within Malaysian environment.

2.1 Malaysian Rating Systems

Following the global concern over climate change and the need for action at the local level Malaysia make a move for consultations with different SBRS around the globe. In April 2009, launched a rating system to suit the local market, it is called Green Building Index (GBI) [21, 22]. The Real Estate and Housing Development Association of Malaysia (REHDA) in 2013 launched GreenRE, or Green Real Estate, an alternative rating systems. GreenRE assess building's performance in terms of energy efficiency, water efficiency, environmental protection, and indoor environmental quality and carbon emissions of the development [23].

2.1.1 Green Building Index

The GBI is an environmental rating system for buildings developed by PAM (*Pertubuhan Akitek* Malaysia/Malaysian Institute of Architects) and ACEM (Association of Consulting Engineers, Malaysia). It is Malaysia's first comprehensive rating system for evaluating the environmental design and performance of Malaysian buildings based on six main criterion: Energy Efficiency, Indoor Environmental Quality, Sustainable Site Planning & Management, Materials and Resources, Water Efficiency and Innovations [21]. The GBI rating system is developed specially for the Malaysian tropical weather, environmental and development context, cultural and social needs [21-25].

The GBI rating system currently developed and utilises seventeen (19) rating tools and seven (7) Design Reference Guides (DRG). The DRG comprises of guides for assessing Residential New Construction (RNC), Non Residential New and Existing Buildings (NRNC & NREB), Industrial New and Existing buildings (INC & IEB), building interior and township. The remaining ten (10) assessment tools were developed for assessing Hotels, Hospitals, Resorts, Data centres and Retails outlets each for non-residential new and existing buildings. Each of the rating tools have six assessment criteria and with exception of township and interior, the matrix of this criteria of some assessment tools together with their credits and parameters allocation are shown in Table 1. The township assessment tool have climate energy and water, environment and ecology, community planning and design, transportation and connectivity, building and resources and business and innovation as its assessment criteria [4, 21 - 23].

Table 1; Matrix of Credits and Parameters Allocation against the Assessment Criteria (ACRE) in GBI's Industrial Tools [26-30]

Assessment Criteria	INC		IEB	
	Parameters	Credits	Parameters	Credits
EEF	9	33	9	38
IEQ	16	22	16	22
SSPM	15	18	7	10
MRE	6	10	6	8
WEF	5	10	5	12
INN	2	7	2	10
Total	53	100	45	100

Table 1; Matrix of Credits and Parameters Allocation against the Assessment Criteria (ACRE) for GBI's Residential and Non-Residential Building [26-30]

RNC		NRNC		NREB	
Pr	Credits	Pr	Credits	Pr	Credits
6	23	9	35	9	38
7	12	15	21	15	21
14	33	13	16	7	10
6	12	7	11	6	9
4	12	5	10	5	12
2	8	2	7	2	10
39	100	51	100	44	100

The GBI initiative aims to assist the building industry in its march towards sustainable development. The GBI environmental rating system is created to [28]:

i. Define green buildings by establishing a common language and standard of measurement;
ii. Promote integrated, whole-building design;
iii. Recognise and reward environmental leadership;
iv. Transform the built environment to reduce its environmental impact; and

v. Ensure new buildings remain relevant in the future and existing buildings are refurbished and upgraded properly to remain relevant.

2.1.2 Green Real Estate (GreenRE)

Green Real Estate (GreenRE) is the second SBRS developed in Malaysia four (4) year after the establishment of GBI. Currently GreenRE have developed 4 rating tools which cover the complete building life cycle performance. The rating tools include non-residential new and existing building, residential new constructions and the township. Each of the rating tool have six (6) assessment criteria and with the exception of township, the matrix of these criteria and their corresponding parameters and credit allocation are shown Table 2 [23, 29].

Table 2; Matrix of Parameters and Credits Allocation in GreenRE Assessment Tools [31-36]

Assessment Criteria	RES		NRB		ENRB	
	Pr	Cr	Pr	Cr	Pr	Cr
EEF	8	83	11	106	10	90
WEF	3	14	4	15	6	25
EPR	7	40	7	41	-	-
SOM	-	-	-	-	7	37
IEQ	4	6	5	10	5	18
OGF	1	7	1	7	1	10
CED	1	4	1	4	1	4
Total	24	154	29	183	30	184

3. Methodology

For the purpose of this study, the material document to be used are Green Building Index and Green Real Estate rating systems which hence forth be referred to in this study as GBI and GreenRE respectively. From several assessment tools developed by these Systems, only three will be considered for comparison based on the maximum available rating tools provided by the GreenRE System and will be referred to in this study as:

i. Residential New Building Tool (RNB),
ii. Non-Residential New Building Tool (NRNB),
iii. Non-Residential Existing Building Tool (NREB)

Even though they were called with different names in the individual systems. Furthermore, GBI and GreenRE will be referred to "Rating Systems", the assessment document developed by these systems will be called "Assessment or Rating Tools". The environmental impact category of the buildings will be referred to as "Assessment Criteria or simply Criteria". While the requirement considered under each of the criteria will be referred to "Parameters".

The associated marks or points required to be fulfil in these parameters will be referred to "Credits". For easier comparison, three GBI and GreenRE rating systems assessment tools was considered and their assessment criteria, the credits allocated in the GreenRE assessment tools will converted to percentage since that of GBI is on per 100basis.

The assessment criteria in the GBI and GreenRE rating systems are:

i. Energy Efficiency (EEF),
ii. Water Efficiency (WEF),
iii. Indoor Environmental Quality (IEQ).

The other criteria that are similar and can be consider the same in this study are:

iv. GBI's Sustainable Site Planning and Management (SPM) and GreenRE's Sustainable Operation and Management (SOM) and Environmental Protection;
v. GBI's Material and Resources (MRE) and GreenRE's Carbon Emission of the Development (CED)
vi. GBI's Innovation and GreenRE's Other Green Features (GFE).

4. Result and Discussion

The result and data obtained from RNB, NRNB and NREB of the GBI and GreenRE rating systems are shown in Table 3 to 15. These Tables described the extent of coverage of each criteria through parameters and credit allocation. This chapter will describe the variation of the parameters and credits allocation to the two system's rating tools as well as their assessment criteria.

Table 3: Criteria and Parameters for Residential New Building Assessment Tools [25-36]

Assessment Criteria	GBI		GreenRE	
	Cr	Pr	Cr (%)	Pr
EEF	23	6	83 (54)	8
WEF	12	4	14(9)	3
IEQ	12	7	6(4)	4
SPM/EPR	33	14	40(26)	7
MRE/CED	12	6	4(3)	1
INN/GFE	8	2	7(5)	1
Total	100	39	154(100)	24

Table 4: Criteria and Parameters in NRNB Assessment Tools [25-36]

ACRE	GBI		GreenRE	
	Cr	Pr	Cr (%)	Pr
EEF	35	9	106(58)	11
WEF	10	5	15(8)	4
IEQ	21	15	10(6)	5
SPM/EPR	16	13	41(22)	7
MRE/CED	11	7	4(2)	1
INN/GFE	7	2	7(4)	1
Total	**100**	**51**	**183(100)**	**29**

Table 5: Assessment Criteria and Parameters for GBI and GreenRE NREB Assessment Tools [25-36]

ACRE	GBI		GreenRE	
	Cr	Pr	Cr (%)	Pr
EEF	38	9	90(49)	10
WEF	12	5	25(14)	6
IEQ	21	15	18(10)	5
SPM/SOM	10	7	37(20)	7
MRE/CED	9	6	5(2)	1
INN/GFE	10	2	10(5)	1
Total	100	44	184(100)	30

Table 6: Average Parameters in GBI Energy Efficiency Criteria [25-36]

S/No	GBI Parameters
1	Minimum EE Performance (EEP)
2	Lighting Zoning
3	Electrical Sub-Metering
4	Renewable Energy Onsite Energy Recovery
5	Advanced Or Improved EEP - BEI And EUI
6	Enhanced Commissioning
7	On-Going Post Occupancy Commissioning
8	EE Verification
9	Sustainable Maintenance
10	External Lighting And Control
11	Internet Connectivity

Table 7: Average Parameters in GreenRE Energy Efficiency Criteria [25-36]

S/No	GreenRE Parameters
1	Thermal Performance of Building Envelope
2	Naturally Ventilated Design and AC System
3	Building Envelope Design/Thermal Parameters
4	Daylighting
5	Artificial Lighting
6	Natural Ventilation (Exclude Carparks)
7	Ventilation in Carparks
8	Ventilation in Common Areas
9	Lifts and Escalators
10	Energy Efficient Practice and Features
11	Renewable Energy
12	Energy Policy & Management

Table 8: Average Parameters in GBI Water Efficiency Criteria [25-36]

Parameters	RNB	NRNB	NREB
Rainwater Harvesting	√	√	√
Water Recycling	√	√	√
Water Efficient - Irrigation/Landscaping	√	√	√
Metering & Leak Detection System	--	√	√
Water Efficient Fittings	√	√	√

Table 9: Average Parameters in GreenRE Water Efficiency Criteria [25-36]

Parameters	RNB	NRNB	NREB
Water Efficient Fittings	√	√	√
Water Usage Monitoring and Leak Detection	√	√	√
Irrigation System and Landscaping	√	√	√
Water Consumption of Cooling Tower	--	√	√
Alternative Water Sources	--	--	√
Water Efficiency Improvement Plans	--	--	√

Table 10: Parameters in the GreenRE Indoor Environmental Quality Criteria [30-34]

Parameters	RNB	NRNB	NREB
Indoor Air Quality Performance	√	√	√
Indoor Air Pollutants	√	√	√
Lighting Quality	--	--	√
Thermal Comfort	--	√	√
Noise Level	√	√	√
High Frequency Ballast	--	√	--
Waste Disposal	√	--	--

Table 11: Parameters in the GBI Indoor Environmental Quality Criteria [27, 28, 35]

Parameters	RNB	NRNB	NREB
Minimum IAQ Performance	√	√	√
Environmental Tobacco Smoke Control	--	√	√
Carbon Dioxide Monitoring and Control	--	√	√
Indoor Air Pollutant (Formaldehyde/VOC)	√	√	√
Moulds Prevention	--	√	√
Thermal Comfort: Controllability of Systems	--	√	√
Air Change Effectiveness	--	√	√
Daylighting	√	√	√
Daylight Glare Control	--	√	√
Electric Lighting Levels	--	√	√
High Frequency Ballasts	--	√	√
Sound Insulation	√	--	--
External Views	√	√	√
Internal Noise Levels	--	√	√
IAQ Before/During Occupancy	--	√	√
Occupancy Comfort Survey: Verification	√	√	√

Table 12: Parameters in the GBI Sustainable Site Planning and Management Criteria [27, 28, 35]

Parameters	RNB	NRNB	NREB
Site Selection & Planning	√	√	--
GBI Rated Design & Construction	--	--	√
Rehabilitation of Brownfield Sites	√	√	--
Development Density & Community Connectivity	√	√	--
Environment Management/Building Exterior Management	--	√	√
Earthworks – Construction Activity Pollution Control	√	√	√
Quality Assessment System for Building Construction Work	√	√	--
Workers' Site Amenities	√	√	--
Public Transportation Access	√	√	--
Green Vehicle Priority - Low Emitting & Fuel Efficient Vehicles	--	√	√
Dedicated Cycling Network	√	--	--
Parking Capacity	--	√	√
Storm water Design – Quantity and Quality Control	√	√	
Heat Island Effect – Greenscape and Water Bodies	√	--	--
Heat Island Effect – Hardscape	√	--	--
Heat Island Effect – Roof (Greenery and Roof)	√	√	√
Composting	√	--	--
Building User Manual	--	√	√

Table 13: Parameter in GreenRE Sustainable Operation & Management [30-34]

Parameters	RNB (EPR)	NRNB (EPR)	NREB (SOM)
Building Operation/Maintenance	--	--	√
Sustainable Construction	√	√	--
Post Occupancy Evaluation	--	--	√
Waste Management	--	--	√
Sustainable Products	√	√	√
Greenery Provision	√	√	√
Environmental Protection and Management	√	√	√
Green Transport	√	√	√
Storm Water Management	√	√	--
Refrigerant	--	√	--
Community Connectivity	√	--	--

Table 14: Parameters in the GBI Material and Resources Criteria [27, 28, 35]

Parameters	RNB	NRNB	NREB
Materials Reuse/Selection	√	√	√
Recycled Content Materials	√	√	√
Regional Materials	√	√	--
Sustainable Timber	√	√	√
Storage & Collection and Disposal of Recyclables	√	√	√
Construction Waste Management	√	√	--
Refrigerants/Clean Agents	--	√	√
Sustainable Purchasing Policy	--	--	√

Table 15: Parameter in Other Assessment Criteria [30-34]

GBI Innovation
Innovation in Design and Environmental Design Initiatives
Green Building Index Facilitator (GIBF)
GreenRE Other Green Features
Green Features & Innovations
GreenRE Carbon Emission of Development
Carbon Emission of Development

Table 16: GBI Assessment Ratings [27, 28, 35]

GBI Ratings		GreenRE Ratings	
Grade	% Credits	Credits	% Credits
Platinum	86 – 100%	91 – Above	52 – 100
Gold	76 – 85%	86 – 90	49 – 51
Silver	66 – 75%	76 – 85	43 – 48
Certified	50 – 65%	50 – 75	28 – 43

4.1 Residential New Building

Table 3 show the parameters and credits allocated for the assessment of residential new buildings by both GBI and GreenRE systems. From Table 3, it can be seen that by comparing the credits allocated and parameters considered in both GBI and GreenRE residential building assessment criteria and tools it can be found that the GBI EEF credit allocation is 23Cr allocated to 6Pr is less than 54cr allocated to 8Pr in the GreenRE EEF allocation. Therefore, allocating high credits and considering high parameters make GreenRE EEF criteria to have more advantage over GBI EEF criteria. From the contents of the parameters also GreenRE have more advantage over GBI EEF criteria. Considering WEF criteria, the credit allocated for GBI residential tool is 12Cr to 4Pr while 9Cr allocated to 3Pr in GreenRE residential tool. Therefore GBI with 12/4 (12Cr allocated to 4Pr) have more advantage over GreenRE with 9/3.

Considering the content of the parameters in the WEF criteria for both the assessment tools it is found that in spite of having different number of parameters the content is approximately the same advantage. For IEQ the

credit allocated to GBI residential tool is 12Cr against 7Pr while 4r was allocated to 4PR in GreenRE tool therefore, GBI having more credits and parameters have more advantage as compared to GreenRE tool with less credit and parameters in IEQ. Considering the content of the parameters in depth, it is found that GBI having more indoor pollutions and problems and more flexible make it having more advantage over GreenRE tool.

Comparing SPM from GBI criteria having 33Cr allocated to 14Pr with EPR from GreenRE tool having 26Cr allocated to 7 parameters which are approximately similar in parameter contents it can be seen that GBI residential tool have more advantage over GreenRE tool in terms of SPM/EPR and the content of the parameters. By merging MRE and INN the remaining criteria considered under GBI residential tool having a total of 20Cr allocated to a total of 8Pr and merging GFE and CED with total credits of 8Cr allocated to total of 2Pr as the remaining considered parameters and credits for GreenRE residential tool. Considering this two merge parameters and credits it can be seen that GBI considered more parameters and allocated more credit and therefore it have more advantage over the GreenRE tool and also in term of parameters content. Considering the combine total parameters, GBI having 39Pr consider more parameters and therefore have more advantage over GreenRE with 24Pr.

4.2 Non-Residential New Building

Table 4, show the parameters and credits allocated for the assessment of non-residential new buildings for GBI and GreenRE assessment Systems. From Table 4, it can be seen that by comparing the credits allocated and parameters considered in both GBI and GreenRE NRNB assessment criteria and tools it can be seen that the GBI EEF credit allocation is 35Cr allocated to 9Pr is less than 58Cr allocated to 11Pr in the GreenRE EEF allocation. Therefore, allocating high credits and considering high parameters make GreenRE EEF criteria to have more advantage over GBI EEF criteria. From the contents of the each parameter under GreenRE and GBI, GreenRE have more advantage over GBI NRNB EEF criteria. Considering WEF criteria, the credit allocated for GBI NRNB tool is 10Cr to 5Pr while 8Cr allocated to 4Pr in GreenRE NRB tool. Therefore GBI with 10/5 have more advantage over GreenRE with 8/4 credits and parameters respectively.

Considering the content of the parameters in the WEF criteria for both the assessment tools it is found that GBI NRNC have an in-depth consideration of two more criteria as compare to GreenRE NRNB WEF criteria. For IEQ the credit allocated to GBI NRNB tool is 21Cr against 15Pr while 6Cr was allocated to 5PR in GreenRE NRNB tool therefore, GBI having more credits 21Cr and parameters 15Pr have more advantage as compared to GreenRE tool with less credit and parameters in IEQ.

Considering the content of the parameters it is found that GBI having more indoor pollutions and problems and more flexibility make it more advantageous over GreenRE tool. Comparing SPM from GBI criteria having 16Cr allocated to 13Pr with EPR from GreenRE tool having 22Cr allocated to 7Pr which are approximately similar in parameter contents. It can be seen that GBI NRNB tool have more advantage over GreenRE tool in terms of parameters considered and vice versa in term of credits allocation and for the content of the parameters in spite of having different number of parameters the content have approximately the same advantage. By merging MRE and INN the remaining criteria considered under GBI NRNB tool having a total of 18Cr allocated to a total of 9Pr. Also merging GFE and CED with total credits of 6Cr allocated to total of 2Pr as the remaining considered parameters and credits for GreenRE NRNB tool. Considering this two merged parameters and credits it can be seen that GBI considered more parameters and allocated more credit and therefore it have more advantage over the GreenRE tool. Also have more advantage in term of parameters contents. Considering the combine total parameters, GBI having 51Pr consider more parameters and therefore have more advantage over GreenRE with 29Pr.

4.3 Non-Residential Existing Building

Table 5, show the parameters and credits allocation for the assessment of NREB. From Table 5, it can be seen that by comparing the credits allocated and parameters considered in both GBI and GreenRE NREB assessment criteria and tools it can be seen that the GBI EEF credit allocation is 38Cr allocated to 9Pr is less than 49Cr allocated to 10Pr in the GreenRE EEF allocation. Therefore, allocating high credits and considering high parameters make GreenRE EEF criteria to have more advantage over GBI EEF criteria in term of credit and the same advantage in term of the contents of the parameter under GreenRE and GBI EEF criteria. Considering WEF criteria, the credit allocated for GBI NREB tool is 12Cr allocated to 5Pr while 14Cr allocated to 6Pr in GreenRE NREB tool. Therefore GreenRE with 14/6 have more advantage over GBI with 12/5 in term of credits and parameters. Considering the content of the parameters in the WEF criteria for both the assessment tools it is found that GBI NREB they have the same advantage over each other as the content consideration are approximately the same. For IEQ the credit allocated to GBI NREB tool is 21Cr against 15Pr while 10Cr was allocated to 5Pr in GreenRE NREB tool therefore, GBI having more credits 21Cr and parameters 15Pr have more advantage as compared to GreenRE tool with less credit and parameters in IEQ.

Considering the content of the parameters, it is found that GBI have considered more indoor pollutions problems and are more flexible make it more advantageous over GreenRE tool. Comparing SPM, MRE and INN the remaining criteria considered under GBI NREB tool have a total of 29Cr allocated to 15Pr. SOM, GFE and CED with credits of 27Cr allocated to 9Pr as the remaining considered parameters and credits in GreenRE NREB tool. It can be seen that GBI considered more parameters and allocated more credit and therefore it have more advantage over the GreenRE tool. GBI NREB have

more advantage in term of parameters contents. Considering the combine total parameters, GBI having 44Pr consider more parameters and therefore have more advantage over GreenRE with 30Pr.

4.4 Assessment Criteria

Assessment criteria are the number of environmental impact categories of building considered by each of the assessment systems for the purpose of fully defining the overall building life cycle performance on the environment. The parameters covered by the categories are shown in Table 6 – 15.

4.4.1 Energy Efficiency

This criteria focuses on the design & performance, commissioning and monitoring, improvement & maintenance of building energy consumption. GBI assessment tools EEF criteria averagely contain certain parameters as environmental impact categories under the energy efficiency to make sure that energy-efficient systems are installed, calibrated and customer's desired results are provided, registering the minimum level of energy consumption to reduce environmental and economic impacts resulted from excessive energy use and to manage the refrigerant for reducing the stratospheric ozone depletion. For the GBI and GreenRE assessment tools, the energy efficiency performance can be obtain through achieving the following parameters as shown in Table 6 and 7 respectively.

4.4.2 Water Efficiency

The parameters in these criteria covers different areas of sustainability in new construction and existing building such as indoor water use reduction, landscaping water use reduction and wastewater strategies. The main purpose is to raise the water efficiency within buildings to decrease the burden on wastewater systems, to eliminate the use of potable water near the project site for landscape irrigation and to decrease the generation of wastewater while raising the local aquifer recharge. The parameters considered by the assessment tools to address the impact of water efficiency and conservation on buildings are shown in Table 8 and 9 respectively.

4.4.3 Indoor Environmental Quality

High performance buildings strive to reduce their impact on their environment by reducing embodied and operational resource inputs, but they also aim to minimize negative impacts on their occupants by creating a healthy, comfortable, and productive indoor environment. Performance of indoor environments is described as Indoor Environmental Quality (IEQ), and quantitative assessment of IEQ has emerged in the last five years as a major activity across the high performance building sector. Indoor environmental quality parameters include acoustics, lighting, indoor air quality and thermal comfort, which have been directly linked to building energy consumption. For example, the single largest energy end-use in a commercial building is Heating, Ventilation and Air-Conditioning (HVAC). It typically accounts for 50~60% of a building's annual energy and it is all about thermal comfort and Indoor Air Quality (IAQ). The parameter utilised to fully assess the indoor environmental quality of the different types of buildings are shown in Table 10 and 11 respectively.

4.4.4 Sustainable Site Planning and Management

Sustainable site planning and design do not impose building design on the site. Rather, they identify the ecological characteristics of the site, determine whether it is appropriate for its proposed use, and design ways to integrate the building with the site. The intent is to lessen the environmental impact of human activity, while using natural characteristics of the site to enhance human comfort and health, and potentially provide a significant portion of the building's energy requirement. Preservation of site resources and conservation of energy and materials in construction and building operations are important results of good site design. The summary of site planning and management parameters in GBI are shown in Table 12.

Sustainable Operation & Management (SOM) criteria focuses on the sustainability of operation and management that would reduce the environmental impacts upon building operation. The Environmental Protection (EPR) criteria focuses on the design, practices and selection of materials and resources that would reduce the environmental impacts of built structures and the parameter allocated by GreenRE are shown in Table 13.

4.4.5 Materials and Resources

This criteria comprises of reused and recycled materials, sustainable materials & resources and policy and waste management. Reuse building materials and products to reduce demand for virgin materials and reduce creation of waste. This serves to reduce environmental impact associated with extraction and processing of virgin resources. Integrate building design and its buildability with selection of reused building materials, taking into account their embodied energy, durability, carbon content and life cycle costs. Facilitating responsible forest management and the reduction of waste generated during retrofit construction and during building occupancy that is hauled and disposed of in landfills. The parameters considered in GBI assessment tools are shown in Table 14.

4.4.6 Other Criteria

To further enhance the building conformance to sustainable environment other parameters from GBI and GreenRE are also assess. This are from the innovation which comprises of any exceptional performance above the requirements set by GBI rating system and any other green features provided beyond the expectation of the

GreenRE rating system together with computation of carbon emission showing considerable saving from the base line emission on the basis of energy and water consumed by the building from the GreenRE assessment tools as shown in Table 15.

5. Assessment Tools Ratings

Considering GBI and GreenRE assessment rating in Table 16, for easier comparison the credits allocation per grade was converted to percentage. Therefore, it can be seen that the maximum scores in term of 100division is 86 – 100Cr for GBI Platinum and 52 – 100Cr for GreenRE Platinum ratings while the minimum score is 50 – 65Cr for GBI Certified and 28 – 43Cr for GreenRE Bronze. From the above discussion, it is easier to score credit and get rated in GreenRE than to get rated in GBI. As 86 – 100Cr give GBI Platinum while only 50 – 100Cr give GreenRE Platinum, 76 – 85Cr gives GBI Gold while 49 – 51Cr gives GreenRE Gold and 66 – 75Cr gives GBI Silver while 43 – 48Cr gives GreenRE Silver. The other are certified and bronze with 50-65% for GBI and 28-43% for GreenRE.

6. Conclusion

From the discussion of the above tables the following conclusion were drawn: GBI have 15 assessment tools and 7 design reference guides and GreenRE have 4 assessment tools and 4 design reference guides. In all the four assessment tool compared EEF and SPM/EPR was given high preference as GBI and GreenRE allocated them with more credits and considered more parameters.

For the residential building tools GreenRE give high preference to EEF with 54Cr and 8Pr over other assessment criteria as compared to GBI EEF with 23Cr and 6Pr. While GBI allocated more credits and considered more parameters to the remaining criteria as compared to GreenRE. For NRNC and NREB, GreenRE give high advantage to EEF and SPM/EPR by allocating more credits and considering more parameters as against GBI while together with 13Pr of SPM, GBI have high advantage for the remaining assessment criteria. For township assessment tools comparison GreenRE and GBI have approximately the same advantages over each other in terms of credit allocation while GBI consider more parameters of 45Pr as against GreenRE with 37Pr. Considering total parameters considered for all the assessment tools GBI consider more parameters of 39Pr/24Pr, 51Pr/29Pr, 44Pr/30Pr and 45Pr/37Pr for RNC, NRNC, and NREB assessment tools for GBI/GreenRE respectively.

It is easier to score credits and high ratings in the GreenRE assessment tools than to get rated in the GBI assessment tools. All the tools were solely developed by groups of expert assigned by REHDA for GreenRE and PAM and ACEM for GBI. All the results from GBI and GreenRE assessment exercise are dependent on the personality, quality and experience of the facilitator or assessor. GBI have more advantage over GreenRE as it consider more categories of buildings, consider more parameters and better rating grade ranges. All the rating systems are pointing to a single similar objective that is the implementing the principle of sustainable building in Malaysian environment.

In comparison with the international community, the rating systems presents strong basis for environmental sustainability in relation to building industry sector for Malaysia as it is evident that each rating system is developed under influence of the nature of the community, climate condition, stakeholders need and the government policies and needs.

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