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ASSESSING THE GREEN ROOF TECHNOLOGY IN GREEN BUILDING RATING SYSTEMS

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ABSTRACT: Green roofs or vegetated roofs are becoming popular for sustainable development. On one hand, research shows that green roofs have numerous environmental benefits such as reduce flood risk, improve rainwater runoff quality, mitigate urban heat island, building energy saving and provide urban wildlife habitat. On the other hand, the development and utilisation of green building rating systems are crucial to appraise existing and new green buildings. The research was conducted foreseeing that the criteria and weight of scoring in such rating systems certainly will influence built environment stakeholders' decision in pursuing green building technologies. A sufficient weight of scoring in the rating system will stimulate the implementation of green roof technology for the construction projects that are adopting that particular green building rating system. However, insufficient weight of scoring will make green roof technology less attractive and eventually being left out in the sustainable development process even though this technology have the potential to mitigate current environmental issues. This paper explores the approach of assessing green building technologies based on rating systems to measure its performance and potential, with an aim to clarify the role and position of green roof technology in various green building rating systems including Leadership in Energy and Environmental Design (LEED), Green Building Index (GBI) and Singapore Building Construction Authority Green Mark. The research methodology involves analysing the relevance and scoring performance of green roof based on the criteria stated in green building rating systems such as sustainable site planning and management, materials and resources, water efficiency and innovation. This paper will also explore the approach of assessing green building technologies based on rating systems to measure its performance and potential.

Keywords: green roof, vegetated roof, Green Building Rating Systems, Green Building Index, LEED, BCA Green Mark, Sustainable Development

1. INTRODUCTION

The scoring performance of green roof technology in various green building rating systems is an important factor influencing built environment stakeholders' decision in whether to pursue this particular green building technology for sustainable development.

1.1 Green Roof's Role in Sustainable Development

The flood risk in Malaysia is increasing due to rapid urbanization of catchments for example urbanized areas. Georgetown and many parts of the places in Kuala Lumpur are so frequently inundated is because of over-development of river valleys (Ngai, 1997). Impermeable surface such as hard roof and pavement are replacing green areas, accelerating the rainwater peak runoff that increase the flood risk in the event of heavy monsoonal and convectional rainfall. Table 1 show that the runoff for conventional roof is very high ranging 0.9-0.95. However, implementation of the green roofs resembling the flat soil with vegetation category ranging 0.1-0.6 and flat lawns with heavy soil category ranging 0.13-0.17 on certain extend will greatly reduce the peak rainwater runoff and flood risk. Therefore green roofs can be very effective tools to mitigate rainwater runoff and without the construction of large capacity and costly drainage system.

Table 1. *Typical Values of Runoff Coefficients (Waterfall, 1998)*

Type of Surface	High	Low
Roof: Metal, gravel, fiber glass, mineral	 0.95	 0.9
Paving: Concrete, asphalt	 1.00	 0.9
Gravel	0.7	0.25
Soil: Flat, bare Flat with vegetation	 0.75 0.6	 0.2 0.1
Lawns: Flat, sandy soil Flat, heavy soil	 0.10 0.17	 0.05 0.13

Urban Heat Island (UHI) effect is the phenomena whereby the city centre area exhibits higher temperature as compared to rural or suburban areas. The increase in anthropogenic heat emissions from combustion of fuel, vehicle emissions and air conditioning, the decrease in green spaces and water; and increase in manmade structures and pavements are the main causes of UHI (Wong, 2002). Cities in Malaysia are facing UHI effect as more and more green spaces are taken up for development. Given the hot and humid condition in Malaysia, green roofs can provide consistant passive thermal protection for buildings and environment. If green roofs are being implemented on a sufficient scale, they have the potential to help mitigating the uprising global warming effects.

Generally, More than half of solar gain by low height building like a typical terraced house is through its roof, as the roof plane is the part of a building that receive the most solar radiation and for the longest duration through the day. Research shows that buildings built not complying to the 2006 UK building regulations will have much lower U-Values associated with poor roof insulation. These findings encourage retrofitting old buildings without good insulation in Malaysia with green roofs. New construction should also consider green roof as a green building design approach at the same time saving the cost for conventional roof insulation (Cartleton et al, 2010). The energy benefits provided by the green roof options also make a noteworthy impact in the life cycle assessment (Kosareo, 2007).

Green roofs also have the potential to be a wild life habitat in urban area. Iinvestigations have indicated that green roof technology may lead to significant gains in biodiversity. Research shows that numerous species of spiders and beetles in the International Union for Conservation of Nature (IUCN) Red List have been found on green flat-roof habitats in Europe (Brenneisen, 2003). There is also evidence for the habitat potential of green roofs for endangered bird species (Brenneisen, 2003; Baumann, 2006). Until now, little consideration has been given to the intangible ecological functions that green roofs may perform as wild life habitat, this maybe due to the current green building technologies that are economically driven.

Figure 1. *A northern lapwing (Vanellus vanellus) on the green roof in Steinhausen,Canton Zoug. (Photo by A. Kaufmann)*

Other research shows that green roofs house a large swathe of invertebrates in London, where at least 10% of which are rare or scarce, indicating the potential of green roofs' as artificial habitats is vast (Kadas, 2006).

From an aesthetic perspective the primary application of green roof is to provide a visually interesting vegetation layer of diverse texture and seasonal colour replacing a rock ballast or dark surface (Weiler, 2009). In fact the deep aesthetic discontent of concerned citizens and environmental activist with the status quo of the built environment is the trigger for Germany's green roof movement (Werthmann, 2007).

1.2 Green Building Rating Systems

Some expert has strong argument that green building is or will soon become a megatrend and building rating systems add objectivity and credibility to the process by offering standards and certification (Rock, 2010) . For credibility, a business must have clearly articulated, independently quantifiable and verifiable standards, and it is not enough to have a set of published standard, and at same time self-evaluate and self-monitor the standards put in place. (Melaver; Mueller, 2009). Therefore a reliable rating system must have a standard by which success is defined and by having quantifiable components, and its components must be reviewed and verified by a third party. Only by doing this, people can compare and assess green buildings on a reliable and independent platform.

In the US and Canada, a commercial green building is generally considered to be the one certified by the LEED green building rating system of the US Green Building Council (USGBC) or Canada Green Building Council. More than 98 percent of the certified green buildings in both countries come from this system (Yudelson, 2008). It is foreseeable that the similar will happen in Malaysia where people will recognize a building as green building only if the building is evaluated and certified by similar green building rating system.

Knowing that a reliable and independent platform is needed, Malaysia's construction industry players are absorbing other countries' experience and at the same time developing elements that adapt local situations. The Green Building Index (GBI) is one of the myriad green rating system that has already been adopted by the UK (BREAM), US (LEED), Singapore (Green Mark), Japan (CASBEE), Australia and New Zealand (Green Star). The GBI and as well as Green Mark are pioneering systems for measuring sustainability levels of buildings in a tropical zone.These evaluation and certification with these two rating systems come with cost just like other green rating systems.

Comparison study between green building rating systems shows that one important gap appears to exist is many of the rating criteria are independently rated by cut-off values lacking an assessment of the tradeoffs between them. As a result, one may find two different combinations of scores that leading to a fulfillment of the same requirement (Smith et al, 2006). This study acknowledges such important gap and explores the impact of it to green roof technology and other green building technologies.

1.3 Impact of Green Building Rating System

As some green building rating system are put into implementation for years and steadily evolve into a mature system, researchers start to study about the various impacts of such rating system on constructors(Mago, 2007), small to medium sized enterprises(Lisowski, 2006) and higher education institutions (Chance, 2010). Researcher also highlight about the emerging significance of green building rating system for example LEED but little is known of the changes that have taken place from such implementation. This raise the question of some professionals adopting green building rating system as an article of faith when critical assessment seldom being carry out to evaluate the actual effectiveness of the green building rating system criteria (Zukowski, 2005). Therefore researchers and built environment stake holders should assess and improve the green building rating systems, considering that these systems will have significant influence on the direction of green building implementation and sustainable development as a whole.

The criteria and weight of scoring in green building rating systems certainly will influence built environment stakeholders' decision in pursuing green building technologies. A sufficient weight of scoring in the rating system will stimulate the implementation of green roof technology for the construction projects that are adopting that particular green building rating system. However, insufficient weight of scoring will make green roof technology less attractive and eventually being left out in the sustainable development process even though this technology have the potential to mitigate current environmental issues.

2. METHODOLOGY

The study methodology is partially adopted from a research exploring outer space technologies for sustainable buildings (Low, 2009) and will assess the potential score that can be achieved by the implementation of green roof technology based on various criteria and items in 3 different green building rating systems. The study is a simplified assessment just to explore the scoring performance of green roof technology under green building rating systems. The 3 selected rating systems are Leadership in Energy and Environmental Design (LEED), Green Building Index (GBI) and Singapore Building Construction Authority Green Mark and the assessment will based on the Non-Residential New Construction category. The potential scores will be compared in terms of the scoring in various criteria and also the maximum potential scoring weight.

2.1 Criteria in LEED, GBI and Green Mark

The three selected green building rating systems have varies criteria and weight of scoring.

***Table 2.1a**. Leadership in Energy and Environmental Design-LEED 2009 for New Construction and Major Renovations Criteria*

	Criteria	Possible Points
1	Sustainable Sites (SS)	26
2	Water Efficiency (WE)	10
3	Energy and Atmosphere (EA)	35
4	Materials and Resources (MR)	14
5	Indoor Environmental Quality (IEQ)	15
6	Regional Priority Credits (RP)	6
7	Innovation and Design Process (ID)	4
	Total	110

***Table 2.1b.** Green Building Index Non-Residential New Construction Criteria*

	Criteria	Possible Points
1	Energy Efficiency (EE)	35
2	Indoor Environmental Quality (EQ)	21
3	Sustainable Site Planning & Management (SM)	16
4	Materials and Resources (MR)	11
5	Water Efficiency (WE)	10
6	Innovation (IN)	7
	Total	100

***Table 2.1c.** Singapore Building Construction Authority Green Mark*

New Non Residential Building Criteria

	Criteria	Possible Points
1	Part 1 Energy Efficiency	116
2	Part 2 Water Efficiency	17
3	Part 3 Environmental Protection	42
4	Part 4 Indoor Environmental Quality	8
5	Part 5 Other Green Features	7
	Total	190

The tables above will be explained in detail in section 2.2.

2.2 Green Roof Technology Potential Scoring in Green Building Rating System

The assessment of green roof technology will base on the requirements of LEED, GBI and Green Mark stated in their criteria and specific items. This study acknowledge the complex assessment process for each rating system, uniqueness of every green building project and also different possible outcome due to different opinion of assessor. Therefore, the focus of this study is not to do a detail evaluation on particular green building projects but to explore the scoring performance of green roof technology under different system. The scoring performance will have a significant impact influencing built environment stakeholders' decision in pursuing green roof technology.

Whenever green roof technology is stated as a criteria requirement fulfilment option, the assessment will consider green roof technology as the primary technology and award the potential maximum scoring points. In situations where green roof technology potentially serves only as a supporting technology in certain criteria and specific items, a pre-set of points will be deem as the contribution from green roof technology.

The potential scores are summarised and put in tables as follow:

***Table 2.2a**. Green Roof Technology Potential Score in Leadership in Energy and Environmental Design-LEED 2009 New Construction and Major Renovations*

	Criteria / Items	Points
	Sustainable Sites (SS)	
1.	SS Credit 5.1: Site Development—Protect or Restore Habitat	1
	SS Credit 5.2: Site Development—Maximize Open Space	1
	SS Credit 6.1: Stormwater Design—Quantity Control	1
	SS Credit 6.2: Stormwater Design—Quality Control	1
	SS Credit 7.2: Heat Island Effect—Roof	1
	Water Efficiency (WE)	
	WE Credit 1: Water Efficient Landscaping	2
	Energy and Atmosphere (EA)	-
	Materials and Resources (MR)	
	MR Credit 4: Recycled Content	0.5*
	Innovation and Design Process (ID)	
	ID Credit 1: Innovation in Design	1
	Regional Priority Credits (RP)	-
	Total	**8.5 (8.0**)**

*Green roof as supporting tool, **Points excluding Green roof as supporting tool

***Table 2.2b.** Green Roof Technology Potential Score in Green Building Index Version 1.0 Non-Residential New Construction (NRNC)*

	Criteria / Items	Points
	Energy Efficiency (EE)	
1.	EE1 Minimum EE Performance	0.5*
	Indoor Environmental Quality (EQ)	
	EQ12 External View	0.5*
	Sustainable Site Planning & Management (SM)	
	SM4 Environment Management: (A)Conservation (B)Open Space	2
	SM11 Stormwater Design – Quantity & Quality Control	1
	SM12 Greenery & Roof	2
	Materials and Resources (MR)	
	MR2 Recycled Content Material	0.5*
	MR3 Regional Material	0.5*
	Water Efficiency (WE)	
	WE3 Water Efficient Landscaping	0.5*
	Innovation (IN)	
	IN1 Innovation	1
	Total	**8.5 (6.0**)**

*Green roof as supporting tool, **Points excluding Green roof as supporting tool

Table 2.2b. *Green Roof Technology Potential Score in - BCA Green Mark for New Non-Residential Buildings (Version NRB/4.0)*

	Criteria / Items	Points
1.	Part 1 Energy Efficiency NRB 1-1 Thermal Performance of Building Envelope Part 2 Water Efficiency NRB 2-3 Irrigation System and Landscaping Part 3 Environmental Protection NRB 3-3 Greenery Provision NRB 3-7 Stormwater Management Part 4 Indoor Environmental Quality Part 5 Other Green Features NRB 5-1 Green Features and Innovations	8 (2*) 0.5* 3 (1*) 3 (1*) - 1
	Total	**15.5 (11.5**)**

*Green roof as supporting tool, **Points excluding Green roof as supporting tool

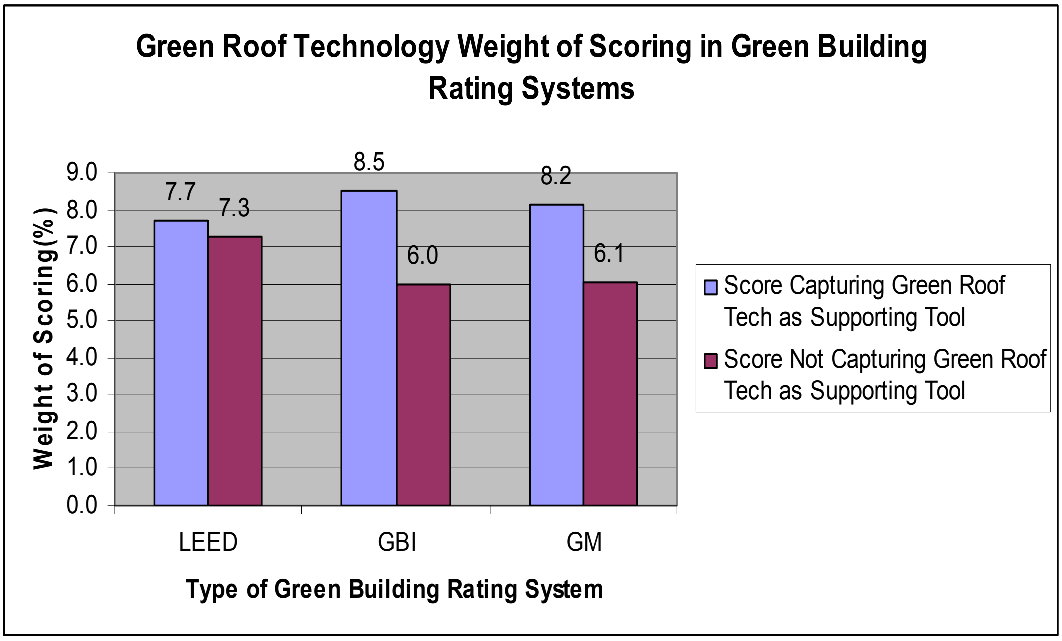

Figure 2*. Green Roof Technology Potential Weight of Scoring in LEED, GBI and GM*

Generally green roof technology have a weight of scoring ranging from 7.7% - 8.5% if the rating systems able to capture the role of green roof technology as a supporting tool, and a weight of scoring ranging from 6.0% - 7.3% if the rating systems fail to capture the role of green roof technology as a supporting tool. LEED scoring criteria is the rating system that most unlikely to overlook or missing out green roof technology as supporting tool in green building assessment with a difference of 0.1%. GBI scoring criteria is the rating system that most likely to overlook or missing out green roof technology as supporting tool in green building assessment with a difference of 2.5%.

3. CONCLUSIONS

The study is a simplified assessment to explore the possibility of using green building rating systems to gauge green roof technology performance. This assessment can be done on other green building technologies such as rainwater harvesting system (Mohammed, T. A. et al, 2007), and the weight of scoring of different technologies can be used as an initial indication of built environment stakeholders' decision in pursuing green building technologies. Built environment stake holders can use this simple assessment to monitor the influence and impact of a particular green building technology. Green building rating system researchers and developers can also utilised this simple assessment to improve the current rating system on capturing green building technology as a supporting tool for other sustainable development approach.

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