AN EVALUATION OF THE EFFECTIVENESS OF THE GREEN BUILDING PERFORMANCE TOOL IN SINGAPORE

Kok Wee Ng[1]
Goran Runeson[2]

[1] Faculty of the Built Environment, University of New South Wales, Australia, kwng88@hotmail.com
[2] School of the Built Environment, University of Technology Sydney, Australia, goran.runeson@uts.edu.au

Keywords: Green Mark, green buildings, sustainability, sustainable construction

Summary

Construction has been accused of causing environmental problems through excessive consumption of global resources from building and construction activities. There have been research on green building design and green materials to minimize environmental impacts. Rating tools such as the BREEAM in the UK, the LEED in the US and the GreenStar in Australia allow for benchmarking and rating building performance in energy efficiency to promote sustainable development and reduce greenhouse gas emissions. In Singapore the Green Mark assessment scheme was introduced in January 2005 by the Building and Construction Authority. It is a government initiative to promote environmental sustainability in buildings in Singapore. It was initially a voluntary programme for new and existing buildings but was made mandatory on 15 April 2008. This paper discusses the introduction of the scheme as the first government-implemented environmental assessment scheme in Singapore. This paper is based on an online questionnaire survey undertaken in January 2008 to examine the impact of the scheme in the construction industry since its introduction. It also provides an overview of the principles of the scheme in enhancing sustainability awareness in construction and presents the survey results, recommendations and direction for future research.

1. Introduction

Building, together with the transport sector, are the key industries in most countries with the greatest impact on urban environment (Ng & Hirota, 2007) and environmental building assessment methods are growing in importance in improving sustainability of the built environment (Ding, 2008). Eliminating or reducing environmental impacts through design of environmentally certified buildings is the primary purpose of building assessment tools (Chau et al., 2000; Seo et al., 2005; Ding, 2008). Secondly, it aims at providing the means for stakeholders to make property investment decisions based on environmental performance of buildings (Shiers, 2000; von Paumgartten, 2003). Finally, it aims to achieve the goal of improving quality of life for building occupants (Ding, 2005; Ha¨kkinen & Nuutinen, 2007).

In January 2005, the Singapore government, through the Building and Construction Authority (BCA), made a commitment to reduce environmental impacts by introducing the Green Mark assessment scheme. It is an initiative to guide the construction industry to move towards more environmentally friendly buildings. So far, over 60 buildings have received Green Mark certification by BCA, ranging from public sector institutional projects to private sector projects (BCA, 2008a).

This paper provides an overview of the Green Mark scheme as the first government-implemented environmental assessment tool in Singapore. This paper is based on an online questionnaire survey undertaken in January 2008 to review the impact of Green Mark scheme in the construction industry since its introduction in 2005. The survey seeks to examine whether there is an uneven uptake of environmental consideration across all the stakeholders in the development process and the increase in market awareness of the benefits of green buildings. This paper also discusses the principles of Green Mark, its implementation and its impact on sustainable buildings in Singapore.

2. The Green Mark Scheme – An overview

Green Mark is a credit award scheme that aims at promoting sustainability in the built environment. In particular the main objectives of the Green Mark scheme are (BCA, 2008a):

a. to promote sustainable development by improving environmental performance of buildings;
b. to employ market forces to bring about environmental awareness and to improve quality of life for occupants;
c. to raise awareness of developers, facility managers and occupants of the benefits of green building;

d. to encourage the best environmental practice in building design, operation, management and maintenance; and

e. to establish key performance indicators for benchmarking green building performance.

The Green Mark scheme attempts to combine features from three major green building rating systems to evaluate environmental performance of buildings and to improve quality of life. They are the Building Research Establishment Environmental Assessment Methods (BREEAM) in the UK, the Leadership in Energy and Environmental Design (LEED) in the US and the GreenStar in Australia. The Green Mark scheme, similar to BREEAM, LEED and GreenStar, gives outcomes as a certificate awarded to individual building based on credits for a set of pre-determined performance criteria.

The assessment classification is based on the total number of credits. This certificate provides recognition for the building environmental performance. The classification rankings in Green Mark are Green Mark Certified (scores 50 to <70), Gold (scores 70 to<80), Gold^{PLUS} (scores 80 to <85) and Platinum (scores 85 and above). Assessment method and certification process provide means of distinguishing green buildings and promoting their uses. The documentation format, third party assessment and post-occupancy evaluation provide a systematic approach to the certification process.

Based on the structure of BREEAM, LEED and GreenStar, six assessment criteria were identified. These assessment criteria contribute to the credibility of Green Mark by ensuring that green building environmental performance goals match up to the desired international rating standards in a transparent manner (Fowler & Rauch, 2006). Other credibility concerns include measurement of environmental impact, market transformation, quality of life, and a track record of accomplishment through post-occupancy evaluation (Lutzendorf & Lorenz, 2006).

Table 1 - Comparison of performance scores for BREEAM, LEED, GreenStar and Green Mark

MAIN ASSESSMENT CATEGORIES	BREEAM '98		LEED 2.1		GREEN STAR v.2		GREEN MARK	
	Points	% of total points	Points	% of total points	Points	% of total points	Points	% of total points
Site/Project development & ecology	128	11	14	20	8	6	10	10
Energy efficiency & atmosphere	208	17	17	25	24	18	30	30
Water efficiency	48	4	5	7	13	10	20	20
Indoor environment quality & environmental protection			15	22	27	20	15	15
Innovation & design			5	7	5	4	15	15
Materials & resources	104	9	13	19	20	15		
Transport	240	20			11	8		
Pollution & emissions	154	13			14	10		
Health & Comfort	150	13						
Management	150	13			12	9	10	10
TOTAL	**1182**	**100%**	**69**	**100%**	**134**	**100%**	**100**	**100%**

The Green Mark assessment scheme covers a wide range of green building issues, environmental impact, resource exhaustion, emissions to environment, indoor environmental quality, and management quality as well as other social aspects in Table 1. The table provides a comparison of assessment criteria between Green Mark and the BREEAM '98, LEED 2.1 and GreenStar v2. Green Mark places a lot of emphasis on energy and water efficiency which are the two main areas of concern in Singapore.

The intention of the Green Mark assessment scheme is to evaluate environmental impact of new and upgraded buildings using locally developed benchmarks and weighs established for each criterion. The values for benchmarks were classified into two main types: numerical and text based. The numerical values reflected the scores achieved and the text scores reflected the building performance grade. The numerical sore range from 0 to 100 and the five text scales represent minimum acceptable scale, average, good, excellent and outstanding performance achieved using best available technology and affordable cost.

In order to accelerate the Green Mark scheme in construction the government launched a Green Mark Incentive Scheme (GMIS) to encourage the adoption of green building design, technologies and practices. GMIS provides developers and building owners with financial incentives for buildings with Green Mark Gold rating or higher in new constructions or retrofitting of existing buildings.

3. Assessing the impact of Green Mark Scheme

3.1 Research method

Green Mark has been a voluntary requirement for the design and construction of projects in Singapore for about three year. In order to examine the impact of Green Mark in promoting sustainability in the construction industry, an online questionnaire survey was developed to investigate its role and impact. The survey was designed and distributed online so that it could obtain a wider coverage and provide a quick and

easy platform for the return of the completed survey. The purposes of the survey were to examine the level of acceptance of Green Mark since its introduction in January 2005 and to explore the role of Green Mark in the construction industry in enhancing sustainability in construction projects. The survey also assesses the impact of its implementation as voluntary to the design and construction for buildings.

The questionnaire was divided into three parts. The first part was intended to obtain general details of the respondents and contained eight questions. Information about the demographics of respondents and details of their professions and organizations were the focus of this part. Part two was intended to examine the viewpoint of respondents in respect to their understanding and acceptance of the green buildings, and it contained 12 questions. Some of the questions were designed as a standard Likert scale where respondents were asked to rate each questions from low to high or from strongly disagree to strongly agree. Part three contained eight questions and was designed to identify the level of expertise the respondents have in the operation of the Green Mark scheme.

The online survey was assisted by the Royal Institution of Chartered Survey (RICS), the Chartered Institute of Building (CIOB) and the Singapore Institute of Architects (SIA) in distributing the survey to their members. The anonymous questionnaire was sent to members of RICS, CIOB and SIA as well as to 150 practitioners in the construction industry in Singapore via email with a URL containing the online survey in January 2008. Many participants also forwarded it to URLs of other practitioners in the industry. Therefore it was difficult to determine the exact response rate. Completed questionnaire were received via online and the survey was concluded in mid March 2008.

3.2 General Information

In mid March 52 completed questionnaires were received and analyzed. Of the returned survey 74% were from male respondents whereas female respondents contributed 26%. The survey respondents came from a variety of backgrounds and details are included in Figure 1. Project managers, Architects and quantity surveyors made up of the majority of the respondents and contributed 18%, 24% and 25% respectively to the total returned surveys whilst the rest was distributed among property managers, developers, engineers and others. Figure 2 presents the survey by age group. The age distribution of the respondents was evenly distributed. Regarding work experience 48% have less than 15 years, 44% have between 16 to 35 years and 8% have more than 35 years respectively. The majority of the respondents, about 49%, work for large companies with staff over 100 and have been established over 40 years in the construction industry.

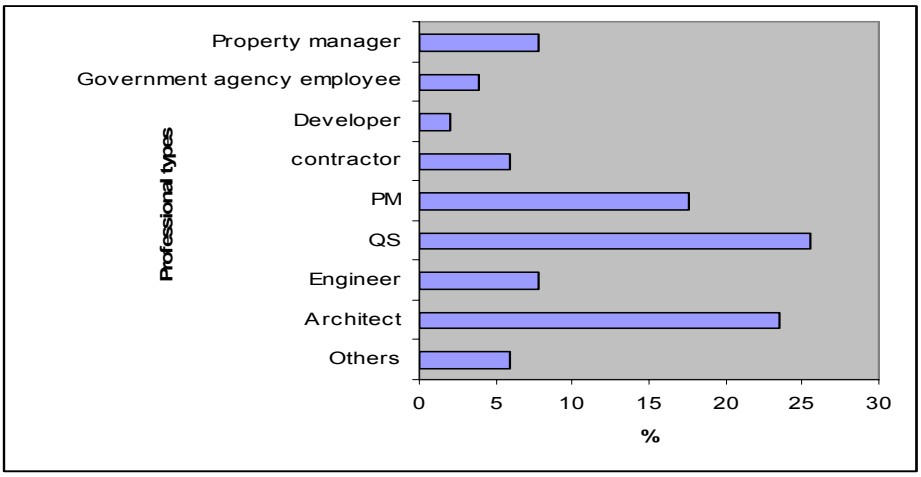

Figure 1 Summary of respondents by professional

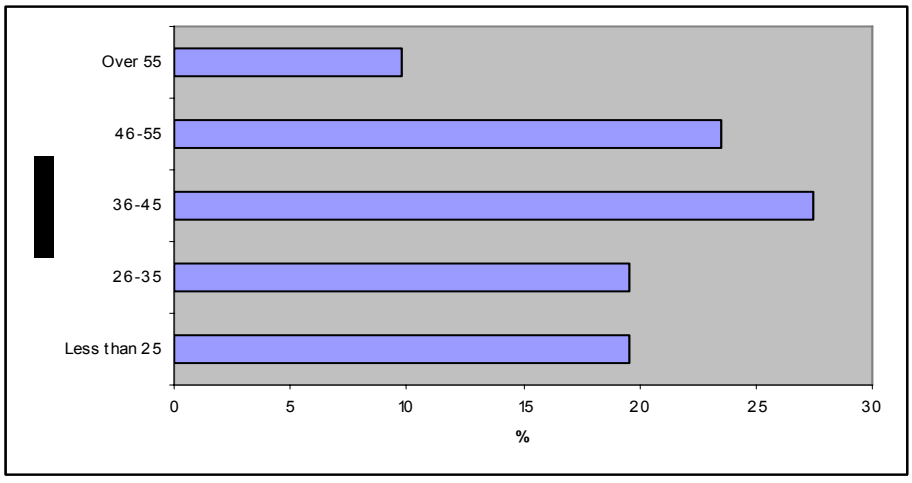

Figure 2 Summary of respondents by age

3.3 Greening the construction industry

The survey indicated that the majority of respondents are well aware of the environmental issues in the construction industry. Approximately 95% have expressed their concern about the environment and 59% have work experience in environmentally related projects. Of the 59% respondents having work experience in environmentally related projects about 50% are engaged in the design whilst 29% are involved in the construction and the rest in maintenance and assessment. Regarding work experience in environmentally related project approximately 82% have only two years work experience in about five projects. About 18% have up to 15 environmental projects with about ten years of such work experience.

In Part II survey respondents were asked to provide their opinions on greening the construction industry in Singapore. The questions were designed using a standard Likert scales, ranging from strongly disagree to strongly agree. The results indicate that over 90% of respondents agreed that environmental issues are important and should be incorporated in the design and construction of projects. About 90% believed that the demands for green buildings in the society will continue to grow and will eventually become an important source of workload in construction.

The respondents were asked to comment on whether research and development in green buildings in the construction industry is sufficient in Singapore. However only 12% agree that the construction industry has done enough to protect the environment whilst 66% disagree and 22% having no opinion. Some propose that the government needs to re-evaluate current regulations and policies in order to develop new directions and guidance for improving sustainability in construction. Some suggest that more grants and funding should be used to encourage research and development in renewable energy development, green technologies and materials, and so forth.

Concerning protection of the environment some suggested using severe legislations, regulations and by-laws as means to protect the environment. Approximately 74% believed that the laws and regulations will become more demanding in construction in the next few years. They recommend on one hand heavy penalties or taxes be imposed on those who pollute the environment. On the other, encouragement may be given by the government to those who pursue environmentally friendly projects through tax incentives or financial benefits.

3.4 Impact of Green Mark Scheme in construction

The Green Mark scheme was introduced in January 2005 as an initiative to raise environmental awareness among construction professionals in the design and construction of projects. However the long-term impact of Green Mark is yet to be reviewed. From the survey 45% of respondents have used Green Mark before of which 81% have used it for less than 5 projects whilst 19% used it for between 6 to 15 projects. Of those who had used the Green Mark before, about 65% used it as a design tool whilst 35% used it just for marketing purposes.

In assessing the impact of Green Mark in the construction industry respondents were asked to rate questions that were designed on a standard Likert scale from strongly disagree to strongly agree. The results are summarized in Table 2. Based on the returned surveys, professionals in the construction industry are generally well aware the importance of Green Mark in construction. The survey results indicated that 70% agree that the scheme is useful in assessing environmental performance of buildings. Green Mark is reasonably user friendly and 54% agreed that the information on the website is sufficient. With regards to assessment criteria 63% believe that Green Mark can help to provide better sustainability outcomes in construction. About 74% of respondents found the assessment criteria achievable.

Table 2 Summary in the use of Green Mark in the construction industry

Proposition	Responses (%)				
	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
The Scheme is useful in assessing environmental performance of buildings	4	4	22	59	11
The information on the website is sufficient	4	15	27	46	8
The criteria set in the Scheme are achievable	4	0	22	67	7
The Scheme will help to provide better sustainability outcomes of buildings	4	4	22	59	11
The assessment criteria are sufficient to cover the environmental aspects promoting green buildings	4	11	22	44	19
The cost of building green under the Scheme will be more expensive than traditional developments	4	7	22	37	30
The duration of building green under Scheme will be longer than traditional development	4	30	26	26	15
The Scheme should be used by all types of projects in the construction industry	4	0	19	62	15

Since the introduction of the Green Mark scheme there have been substantial discussions on increased construction cost and time due to compliance with the scheme. The use of Green Mark may have impacted on the overall construction cost due to incorporation of green features in buildings. Some have raised concern that compliance to Green Mark will escalate the overall budget which will impact on financial return. Approximately 67% of the respondents agree that the implementation of Green Mark has increased the overall construction cost but only 41% agree that Green Mark may increase the overall construction duration. In accordance with a preliminary study undertaken by the BCA the Green Mark certified buildings have a cost premium between 0.3% to 8% depending on the awards and building types (BCA, 2008b). The Green Mark Certified buildings are at the lower end of the range whilst Gold Platinum has the highest costs premium of up to 8% due to higher performance designs. The higher cost premium of green buildings is recovered from long-term energy and water cost savings.

There is no great disparity in the payback periods for the Green Mark certified buildings ranging from 2 years to 8 years (BCA, 2008b). However it is hard to ascertain whether Green Mark has increased the construction cost and time and further research is needed. About 77% of respondents agree that Green Mark should be applied to all types of construction. However many believe that the scheme needs further development to improve it usefulness. There is no indication of the details of improvement that needs to be made in Green Mark.

The respondents were also asked to comment on the limitations of the scheme in enhancing sustainability performance of buildings. They raised the issue that some developers may like to get the certificate at the lowest pre-determined costs. Developers in Singapore are not likely to spend more than the construction budget if there are no real benefits of green features such as solar, rainwater storage and so forth. Unfortunately wind tunnel tests or acoustic design are usually last on the list as they have initial costs which may lead to other costs. Too much emphasis on green features will lead to the presumption that green buildings are expensive and thus lessen the motivation to building green. They believe that in order to make Green Mark more successful team work and team participation from all construction professionals are important. The government can make Green Mark a requirement for the approval of building plans. They also suggest that sufficient information on green buildings should be made available through the development of a vibrant database that has information of all green innovations in the world as reference materials.

Some raise concerns that Green Mark, like other environmental building assessment methods such as BREEAM, focuses on the evaluation of design against a set of sustainability indices. The scheme includes six main areas (refer to Table 1) but does not include financial matters in the evaluation framework. This may contradict the ultimate principle of a development, as financial return is fundamental to all projects. It is important to include economic analysis in the framework and to emphasize potential long-term savings in order to convince people to adopt sustainable practices when building,

In addition, building life cycle has not been incorporated in the evaluation process in the Green Mark scheme. As Curwell (1996) states, life-cycle analysis is important in environmental assessment of buildings as it gives a balanced assessment between a development and the environment. Therefore, a whole-of-life approach is an essential method to evaluate and integrate the costs and benefits associated with sustainable construction. Kats (2003), states that the lack of life cycle costing is one of the obstacles to sustainable buildings. Therefore the ongoing maintenance, repair and replacement of the building should also be included in the evaluation process.

Further, embodied energy has not been included in the evaluation process although it is growing in importance. Construction consumes energy in two principal ways. Firstly, it consumes energy through the construction of buildings and related facilities. In general the energy is used to produce building materials and their subsequent on-site assembly at their final destination. Secondly, it consumes energy in the later use of the building and related facilities in the form of heating, ventilation and cooling, lighting, hot water, and appliances and equipment. It is important to assess the building's entire life cycle on the environment including energy consumption embodied in the process of recovery of raw materials and the manufacturing process. Therefore using low embodied energy materials and recyclable materials have become extremely important (Weir & Muneer 1998). The energy embodied in construction can represent up to one-fifth of national energy consumption (Treloar et al 2001) and it is significant because it occurs immediately and the total energy consumed in the production of building materials can be equal, over the life cycle of a building, to the requirements for operational energy (Pullen 2000).

4. Conclusion

The literature review of existing assessment tools and design methodologies has shown a plethora of environmental issues addressed. Study revealed that not all tools have taken account of economic and social parameters. It is evident that a more holistic approach would result in a more pragmatic and operational outcome. It seems that intentions behind the design of these assessment tools are to be guidelines during the design process and as general green assessment rather than as a specific architectural evaluation tool of building performance.

Construction is one of the largest users of environmental resources and one of the largest polluters of the man-made and natural environment. The improvement in the performance of buildings with regards to the environment will indeed encourage greater environmental responsibility and place greater value on the welfare of future generations. There is no doubt that Green Mark contributes significantly to achieving the goal of sustainable development within construction. On one hand, it provides a methodological framework to measure and monitor environmental performance of buildings, whilst on the other it alerts the building profession to the importance of sustainable development.

The questionnaire survey has provided a preliminary investigation on the impact of Green Mark scheme as introduced by the BCA in January 2005. However, Green Mark has limitations as examined in this paper reducing its effectiveness and usefulness. There is a requirement for greater communication, interaction and recognition between members of the design team and various sectors in the industry to improve and promote the use of the scheme. In considering the advantages and disadvantages that the Green Mark Scheme may have, it has come into effect quite smoothly and with continued improvement and updating, it could become one of the most important planning and design tools in the construction industry.

References

Building and Construction Authority (BCA) 2008a, Green Mark Scheme assessment criteria. Building and Construction Authority (http://www.bca.gov.org.sg Logon: January 2008)

Building and Construction Authority (BCA) 2008b, Business case for green buildings in Singapore. Building and Construction Authority.

Chau, C.K., Lee, W.L., Yik, F.W.H. & Burnett, J. 2000, Towards a successful voluntary building environmental assessment scheme. Construction Management and Economics, Vol. 18, pp. 959-968.

Curwell, S.1996, Specifying for greener buildings. *The Architects' Journal*, January, pp. 38-40.

Ding, G.K.C. (2008) "Sustainable construction - The role of environmental assessment tools", Journal of Environmental Management, Vol. 86, No. 3, p 451-464.

Ding, G.K.C. (2005), "Developing a multicriteria approach for the measurement of sustainable performance", Building Research & Information, Vol. 33, No. 1, p 3-16.

Flower, K.M. & Rauch, E.M. 2006, Sustainable building rating systems. United States Department of Energy, USA.

Häkkinen, T. & Nuutinen, M. 2007, Seeking sustainable solutions for office buildings. Facilities, Vol. 25, No. 11/12, pp. 437-451.

Kats, G. 2003, The costs and financial benefits of green buildings. California's Sustainable Building Task Force.

Lutzendorf, T. & Lorenz, D.P. 2006, Using an integrated performance approach in building assessment tools. Building Research & Information, Vol. 34, No 4, pp. 334-356.

Ng, K.S. & Hirota, K. 2007. Indicators for study of micro-climate impacts on urban sustainability. in proceedings of Clima 2007 Wellbeing Indoors, Finland, 9th REHVA World Congress.

Pullen, S. 2000, Energy use in the construction and operation of houses. *Architectural Science Review*, Vol. 43, No 2, pp. 87-94.

Seo, S., Trucker, S., Ambrose, M., Mitchell, P. & Wang, C.H. 2005, Technical Evaluation of Environmental Assessment Rating Tools. Forest and Wood Products Research and Development Corporation (FWPRDC).

Shiers, D. 2000, Green developments: environmentally responsible buildings in the UK commercial property sector. Property Management, Vol. 18, No 5, pp. 352-366.

Treloar, G.J., Fay, R., Ilozor, B. & Love, P.E.D. 2001, An analysis of the embodied energy of office buildings by height. *Facilities*, Vol. 19, No 5/6, pp. 204-214.

von Paumgartten, P. 2003, The business case for high performance green buildings: sustainability and its financial impact. Journal of Facilities Management, Vol 2, No 1, pp. 26 - 34.

Weir, G. & Muneer, T. 1998, Energy and environmental impact analysis of double-glazed windows. *Energy Conversion Management*, Vol. 39, No 3/4, pp. 243-256.