

Green Mark Scheme in Singapore: A Comparative Analysis between Singapore and China

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Abstract: The Green Mark Scheme develops rapidly and gets wide acceptance in areas outside Singapore since it was launched by the Singapore Building and Construction Authority (BCA) in 2005. Now, it has specific published versions for use in China. Overviews of green building scheme development in both countries were made. An comparison analysis is made between the BCA Green Mark International for Residential Buildings for Use in China (version RB/1.0, referred to as GMI RB/1.0) and Assessment Standard for Green Building (GB/T 50378-2014, referred to as GBL 2014) in terms of rating levels, rating methods, categories, credit settings, and etc. Both two schemes put significant attention to utilization of sustainable energy. As Singapore has a tropical rainforest climate with no distinctive seasons, high temperature and humidity, energy efficiency features account for a large proportion in the GMI RB/1.0. However, it is found that, due to the insufficient consideration of the climate and geographical conditions in China, some requirements in GMI RB/1.0 are extremely difficult or unlikely to achieve for development in China. The reasons are analyzed based on the development submitting both GM certification and GBL in Chongqing, China.

Key words: Green Mark, GBL, green building, comparative analysis

The Topic: T2.1 Design and Innovation

1 Introduction

Green building is not only the inevitable trend of future development of building industry, but also the critical area of addressing the global climate change challenges. Developing green buildings has gained high priority in many countries [1, 2]. Green building schemes play an important role in promoting green building development [3, 4].

China's energy structure is mainly composed of coal, oil, natural gas and other non-renewable energy. Energy consumption per unit building area is also much higher than that of developed countries in the world. Therefore, developing green buildings in China has of practical significance. On January 1, 2013, General Office of the State Council of China issued 'Green Building Action Plan', which clearly pointed out the need to speed up research and development of green building technologies. The implementation of green building has become an urgent task of sustainable development in China.

Green buildings achieved great success in Singapore. The Green Mark Scheme develops rapidly and gets wide acceptance in areas outside Singapore since it was launched by the Singapore Building and Construction Authority (BCA) in 2005. As an emerging scheme, there are few studies focus on the comparative analysis between Green Mark Scheme and China Evaluation Standard for Green Building. The purpose of this research is to contribute to a better understanding of green building assessment tools in Singapore and China and each distinguishing features in terms of comparative analysis on rating levels, rating methods, categories, credit settings, and etc. Making this research is becoming necessary in order to give suggestions about further improvement of China green building assessment tool and recommendations for Green Mark Scheme to achieve a better use in China.

2 Overview on China GBL

China published its first green building scheme Evaluation Standard for Green Building with a code GB/T 50378-2006 (GBL 2006) which combined the practice experience and research results of green building in the last few years. Then Green Olympic Building Assessment System was proposed, indicating the framework of China's green building

development idea. At this point, a prototype of China's green building assessment system which emphasized '4 saving and 1 environment protection', i.e. land saving, energy saving, water saving, material saving and environment protection, was established.

In April 2014, the Ministry of Housing and Urban-Rural Development of China (MOHURD) announced the new version of GB/T 50378-2014 (GBL 2014) which has been implemented from January 1, 2015. GBL 2014 added a new evaluation indicator named Construction Management, thus there are seven indicators in total, namely Land Saving and Outdoor Environment, Energy saving and Energy Utilization, Water Saving and Water Resource Utilization, Material Saving and Material Resource Utilization, Indoor Environment Quality, Construction Management, and Operation Management. Every building development will have to meet the minimum score requirements for each indicator, and the final rating will be determined by the total score. A score of at least 50 points is needed for One Star Rating, 60 points or more needed for Two Star Rating, and 80 points or more need for the top Three Star Rating. What's more, additional bonus items are set to encourage the improvement and innovation of green building technology and management.

By the end of 2014, China's total number of green building projects has reached 2538, with an overall building area of 290 million m² [5].

3 Overview on Green buildings in Singapore and GM

Singapore, a densely populated island country with an area of less than 720 km², lacking of natural resources, has realized the significant importance of developing green buildings. Singapore has made active efforts on promoting green building and environmental sustainability [6]. Singapore Building & Construction Authority (BCA) launched Green Mark (GM) scheme in 2005. The original version of Green Mark was composed of two parts, i.e. new buildings and existing buildings. In the next few years, the category of Green Mark Scheme was considerably extended into a big system including 17 different types of buildings. To promote the development of green building, Singapore government issued a series of economic incentives. A sum of 20 million Singapore dollars was set aside on 'Green Mark Incentive Scheme (GMIS)' on 15 December 2006 for a period of 3 years, in order to help accelerate the adoption of environmentally-friendly green building technologies and building design practices in Singapore. And later Green Mark Incentive Scheme for Existing Buildings (GMIS-EB) was launched in 2009, followed Gross Floor Area (GFA) Incentives in April 2009, Green Mark Incentive Scheme-Design Prototype (GMIS-DP) in 2010, Building Retrofit Energy Efficiency Financing scheme (BREEF) in 2011 and a series of other incentives. Wide coverage of incentives and considerable rewards contributed greatly to great success of GM and rapid development of green buildings in Singapore. As of 2012, a total of nearly 800 construction projects received GM certification, with a total floor area equivalent to 11% of Singapore total available land area[7].

Different from evaluation systems such as BREEAM, LEED and CASBEE which are voluntary for application, Green Mark has actually become a mandatory standard in Singapore. In 2006 Singapore 'Green Building Master Plan' was introduced with a compulsive requirement that all public sector buildings must achieve GM Certified level. In April 2008, Singapore implemented 'Building Control Regulation' requiring all new construction projects with an area of not less than 2000 m² and all existing buildings under retrofitting to reach GM Certified level [6].

Singapore government is committed to creating a safe, efficient, recycling and environment-friendly building environment in the development of green buildings. The achievements of GM has been generally recognized.

4 Comparative Analysis on GMI RB/1.0 and GBL 2014

Green Mark with a great success in Singapore, also started its international exploration. Back in 2007, a collaborative agreement was signed between the governments of China and Singapore to jointly develop a socially harmonious, environmentally friendly and resource-conserving city in China. The two governments co-founded the Sino-Singapore Tianjin Eco-City which aims to achieve 100% green buildings as one of its targets in the building development[8]. In order to promote the development of Green Mark Scheme in China, BCA issued BCA Green Mark International for Residential Buildings for Use in China (version RB/1.0, referred to as GMI RB/1.0) in 2013, in which requirements on building envelope and other terms were modified according to the actual conditions in China to make it easier to use. Recently years, there are projects completed green building evaluation under GMI RB/1.0 in China. Consequently, it is necessary to conduct a comparative analysis on the GMI RB/1.0 and GBL 2014 in order to give suggestions about further improvement of China green building evaluation and GMI RB/1.0 to achieve a better use in China.

4.1 Rating levels

In both green building schemes, the environmental performance of a building development is determined by the

numerical scores achieved in accordance with the applicable criteria and the prerequisite requirements on the level of building performance. Depending on the level of building performance and score achieved, the building development will be eligible for certification under one of the three rating namely One Star, Two Star or Three Star in GBL 2014, and one of the four rating namely Certified, Gold, Gold Plus or Platinum in GMI RB/1.0, as shown in Table 1 and Table 2. The design of the building development shall achieve not less than 40 scores in each category in GBL 2014, while in GMI RB/1.0, 30 points in category 'Energy efficiency', and 20 points in other categories are the minimum requirements to be eligible for certification.

4.2 Rating methods

Both schemes divide buildings into two kinds, i.e. residential buildings and public buildings and determine the rating level by the total scores achieved. There are two assessment stages in GBL 2014, i.e. design assessment and operation assessment. The operation assessment can be carried out after project completion at least one year. However, there is no different assessment stages in GMI RB/1.0. Projects in design phase can also apply for accreditation. In order to ensure that designed green features to be implemented, BCA requests developers to provide valid tender documents during assessment process in which clearly specify the application scope and indicator parameters of energy saving measures. For projects certified by Green Mark, a site verification upon project completion would be conducted by BCA, including review of delivery records, updated documents on green features, building energy performance data and photographic evidences.

4.3 Categories

The two green building schemes are similar in assessment categories which all contain categories about energy, water, material, indoor environmental quality. However, there were different categories in different assessment stages in GBL 2014. Items about construction and operation management were added in operation assessment. Thus, projects would be assessed under 7 categories with each 100 scores in operation assessment in GBL 2014. In order to promote the adoption of new innovative green features, up to 10 bonus scores can be achieve in category 'Innovation'. Scores obtained from seven categories are then weighted, and added with bonus scores together to arrive at a total score. The weights for different categories in GBL 2014 are shown in Figure 1.

There were also bonus points in GMI RB/1.0. In category 'Energy efficiency', up to 20 points can be added to encourage the utilization of solar energy and other renewable energy, while items in category 'Other green features" also encourage the use of other green features that are innovative and have positive environmental impact, such as self-cleaning façade system, infiltration trenches and etc.

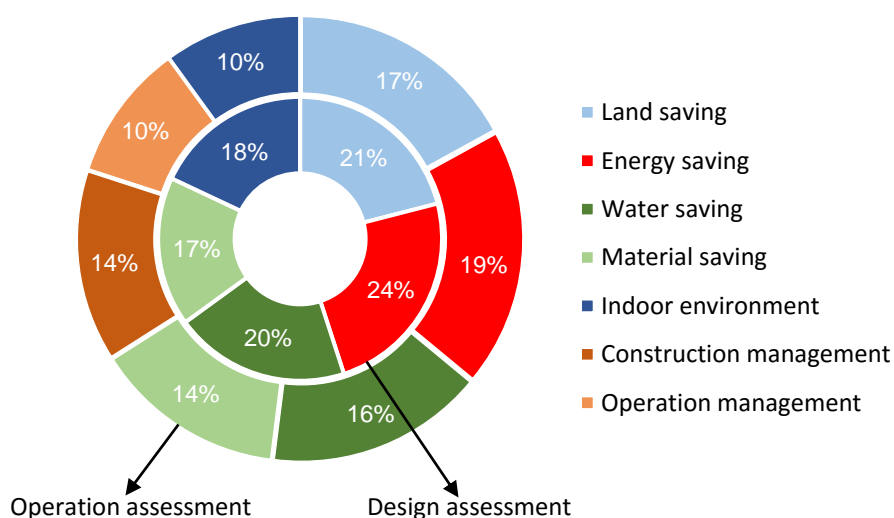


Figure 1 Indicator weights for residential buildings in GBL 2014

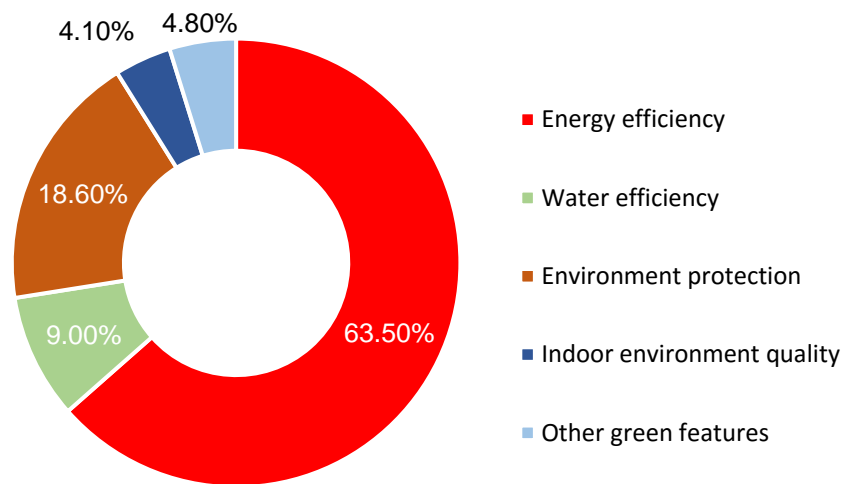


Figure 2 Point allocations in GMI RB/1.0

The most noticeable difference between two green building schemes is the weight distributions. There are obvious difference among point allocations in GMI RB/1.0, as shown in Figure 2. The weight of category ‘Energy Efficiency’ reached 63.50% in GMI RB/1.0, followed by category ‘Environment protection’ with an occupancy of 18.60% and category ‘Water efficiency’ with an occupancy of 13.80%. The large contribution of energy conservation and environmental protection features to green buildings reflects the characteristic of GM that highlights energy efficiency requirements, and the condition of natural resources shortage in Singapore. However, unlike GM, the category weights in GBL 2014 are approximately even distributed, corresponding with the guiding concept ‘Overall consideration, general balanced’ of green building development in China.

4.4 Credit settings

All credits in GBL 2014 and GMI RB/1.0 can be divided into 7 categories, namely ‘energy’, ‘water’, ‘indoor environment’, ‘outdoor environment’, ‘site’, ‘material’ and ‘innovation’. Table 3 gives an overall comparison about credit settings between GBL 2014 and GMI RB/1.0.

Table 3 Comparison about credit settings between GBL 2014 and GMI RB/1.0

Category	Credit	GBL 2014	GM RB/1.0
Energy	Thermal performance	Yes	Yes
	HVAC	Yes	Yes
	Efficient lighting	Yes	Yes
	Equipment efficiency	Yes	Yes
	Passive design	Yes	Yes
	Renewable energy	Yes	Yes
Water	Water management planning	Yes	NO
	Water monitor	Yes	Yes
	Water efficient fittings	Yes	Yes
	Irrigation system	Yes	Yes
	Non-traditional water utilization	Yes	Yes
Indoor environment	Noise insulation	Yes	Yes
	Natural ventilation	Yes	Yes
	Daylighting	Yes	Yes
	Thermal comfort	Yes	Yes
	Indoor air pollutants	Yes	Yes

Category	Credit	GBL 2014	GM RB/1.0
	Shading	Yes	NO
	Indoor air quality in wet areas	NO	Yes
Outdoor environment	Urban heat island control	Yes	No
	Greenery	Yes	Yes
	Public services access	Yes	Yes
	Public transport	Yes	Yes
	Noise control	Yes	NO
Site	Site ecology	Yes	NO
	Site safety	Yes	NO
	Sustainable construction	Yes	Yes
	Land use per capita	Yes	NO
Material	Sustainable material	Yes	Yes
	High performance structure	Yes	NO
	Low impact structure	Yes	NO
	Concrete	Yes	Yes
	Minimum decoration	Yes	NO
Innovation	Green features and innovations	Yes	Yes

As can be seen, there are many similarities in two schemes which both cover the whole life cycle of building development. However, differences still exist in the following aspects.

- Requirements on land use.

GBL 2014 has a specific section on requirements about land conservation, such as restrictions on residential land per capita index. Due to severe scarcity of land resources, Singapore attaches great importance to efficient and intensive land use. However, its land use policies are issued by other government departments, such as Singapore Land Authority (SLA), and therefore BCA did not take requirements on land use in the preparation of Green Mark Scheme.

- Quantitative indicators.

GMI RB/1.0 contains much more distinctive quantitative indicators than GBL 2014, such as EEI (Energy Efficiency Index) used to measure the energy consumption of public facilities, GnP (Greenery Provision) used to comprehensive evaluate the afforestation of the development, CUI (Concrete Usage Index) used to encourage designs with efficient use of concrete for building components, and so on. These quantitative indicators are convenient to calculate, which to a certain extent, simplify the assessment process of GM.

- New energy development and utilization.

Located in Southeast, Singapore is rich in solar energy resources. GMI RB/1.0 attaches great importance on energy conservation and new energy utilization. Each use of 3 kWp (kilo Watt peak) solar energy can obtain 1 point, up to a maximum of 20 bonus points. GBL 2014 set that use renewable energy to provide no less than 20% of domestic hot water as the minimum score requirement. Compared to the latter, GMI RB/1.0 score requirements on renewable energy are more relaxed. As for utilization of other kind renewable energy, developers shall coordinate with BCA and the points scored are based on the EEI and replacement percentage of electricity by renewable energy source, which limits the use of other renewable energy sources to some extent. In contrast, GBL 2014 encourages all kinds of renewable energy.

- Lack concern of China conditions.

GMI RB/1.0 still contains some items that have obvious Singapore geographical characteristics, making them too difficult to achieve in China. Singapore has a tropical rainforest climate with no distinctive seasons, uniform temperature and high humidity. Great attention is paid to achieve good natural ventilation for better indoor comfort in GMI RB/1.0. Green Mark Platinum certification requires an area-weighted average wind velocity within the unit of not less than 0.60 m/s based on the ventilation simulation analysis. Non-compliance will not be eligible to obtain a Platinum certification. The climate in China differs from region to region because of the country's highly complex topography. It is extremely difficult for some regions in China to meet the requirements.

4.5 A case analysis in China

A building development under construction in Chongqing, China, covers a floor area of about 27200 m² and mainly includes eleven multistory residential buildings, one multistory commercial building, and one kindergarten, with a total building area of 48300 m². The project is developed by a Singapore property conglomerate. Located in China, it still needs to achieve at least Green Mark Certified level which is a mandatory requirement from the Singapore BCA. At the same time, GM is now accelerating its internationalization promotion in the world. The project had already set an ambition to achieve the Green Mark Platinum award from the very beginning of the planning stage.

The development obtained a total score of 103 points under GMI RB/1.0, as shown in Table 4, meeting the requirements of a Green Mark Platinum award; an overall score of 86.15 points was achieved in GBL 2014, as shown in Table 5, eligible for certification under a Three Star award. Although the building development achieved the highest rating level in both green building schemes, the contributions of each category are quite different. There are 64.5 points achieved from the category ‘Energy efficiency’ with an occupancy of 62.6% in GMI RB/1.0, while the contribution of category ‘Energy saving’ reached only 23.1% in GBL 2014. What’s more, scores relevant with indoor environment merely reached 4.4% in GMI RB/1.0, nearly a quarter of that in GBL 2014. The point allocations are in accordance with the characteristic of GM that highlights energy efficiency requirements, and the condition of natural resources shortage in Singapore. On the other hand, an approximately even distribution of scores achieved in GBL 2014 corresponds with the guiding concept ‘Overall consideration, general balanced’ of green building development in China.

Table 4 Scores under GMI RB/1.0

Categories	Energy efficiency	Water efficiency	Environmental protection	Indoor environmental quality	Other green features	Total
Points	64.5	11.0	20.0	4.5	3.0	103.0
Weights	62.6%	10.7%	19.4%	4.4%	2.9%	100.0%

Table 5 Scores under GBL 2014

Categories	Land saving	Energy saving	Water saving	Material saving	Indoor environment	Innovation	Total
Points	17.43	19.92	15.6	11.9	15.3	6	86.15
Weights	20.20%	23.10%	18.10%	13.80%	17.80%	7%	100%

Table 6 shows the quantitative indicators of the project in GMI RB/1.0. As can be seen, all quantitative indicators met the requirements of Green Mark Platinum award or reached the most advanced level. *GnP* is calculated volume covered by plants using Green Area Index (GAI) listed in GMI RB/1.0. *CUI* is defined as the volume of concrete in cubic metres needed to cast a square metre of constructed floor area. *EEl* is calculated as electricity consumption for common facilities per gross floor area. All these indicators can be quantitatively measured by simple methods, to a certain extent, simplify the evaluation process of the Green Mark.

Table 6 Quantitative indicators of the development in GMI RB/1.0

Indicators	Values	Requirements	GM Scores
<i>GnP</i>	13.2	$1.0 \leq GnP < 2.0$, 1 point	4
		$2.0 \leq GnP < 2.5$, 2 points	
		$2.5 \leq GnP < 3.0$, 3 points	
		$GnP \geq 3.0$, 4 points	
<i>CUI</i>	0.305	≤ 0.35 for Platinum award	5
<i>EEl</i>	32.47	Bonus credit	1

5 Conclusions

This article overviewed green building scheme development in Singapore and China and made a comparison analysis between the Singapore BCA GMI RB/1.0 and China GBL 2014 in terms of rating levels, rating methods, categories, credit settings, and etc. It is found that both two schemes put significant attention to energy efficiency features and utilization of sustainable energy. The large contribution of energy conservation and environmental protection features to

green buildings in GMI RB/1.0 reflects the condition of natural resources shortage in Singapore. However, unlike GM, the category weights in GBL 2014 are approximately even distributed, corresponding with the guiding concept ‘Overall consideration, general balanced’ of green building development in China. What’s more, it is also found that, due to the insufficient consideration of the climate and geographical conditions in China, some requirements in GMI RB/1.0 are extremely difficult or unlikely to achieve for development in China. There is a long way to go for BCA GM international promotion.

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