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Green building evaluation system implementation

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ABSTRACT

The Green Building concept is very popular worldwide. The adverse impact of construction on the environment significantly promotes the development of the green building concept worldwide. Green buildings are generally termed as environmentally friendly buildings. Therefore, over the past several decades, there have been many green building rating tools developed by institutions to evaluate these buildings. However, a majority of the green buildings certified with these rating tools are assessed primarily on their design and construction. The life-cycle of a green building extends beyond these initial phases, with its full benefits becoming more apparent during the operational stages of the building. However, there is a clear lack of green building projects obtaining green certificates that evaluate the operational stages of the building. Therefore, this research aims to identify the barriers preventing the certification of green buildings in their operational stages. Initially, commonly used international green building rating tools were identified and analysed on the evaluation criteria. Following this analysis, Chinese standards on green building evaluation were also discussed in detail. Furthermore, a case study building with three-star certification for the operational stage was incorporated into the analysis. This case study building was analysed with the Chinese standards, namely Chinese evaluation standard green building (ESGB) 2014, along with other international standards such as the Leadership in Environmental and Energy Design Leadership (LEED), the Building Research Establishment's Environmental Assessment Method (BREEAM), and Green Star. Structured interviews were also carried out to identify the barriers, while measures to overcome these barriers were also discussed. The inconsistency of government regulations, the inability of the market to protect developers' interests, and the inability to meet technical requirements were identified as the three main barriers.

1. Background and introduction

With the increased development of urbanization, environment and energy issues have drawn additional attention from the public and society [1,2]. The promotion and implementation of the green building concept has therefore become a primary theme of modern construction [3], because it is seen to promote buildings that are healthy, safe, comfortable, and environmentally friendly. Due to different levels of economic development, geographical surroundings, resource availability and other factors, there has been no mutual definition of green buildings in the literature [4]. The United States Environmental Protection Agency defined the concept (also known as green construction or sustainable building) as both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from sitting to design, construction, operation, maintenance, renovation, and demolition [5].

Conversely, according to the basic requirements of sustainable development in China, green building is defined as a building that, to the greatest extent, saves resources (energy, land, water, materials), protects the environment and reduces pollution throughout the whole life-cycle, so as to provide people with healthy, suitable and efficient use space, which is also in harmony with nature [6]. This definition stressed that more attention should be focused on the green concept in the whole life-cycle of a building, which in turn puts forward additional requirements on the implementation of green buildings.

After establishing the green building concept, there was a need to develop a framework to evaluate the implementation and performance of green buildings. Therefore, in 1990, the Building Research

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Establishment's Environmental Assessment Method (BREEAM) was developed, evaluating buildings in a more detailed and broader perspective [7]. From this point, additional green building rating tools were developed, including the Leadership in Environmental and Energy Design Leadership (LEED), and Green Star. According to Doan et al. [8], BREEAM is considered as the strongest rating system at present. Furthermore, these rating tools evaluate green building while considering various criteria. Criteria such as indoor environment quality, energy, and material are commonly focused in green rating systems [8,9]. However, most of these green building rating tools evaluate buildings in two stages. One stage is during the building design, and the other involves the actual building performance.

The process of certifying green buildings are different based on the various green building rating tools. In BREEAM, there is a pre-assessment stage to predict a likely score by using a pre-assessment estimator. This is not a certified rating and is not a final score, but it will help to understand what can be achieved [7]. Next, the project must be registered by the assessor, and this must be done as early as possible in the process. During the certification stage, most of the schemes certify considering the design stage and post-construction stage. The assessor submits evidence to Building Research Establishment (BRE) Global for certification purposes. Afterwards, BRE Global issues certificates. Finally, BRE Global lists certified buildings and assets. Similarly, other green building rating tools also specify their ratings according to the stages of the building life-cycle.

Most green buildings in China or overseas obtain the green label only for the phase of design instead of operation [10]. For example, the construction area for the United Kingdom BREEAM In-Use (operation building) merely accounts for 3.04% of the total area of BREEAM certification. Similarly, the construction area of United States LEED O&M (Operation and Maintenance) only accounts for 4.51% of the total area of LEED-certified projects. The certified green building for operation only accounts for 6.35% in China. Further, the total number of green buildings in the phase of operation accounted for 6.79% of the total number of green building projects and the area of those only comprised 4.08% of the total new building area nationwide [11]. Thus, the number of actual green buildings which can provide people with healthy, comfortable and environmentally friendly space is still very limited. It is the reason why there are many criticisms of green buildings. Therefore, additional industry practitioners and researchers begin to call for real implementation of green buildings and advocated that the evaluation of green buildings should only be for the operational phase. Nowadays, the post-evaluation of green building has drawn additional attention. This illustrates that there is a significant lag in obtaining certification during the operational stages of green buildings. Therefore, this research aims to identify the barriers preventing the certification of the green building during the operational stages and the strategies to overcome these barriers.

2. Review of existing green building rating tools

2.1. Barriers in green building implementation

There is much research carried out focusing on the green building implementation. Sharif et al. [12], developed an implementation framework for green buildings in Malaysia. However, this research focused on the initial implementation of the green building, and the operational stage is not included in the research. Similarly, Cohen, et al. [13], suggested that incentives to both builders and buyers act as an enabler in green building implementation at the initial stages. In both these types of research, the green building certification considered the design stage only.

In a study to identify the barriers to green building development in Vietnam, while legislative and institutional barriers are widely perceived as the most challenging obstacles [14]. This research identified 41 barriers to green buildings in Vietnam from the literature and validated them by a survey of 215 construction professionals and government officers. However, these barriers only considered the green building development in the initial stages, and the certification in operational stages was once again not included. A similar study was carried out to examine the criticality of various barriers preventing the wider adoption of green building technologies and identified that lack of information, cost, lack of incentives, lack of interest and demand, and lack of green building codes and regulations are the most reported barriers in the literature [15]. However, in this research also, the green building implementation only focused on the initial green building development and barriers preventing green building certification in operational stages are not clearly discussed. Similarly, there are many research studies carried out focusing on the barriers to green building implementation in the initial decision making stages, and there is a clear lack of research on identifying the barriers to lack of certification in the implementation stage [16,17]. The savings and benefits of green buildings occur throughout the operational stage of the green building. Therefore, it is essential to obtain the green certification in operational stages to get the desired positive outcomes of green buildings. If the green buildings do not operate according to the initial designs with the forecasted savings, the aim of implementing green buildings will not be fulfilled. Therefore, this research provides a novel approach to identify the barriers to implementing green buildings in the operational stages of the building.

2.2. International green building rating tools

There are various green building rating tools developed by many countries. Each of these green building rating tools uses various methods to evaluate green buildings. Certain tools initially evaluate the green building design and afterwards certify for building operation. However, tools such as Green Star has a separate toolkit to evaluate green building operations [18]. This research focuses on international green building rating tools such as BREEAM, LEED and Green Star considering the worldwide usage.

2.2.1. LEED

United States Green Building Council launched LEED in 1994 [19]. LEED is the most widely used green building rating system in the world with 1.85 million square feet of construction space certifying every day and accepted in more than 150 countries worldwide [19] and also considered to be the most perfect, influential evaluation system among all the green building assessment systems worldwide [20,21]. LEED certification provides independent verification of a building or neighbourhood's green features, allowing for the design, construction, operations and maintenance of resource-efficient, high-performing, healthy, cost-effective buildings. LEED does not specify the phase to be evaluated. As a result, most buildings concentrate on design phase rather than the operational phase. As of 2015, LEED v4 rating system had 358 projects registered for new construction with the design phase whereas there were only 122 projects registered for operational and maintenance certification [22].

2.2.2. BREEAM

BREEAM is the first most building assessment method in the world, since its inception in 1990 [7]. BREEAM sets the standard for best practice in sustainable building design, construction and operation and has become one of the most comprehensive and widely recognised measures of a building's environmental performance. BREEAM is widely used in Europe and many parts of the world as well. Further, as of September 2015, BREEAM had certified over 425,000 projects and 1.9 million registered projects over 60 countries [23]. As the first green building evaluation system, it has a profound impact on the other green building evaluation systems and facilitates the development of green buildings. However, this system does not specify the phase to be evaluated so that most buildings focus on the evaluation of design phase

Table 1
Details of international green building rating tools.
Developed from Refs. [7,18,22,32–34].

Description	LEED	Green Star	BREEAM
Parent Organisation	United States Green Building Council	Green Building Council of Australia	Building Research Establishment
Type of Ratings	• LEED Certified • LEED Silver • LEED Gold • LEED Platinum	• One Star -Not eligible for certification • Two Star-Not eligible for certification • Three Star -Not eligible for certification • Four Star-Green star certified rating " Best Practice" • Five Star-Green star certified rating " Australian Excellence" • Six star Green star certified rating " World Leader"	• Unclassified • Pass • Good • Very good • Excellent • Outstanding
Type of schemes available (latest in use)	LEED version 4 • Building Design and Construction (BD + C), • Interior Design and Construction (ID + C), • Building Operations and Maintenance (O + M), • Neighbourhood Development (ND) • Homes.	• Design and As built • Interiors • Communities • Performances	BREEAM International • BREEAM International New Construction (NC) • BREEAM International Refurbishment & Fit-Out • BREEAM In-Use International • BREEAM Communities Bespoke International.
Widely used scheme	Building Design and Construction (BD + C)	Design and As built	BREEAM International New Construction (NC)
Relevant scheme for operational evaluation			
Main credit categories Operational schemes	• Location and transport • Sustainable sites • Water efficiency • Energy and atmosphere • Material and resources • Indoor Environmental quality • Regional priority • Innovation	• Management • Indoor environment quality • Energy • Transport • Water • Material • Land use and ecology • Emissions • Innovation	• Management • Health and wellbeing • Energy • Transport • Water • Material • Waste • Land use and ecology • Pollution • Innovation

instead of operational phase.

2.2.3. *Green Star - Australia*

Green Building Council of Australia (GBCA) was launched in 2002 as a national not-for-profit organisation focusing on the development sustainable property industry in Australia [18]. In 2003, GBCA launched its green building rating system as "Green Star". Australia is the largest single contributor of greenhouse gases and generates 40% of waste; Green star is aimed to improve environmental efficiencies in buildings, while also boosting productivity, creating jobs and improving the health and well-being of communities [24]. Initially, GBCA had Green legacy tools, and by the end of 2015, all these tools were superseded by a new set of green building rating tools. These tools include four green building rating tools for Design and As built, Interiors, Communities and Performances and also it assess the sustainability of projects at all stages of life cycle. Green Star performance tool assesses green buildings during its operational stage.

Each of these tools has different schemes and various criteria. All these are illustrated in Table 1 as follows.

According to Table 1, in LEED and Green Star, widely used green building rating tools are new construction and design and as-built respectively. Tools focusing on operational phase of buildings are not popular among the users.

2.3. *Green building evaluation development in China*

Currently, green building development in China is still at its initial stage [25]. However, by now there are many approaches adopted by the government and other policy-making authorities to promote green buildings in China. Some top-down compulsory and promotion policies for the development of green buildings in China including the General Office of the State Council published the Green Building Action Plan issued by the Ministry of Housing and Urban-Rural Development and the National Development and Reform Commission on 1 January 2013, which claimed that 20% of new buildings should meet green building standards by the end of 2015 [26]. In March 2014, the New Urbanization Plan (2014–2020) released by the CPC Central Committee further defined the medium-term goal of the green building development. It claimed that by the end of 2020, green buildings should comprise at least 50% of new buildings [27].

Since 2001, China has made legislation and regulations about green building as shown in Fig. 1. From the beginning of 2008 to the end of 2015, the green building certification review system was implemented in China. There were 4071 certified projects with the total area of 472 million square meters for green building, among which there are 3859 projects with the area of 444 million square meters of green design, and 212 projects with the area of 28 million square meters for green operation [28].

2.3.1. *Chinese evaluation standard of green building (ESGB)*

According to the introduction, similar to other countries and tools, evaluation of operational phase of buildings is at a minimum. However, in China, there is a country-specific green building rating tool named as Chinese evaluation standard of green buildings.

The concept of green building was first introduced into China in the 1990s and the evaluation standard was then developed. In June 2006, the Ministry of Construction issued "the green building evaluation criteria" (Evaluation Standard for Green Building, hereinafter referred to as ESGB) (GB/T50378-2006) which was the first national standard for evaluating green buildings in China, and published the 2014 edition of "green building evaluation criteria" (GB/T50378-2014) in January 2015. The differences between the standards are shown in Table 2.

According to Table 2, evaluation object refers to the type of building. Further, evaluation phase considers the design and operation

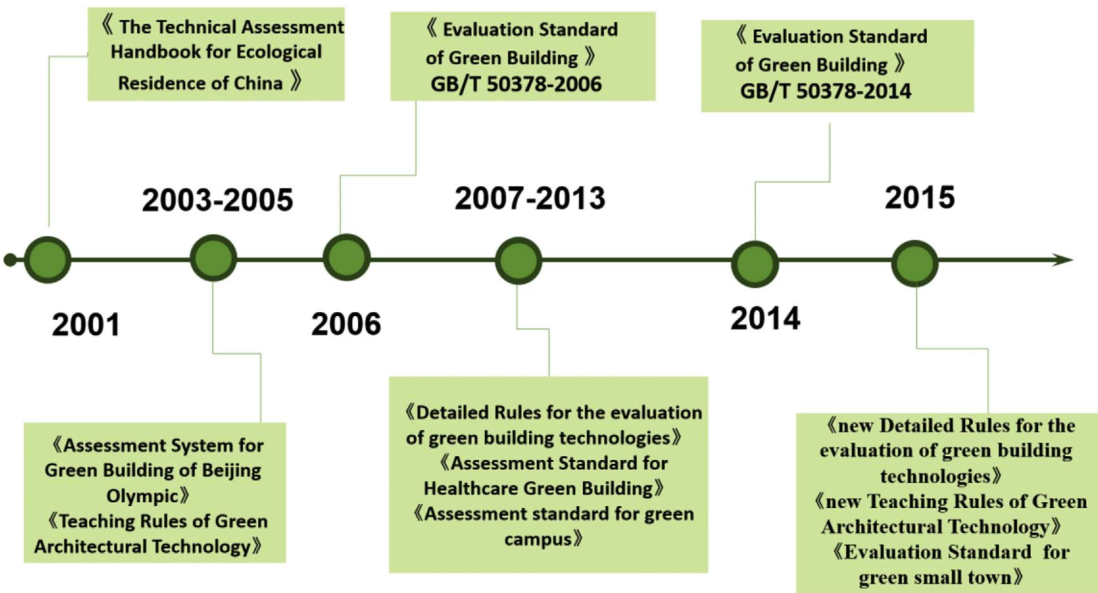

Fig. 1. Green building evaluation standard development process of China.

Table 2
Comparison between EBGS2006 and EBGS2014.

	EBGS2006	EBGS2014
Evaluation object	Residential building, public building (office, shopping mall, hotel)	Residential building, public building (unlimited)
Evaluation phase	Design evaluation and Operation evaluation (after 2008)	Design evaluation and operational evaluation
Evaluation system	Land saving and outdoor environment, energy saving, material saving, water saving, indoor environmental quality, operation management	Land saving and outdoor environment, energy saving Material saving Water saving Indoor Environmental quality Operation management Construction management
Evaluation Method	Counting the number of provisions	Total Scores ★ $50 \le \Sigma Q < 60$ ★★ $60 \le \Sigma Q < 80$ ★★★ $80 \le \Sigma Q$
additional item	Null	Innovation (below 10)

evaluation. Design evaluation includes (1) Land saving and outdoor environment; (2) Energy saving and utilization; (3) Water saving and utilization; (4) Material resource utilization; and (5) Indoor environmental quality. Operational evaluation is included in another two chapters: (6) Construction management; and (7) Operation management, which covered the life-cycle of buildings.

The evaluation system of Chinese green building rating tool is divided into first level indicators and second level indicators, the latter of which must have control conditions and scoring items. In addition, both of them have set up innovation plus. Based on the six indicators: (1) land saving and outdoor environment; (2) energy saving and utilization; (3) water saving and utilization; (4) material saving and utilization; (5) indoor environment quality; and (6) operational management in the original "green building evaluation criteria" GB/T50378-2006, the newly-revised "green building evaluation criteria" GB/T50378-2014 adds "construction management" for effectively covering the whole life-cycle. These evaluation criteria have weighting factors for scoring. The highest item is energy saving, which indicates that with the global energy crisis, each country has paid additional attention to energy saving and emissions reduction. The second one is land saving and outdoor environment. In addition to the energy crisis, the deterioration of global environment is also very urgent. With the development of the living standard, the awareness of environmental protection has been improved in China. Therefore, this evaluation standard is in line with national conditions.

These evaluation methods have quantitative evaluation and control rating. If the evaluation result meets the fixed terms, it will be classified into "fulfilled", otherwise "unfulfilled". This expression is simple and clear and has its unique advantages. The rating of domestic green building standards keeps consistency with LEED, learning from the international green building standards and expertise. (EBGS2006 changed "the general item" in the old standard into "the rating item" and cancelled "the preferences"). The total score of the evaluation system is 100, which is the sum of the scores of the corresponding categories. The minimum score of green building should not be less than 40 points for each criterion.

The green building certification is an evaluation activity based on the Green Building Evaluation Standards and other relevant national standards and regulations. Experts organized by the State Ministry of Housing evaluate the residential and public projects being designed, constructed or having been completed from seven aspects: (1) land saving and outdoor surroundings; (2) energy saving and utilization; (3) water saving and utilization; (4) material utilization; (5) indoor environmental quality; (6) operation management; and (7) construction management. The experts determine the suitable weighting coefficient of the seven aspects and finally summarize the evaluation to make sure whether it is in accordance with the green building standards.

Green building identification is divided into two categories: Green Building Design Evaluation Identification (which is conducted after the examination of construction design); and Green Building Operation Evaluation Identification (which is carried out after one-year use of the building). To evaluate whether a green building has truly achieved the effect of environmental protection, it should be evaluated by all indicators. The design evaluation identification is for the drawing and the plan instead of the construction and operation.

3. Research methodologies

A case study in China was investigated in this research project. Case

Table 3
Details of interviewers.

Description	Designation	Affiliation	Level of experience (years)
Interviewer 1	Engineer	The Housing and Construction Bureau	3
Interviewer 2	Director	Real Estate Company	10
Interviewer 3	Associate Director	The Housing and Construction Bureau	5
Interviewer 4	Engineer	Contractor	6
Interviewer 5	Researcher	University	5

study research is accepted as a scientific tool in qualitative research [29]. According to Yin [30] case studies involve the study of a phenomenon in its real-life context with the use of six sources of evidence namely documents, archival records, open-ended interviews, focus interviews, structured interviews and surveys and observations. Interviews are one of the most important sources of information and useful in capturing data especially in case studies [31]. It is essential to interview key players in the project to gain an understanding of the project, striking a balance between those who can offer different insights. After identifying the case researchers conducted structured interviews with 5 professionals directly involved in the project. Table 3 illustrates the details of the interviewers.

Apart from the interviews researchers made close observations to derive conclusions. Further, documents were evaluated to understand how this building obtained certain green featured within the operational stage.

3.1. Introduction to the case study

Shenzhen Vanke project is located in Banxuegang area, Buji town, Longgang district of Meilin, accessed by the Shenzhen Vanke Real Estate Co., Ltd. in 2003 through a public auction market, with a total area of 44.04 million square meters, 45.27 million square meters of construction area as well as more than 4000 households. This project belongs to the residential project and has complete ancillary facilities which include commercial matching and nine-year public schools of 30,000 square meters.

The four-phase of this project is located in the northeast of Shenzhen Vanke project, designed in June 2005 and completed in January 2009. It covers 96,201 square meters and 125,986.21 square meters of construction area. This project includes high-rise residential, low-rise residential, commercial, residential facilities and kindergarten. The number of high-rise residential accounts for 81.2% of the total number; the green site rate takes up 38.1%; the high-rise residential utilized the shear wall structure while the low-rise residential used frame structure.

In April 2006, the four-phase of Shenzhen Vanke Project had passed the review of the Country's top ten key energy conservation projects judged by the National Development and Reform Commission and was the only Green Building Integrated Demonstration Projects. In June 2006, the four-phase of Shenzhen Vanke Project had become the first batch of circular economy demonstration projects and the first green building demonstration projects. It has obtained a three-star grade for the design stage in March 2009 and three-star grade for the operational stage in February 2011.

4. Key results of operational evaluation

This case study project obtained three-star grade for the operational stage. As such, initially, the key criteria of this project are evaluated considering each of the evaluation parameters.

4.1. Land saving and utilization

This project took the original topography, climate in the south, ecological planning and technical difficulties into account. The project is reasonable to develop the use of underground space, high-rise residential underground space for parking and equipment, low-rise residential underground space for storage. Besides, it ultimately ensured the continued operation, reflecting the true value of the whole life-cycle of green building.

4.2. Energy saving and utilization

As Shenzhen belongs to such an area with hot summer and cold winter, therefore, based on its own climate characteristics, this project optimized the community planning and apartment design by introducing the concept of natural ventilation. For example, the opening of the window should be accounted for more than 10% of the floor area, which was higher than the design standard of 8%. Although it increased the construction cost, it was beneficial to the indoor natural ventilation.

The project uses the solar hot water system, in which the high-rise residential use a direct-insert solar vacuum tube hot water system. The lower house uses the solar panel hot water system. The upper and lower floors total 227 households use solar thermal system, accounting for the total number of 836 households 27%.

4.3. Water saving and utilization

The four-phase of Shenzhen Vanke Project utilized 100% water-savings appliances which can effectively conserve water. It is the first project in the south with the wide use of reclaimed water. High-quality miscellaneous drainage, sewage is the sources of reclaimed water that can be used in irrigation, road spraying, landscape watering and others. This system of scale waits for the developers to build water stations, and needs for recognition from society and customers, and asks for effective technology solution of high performance and easy maintenance which to some extent will hinder the promotion of water system. If the city voluntarily intervenes to provide the reclaimed water, then there will be a better solution with municipal reclaimed water usage.

5. Material saving and utilization

The four-phase of Shenzhen Vanke Project involved simple elements of residential building design. Decorative construction costs accounted for only 0.27% of the project cost which was far less than the requirements of 2%, and the buildings used 100% the ready-mixed concrete.

Solid waste produced in the project included cardboard, metals, concrete blocks, asphalt, beverage cans, plastic, glass, gypsum board, wood products, and others. Recycled waste took up 41.41% of the total amount of the wastes as shown in Table 4. The recycled material can be reused in the building as a result of saving raw material, reducing waste

Table 4
Ratio for waste utilization.

Material	Material usage (kg)	Weight of waste material (kg)	Amount of waste material reuse (kg)
Mortar	44,154,896.00	4,415,489	1,324,646
Stone	2,620,441.20	131,022	65,511
Building Blocks	14,277,297.42	2,141,594	1,070,797
Steel	11,687,603.73	584,380	584,380
Aluminum Alloy	576,251.31	28,822	28,822
Glass windows & doors	2,433,849.48	121,692	–
Total waste		7,422,999	
Amount of waste utilization			3,074,156
Ratio			41.41%

Table 5
Evaluation criteria addressed in international green building rating tools.

Green building rating tools	LEED v4 Building operational and maintenance								Green Star Performance v1.1
Evaluation criteria of Chinese tools	Evaluation criteria of international tools								
	Location and transport	Sustainable sites	Water efficiency	Energy and atmosphere	Material and resources	Indoor environmental quality	Innovation	Regional priority	Management
Land saving and utilization	-	✓	-	-	-	-	-	-	-
Energy saving and utilization	-	-	-	✓	-	-	-	-	-
Water saving and utilization	-	-	✓	-	-	-	-	-	-
Material saving and utilization	-	-	-	-	✓	-	-	-	-
Green building rating tools	Green Star Performance v1.1								BREEAM International New construction
Evaluation criteria of Chinese tools	Evaluation criteria of international tools								
	Indoor environmental quality	Energy	Transport	Water	Material	Land use and ecology	Emissions	Innovation	Management
Land saving and utilization	-	-	-	-	-	✓	-	-	-
Energy saving and utilization	-	✓	-	-	-	-	-	-	-
Water saving and utilization	-	-	-	✓	-	-	-	-	-
Material saving and utilization	-	-	-	-	✓	-	✓	-	-
Green building rating tools	BREEAM International New construction								
Evaluation criteria of Chinese tools	Evaluation criteria of international tools								
	Health and wellbeing	Energy	Transport	Water	Material	Waste	Land use and ecology	Pollution	Innovation
Land saving and utilization	-	-	-	-	-	-	✓	-	-
Energy saving and utilization	-	✓	-	-	-	-	-	-	-
Water saving and utilization	-	-	-	✓	-	-	-	-	-
Material saving and utilization	-	-	-	-	✓	✓	-	-	-

generation, and lowering environmental impacts on the production and transportation of the needed material. Using recycled material is a very environmental and friendly way that not only saves money but also reduces carbon emissions, fully reflecting the necessity of material saving for green buildings.

The integration of civil engineering and decoration provides a comprehensive solution for households for the owners, which does not need major adjustments to the pipeline after registering so that the owners can directly carry out the construction of interior decorations. That will save the material in the process of construction and reduce barriers in the late decoration of the buildings with the consideration of actual needs of the owners as well as in line with the requirements of green building operation.

These are the main key parameters addressed to obtain ESGB 2014. However, it is worth identifying whether this project caters other green building rating tools during the operational phase as well. Therefore, researchers identified the possible credit points that can be addressed in international rating tools as well. Table 5 illustrates the findings considering other international building rating tools within the operational phase.

The case study project obtained the required level of points considering four criteria namely land use, water, energy and material. International tools include these evaluation criteria in the green building evaluation. According to Table 5, LEED, BREEAM and Green Star, green building operational rating tools consider these evaluation criteria. Further, this project uses 100% water saving appliances leading to massive savings in the operational stage. This strategy will be rewarded in all the three international rating tools. Apart from the main evaluation criteria, this project addresses emission sections in Green Star and also waste section in BREEAM (refer Table 5).

As illustrated in previous sections, this case study obtained three stars for the operational stage. Further, Table 5 addresses a couple of evaluation criteria in international green operational ratings as well. However, according to the introduction, there is a clear lack of projects obtaining certification during the operational stages. Therefore, researchers conducted interviews among key roles of this project to identify the obstacle faced in obtaining this certification.

6. Interview results and discussion

The following step of the research presents the structured interviews with the key players of the project. After a significant analysis of the interview responses, researches identified the following barriers for promoting operational stage certification of green buildings.

6.1. Inconsistency of the government regulations

Since 2008, China began to implement the green building evaluation label. Local government take coercive measures for promoting green buildings that only after obtaining green building design evaluation label, the government issue the construction permit or will the acceptance be completed, which mandatory design evaluation for the buildings. However, the evaluation of operational stage is carried out after a-year completion which makes it difficult for the government to supervise the evaluation of operational stage.

6.2. Inability of the market to protect developers' interests

For some developers, the certification of design stage is just access to the approval of construction and completion of acceptance. However, in the actual situation, developers concern on the cost of adopting a set of water systems and its maintenance cost comparing to annual savings from the usage of the system, of which it can be resulting not meeting developers' requirements on profits even if it is conducive to sustainable development.

6.3. Inability to meet the requirements

To obtain a star certification of green buildings, in the design process, there are green building technologies which can be combined, most of which do not put to use and at the same time, some of which do not work well for technical operation. There is no complete system of alternative technologies for designers when designing green buildings. Green building requires a variety of new material when being constructed while the property of domestic material cannot meet the requirements. The new material, therefore, needs to be imported, which increases not only the cost of material but also the transportation. Meanwhile, the utilization of new material to a certain extent also affects the design of the building. For example, the usage of sound insulation floor influences the story height.

6.4. Measures and suggestions for promoting green buildings

With the development of globalization, green building evaluation systems in other countries are used for evaluating the architecture of China, of which BREEAM and LEED are the most commonly adopted. Whether the other evaluation systems are in line with Chinese national conditions and development remains to be further explored and studied. However, most of the interviewees' suggested similar measures to promote green buildings within the operational stages. Further, these measures can be used to overcome the barriers.

6.5. Central macro-control and local specific implementation

Government is the policy maker, who develops the framework of green buildings, including laws, regulations, and incentive mechanism. Technically, the government is also the supporter of research and development. Green buildings cannot be separated from the application of new technologies. Therefore, the government has the responsibility to promote the development of technologies. Due to different climate conditions in China, specific standards for different regions are lacking. Evaluation systems should contain quantitative standards with high qualities, research and application on quantitative, qualitative index must be enhanced.

Based on the basic conditions of China, the central government should develop the framework of the implementation of green building evaluation systems. Meanwhile, the local government, not only referring to the provincial administrative units but also the municipal government, should develop green building policies suitable for the local conditions, such as Shenzhen, Dalian and other places, which have formulated specific rules for their development of the city.

6.6. Coordination of various departments

The construction and evaluation of green buildings is not a department's or agency's responsibility. It needs to take energy, land, water resources, material, indoor environment and other factors into account, which requires the coordination of the Development and Reform Commission, the Planning Department, Construction Department, Financial Department, Transportation Department and other departments as well as strengthened supervision and implementation of green buildings. All departments should study how investments in green buildings contribute to local economy. They should also launch a communication campaign to inform developers that green building offers a higher net operating income.

6.7. Implementing compulsory measures

Most green building evaluation systems around the world are voluntary basis for the implementation, which requires a high degree of consciousness of the enterprise. However, it is necessary to take compulsory measures for some large construction projects from the longterm interests. The government should play an important role in promoting green building implementation.

According to the interviews, in China, there is a requirement to obtain a green building design evaluation label, before obtaining the construction permit. This strategy has a significant impact on developing green designs. However, this approach can further be extended to cover the operational phase as well.

6.8. Training professionals of green buildings

Lack of knowledge of technologies has become an obstacle in green building development. The existing evaluation system does not qualify green buildings from the personal perspective. Therefore, it is necessary to train relevant personnel as well as conduct qualification examination. The government should continue to support research and development on energy saving technologies for promoting technical communication. Moreover, improving the level of property management is equally important. Currently, the personnel of property management do not understand the true meaning of green buildings, which greatly affects the operational stage of green buildings. Therefore, it is necessary to pay additional attention for strengthening the cultural quality and professional level of property management personnel, and thus improving their awareness of green buildings.

6.9. Practical design

Design drawings should consider quality, cost, schedule and other factors, not only about obtaining green building evaluation labels for design stage. After the completion of designing, designers should cooperate with owners and property sector in the process of green building evaluation label for the operational stage, and all things about green technologies and material to the relevant department, ensuring that green buildings can operate as it should from the design phase.

6.10. Improvement of the green building market mechanisms

Market demand constraints the trend of green building. Market regulation, however, would guide green buildings to a better direction. The transparency of market information is an important guarantee for the promotion of green building operation evaluation. Open and true information can help stakeholders understand risks and benefits, plus providing an important reference for green building investment. At the same time, it can guarantee the implementation of green buildings by introducing market competition mechanism and establishing a professional green building consulting agencies. Regarding the new agencies, new material and new technologies, it is necessary to strengthen the promotion and advocate innovation, attracting qualified investors.

6.11. Addressing the developers' interest

One of the main barriers to implementing green building operational certification is that the lack of interest of the developers. If the building has a green design certificate, that will provide a developer with a profit due to higher demand of the building. However, during the operational phase of the building, only the building user will be rewarded. Therefore, developers are not motivated to obtain an operational stage certification of green buildings.

7. Summary and conclusions

The relevance of the presented research lies in addressing the insufficient research effort on the operational performance of the green building concept. The existing research projects mostly focus on the design phase, which leads to the lack of feasibility for green building. However, the new green buildings are still in accordance with traditional construction modes which consume additional manpower, financial and material resources, resulting in economic and ecological disadvantages. The promotion of green building operation is therefore the next step of the evaluation process, and is also a reasonable means to control the operational stage.

After reviewing the existing green building rating tools, this paper presents a case study in China, the Shenzhen Vanke project. This paper presented the evaluation of the key criteria of this Shenzhen Vanke project, which included Land saving; Energy saving; Water saving; and Material saving & Utilization for the operational stage. For example, this analysis showed that the decorative construction cost of the project comprised only 0.27% of the total project cost, which shows less than 2% requirement.

Based on the case study results, this paper also analysed the barriers of operating green buildings and provided suggestions for further measures and developments. The promotion of effective operating green buildings as per design requirements must combine the participation of various stakeholders with the concept of sustainable development, life-cycle consideration, and other related concepts. Considering the status of green buildings and basic national conditions, stakeholders should find a suitable road for the development of green buildings while paying full attention to the operational stages of green buildings.

Furthermore, it was observed that both international and Chinese standards have similar evaluation criteria for operational stages. However, regulatory bodies and governments have a significant role to play in developing standards and policies to promote the usage of green building certification during the buildings' operational stages.

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