Comparison of Both Old and New Versions of the Evaluation Standard for Green Building in China with LEED in American

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Abstract At present, energy saving and emission reduction have become a central task for all countries and governments, and green building has become a research hot spot at the same time. Green building is the building which maximizes the conservation of resources, protection of the environment, and realization of coordinated unification between human and nature in the whole life cycle of the building. Green building is an important embodiment of sustainable development strategy. At the beginning of the 1990s, the concept of green building was introduced to China. In recent years, in order to promote the development of green building, China issued a series of related approaches and normative documents, such as Evaluation Standard for Green Building (GB/T50378-2006). Recently, in order to improve the green building standard, the Ministry of Housing and Urban Construction gives out the announcement, approving the Evaluation Standard for Green Building as the national standard, numbered GB/T50378-2014. The US Green Building Rating System (LEED) is now considered to be the most sophisticated and influential among all kinds of environmental protection assessments. In the revision of the Evaluation Standard for Green Building, certain aspects of LEED were consulted, so there is similarity between the two standards. But Evaluation Standard for Green Building also has its own characteristics based on China's conditions. So this chapter pays attention to the comparison of the Evaluation Standard for Green Building (the latest revision), Evaluation Standard for Green Building (GB/T50378-2006), and US LEED standards. It uses the following eight aspects: evaluation phase, evaluation objects, index categories, refined indicators, scoring points, evaluation methods, evaluation results, and weight distribution to show the similarities and differences among the three standards. And it can point out the advantages and shortcomings of Evaluation Standard for Green Building in China and makes reasonable suggestions.

Keywords Comparison · Evaluation Standard for Green Building · LEED · Standard

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1 Introduction

Green building refers to the architecture which makes scientific planning, guidance, and advanced applicable technology to decrease the consumption of resources and energy, reduces waste generation and damage to the ecological environment, provides users a comfortable, healthy working and living environment, and ultimately achieves symbiosis with nature in its entire life cycle (Zuo and Zhen 2014).

At the beginning of the 1990s, the concept of green building was introduced to China. In recent years, in order to promote the development of green building, China issued a series of related approaches and normative documents. On June 1, 2006, China began to implement Evaluation Standard for Green Building (GB/T50378-2006) [hereinafter referred to as the "standard (2006)"] (Wan et al. 2009). On November 15, 2007, the Green Building Evaluation Standard issued, which marked that green building evaluation in our country has entered a new stage.

Recently, the Ministry of Housing and Urban Construction gives out an announcement, approving the Evaluation Standard for Green Building as the national standard, numbered GB/T50378-2014,[1] [abbreviated as "standard 2014"] and it will come into effect from January 1, 2015. New version of Evaluation Standard for Green Building has more requirements and more extensive content than the 2006 version. In the revision process, the standard summarizes recent practical experience and research results of green building evaluation, carried out a number of research and trial and evaluation, used the experience of the relevant foreign advanced standards, and solicited opinions from the relevant parties. For the revised criteria, the target range has been extended, the evaluation phase is clearer, evaluation method is more scientific, and evaluation index system is more perfect and innovative.

The US Green Building Rating System (LEED) is now considered to be the most sophisticated and influential among all kinds of environmental protection assessments, green building assessment, and building sustainability assessment criteria all over the world. And many countries used it as the model to build their own green building and building sustainability of the Evaluation Standard (Seinre et al. 2014).

In this chapter, the two versions of the Evaluation Standard for Green Building (GB/T50378-2006) (Evaluation Standard for Green Building 2006) (GB/T50378-2014) were analyzed with LEED (Green Building Council 2008), in order to identify the advantage of the "standard (the latest revision)" comparing to the "standard (2006)," and put forward recommendations for continued improvement of the Evaluation Standard for Green Building.

[1] Evaluation standard for green building (draft) (EB/OL). Beijing: Ministry of Housing and Urban-Rural Development of the People's Republic of China; Available from http://www.mohurd.gov.cn/zcfg/jabwj_0/jsbwjjskj/201209/t20120919_211434.html (in Chinese).

2 Comparing the Similarities and Differences of China's Evaluation Standard for Green Building and LEED in USA

In the revision of the Evaluation Standard for Green Building, certain aspects of LEED were consulted, so there is similarity between the two standards. But Evaluation Standard for Green Building also has its own characteristics based on China's conditions. This section gives detailed analysis and comparison of LEED and Evaluation Standard for Green Building (old and new versions), which includes the following: the assessment phase, evaluation objects, index comparison, refined indicators, scoring points, evaluation methods, evaluation results, and the weight setting (Li and Ling 2011).

2.1 Evaluation Phase

Buildings that adopted LEED evaluation criteria can be divided into three phases according to the progress of the project: design, procurement, and construction phase. Design phase mainly refers to take energy, water, and building comfort of use into consideration during the design, such as air-conditioning systems, water recycling, lighting, and other aspects; Construction phase mainly refers to site controlling, construction waste management, and indoor construction and air quality control; Procurement phase mainly refers to the procurement of recycle materials, local materials, renewable materials, and low volatile materials. Commissioning, energy-saving device measurement, and the thermal comfort survey can be taken after the construction is completed.

The standard (2006) of green building assessment focuses on the operational phase. It says the evaluation shall be conducted one year after the building put into use. The evaluation emphasizes on the actual performance and running effect of the building.

The assessment phase of the revised standard can be divided into the design evaluation and operation evaluation, and adding architecture design and four environmental performances evaluation to it.

Operation evaluation is not only to evaluate green measures, but also to evaluate the practical effect produced by these green measures. In addition, it also pays attention to green footprint produced in construction process of green architecture and scientific management during normal operation.

Although the design evaluation is not as comprehensive as operation evaluation, it also has a great meaning and value. First, these green measures involved in the design evaluation have been proved to be effective, and these effective measures greatly ensure that the effect is obvious. Second, the design evaluation is a forward evaluation and can find problems early, thus helps solve problems and improves the evaluation effect. Finally, from the perspective of implementation, the design evaluation is easier than operation evaluation in a wide range.

2.2 Evaluation Objects

According to different types of buildings and different stages of life cycle, the core products of LEED can be subdivided into eight categories: existing building, core and shell, new construction, school, neighborhood development, retail health care, homes, and commercial interiors (Ouyang 2008). The evaluation objects of standard (2006) are divided into residential buildings and public buildings which includes three types: office, shopping malls, and hotels. The new version green building standard extends the applicable scope to all types of civil construction.

Considering China's construction market situation at that time, when old version of the standard compiled, it mainly focused on evaluating the residential construction with large amount and public buildings with large resource consumption. The new green building standard extends the applicable scope to all types of civil construction, to meet the needs of the present stage of green building practices and evaluation work.

Compared with the LEED family of different types of buildings, the standard (2006) covers less evaluation objects, and the division is not detailed enough. The standard (the latest revision) tends to cover more comprehensively in terms of subject.

2.3 Index Categories

Table 1 is the comparison of indicator categories among LEED (with LEED-NC, for example) and the old and new versions of standard, and you can see that the top

Table 1 Index categories comparison of LEED and China standard

	LEED	Standard (2006)	Standard (latest revisions)
Similar indexes	Sustainable sites	Land saving and outdoor environment	Land saving and outdoor environment
	Water efficiency	Energy saving and energy utilization	Energy saving and energy utilization
	Energy and atmosphere	Water saving and water utilization	Water saving and water utilization
	Materials and resources	Material saving and material utilization	Material saving and material utilization
	Indoor environment quality	Indoor environment quality	Indoor environment quality
Dissimilar indexes	Innovation in design	Operation management	Operation management
	Regional priority		Construction management

five categories are similar indexes of the three standards, involving two aspects: energy and resources, and environment load and indoor environment quality.

Different indexes reflect in the following aspects: (1) LEED displays the whole building life cycle by combining the building design (LEED-NC) and operations management (LEED-EB), standard (the latest revision) increases construction management evaluation index to cover the whole life period and phase of building, and this does not reflect in the standard (2006); (2) LEED sets design and innovation index. The standard (2006) sets preference item in every type of indicators to reflect innovation. The standard (the latest revision) adds innovation items uniformly, innovation item can also be classified into seven indexes, respectively, but in order to separate the requirements and measures and encourage green building with the basic requirements in seven district areas, the standard (the latest revision) will put all the provisions of the innovative item together, listed as a separate chapter; (3) Besides, LEED adds geographical advantage item in view of the climate and resources in different areas of the United States, projects meeting the indicators can get extra points; While the Chinese green building standard reflects a region difference by setting some control items to decide whether the building can take part in the evaluation. In a word, it can be seen that the indexes of China standard have the advantage of dividing index categories more concise, but not as clear and detailed as LEED.

2.4 Refined Indicators

The specific indicators of the standard (2006) are divided into control, general, and preferences items. Among them, the control item is the essential term of green buildings; preferences item primarily refers to the items that are difficult to achieve and have higher requirements. The new version of green building standards would keep the original control item unchanged, cancel the general and preferential items, merge them into a score item, and set the innovative item at the same time. Similar to the new version standard, every index of LEED is made up of required item and score item.

Although the refined indicators are similar, the detailed contents are different. Each index control item number in Evaluation Standard for Green Building ranges from 2 to 10, and these indicators must be realized at the same time. This will reduce independent selection of green building and thus ignores the region differences; by contrast, the rigid index of LEED is much less, each category sets 1–3 control items. But, the LEED emphasizes integrality and comprehensive of performance; users can evaluate and design the building according to the technical and economic conditions of the region.

In addition, the operation management index in the Evaluation Standard for Green Buildings mainly aimed at late green construction management and property management. Developing appropriate management indicators in view of the status of national conditions will help strengthen the role of people in green building management, so as to improve the design and operation efficiency, promote the healthy and long-term development of green building (Zhang 2011).

2.5 Scoring Points

LEED evaluation points are divided into three types: Prerequisite, any eligible projects must meet all the conditions to assess the premise, otherwise it will not pass the LEED certification; Credits, that is, in the five aspects mentioned above, every level of LEED certification should meet the requirements of the corresponding points; innovation credits, if evaluating project adopts technology measures that were not mentioned in the LEED and achieves significant effect, it should be rewarded certain innovation points. In order to stimulate the project that addresses geographically specific environmental priorities, it also can get the corresponding points.

LEED clearly gives the purpose, requirements, technical measures recommended, as well as the proven documentation required to submit of each score point. Each score point contains a number of sub-items and each sub-item is based on the above score point. Meanwhile, LEED also made reference to ASHRAE Standards (American Society of Heating, Refrigerating and Air-Conditioning Engineers) and other department standard and made a clear definition to some evaluation concept that makes it easy to understand and operate.

The standard (2006) is not satisfying in terms of scoring points. The entries are scattered; most evaluation contents are qualitative and lack of necessary technical parameters and practical experience so that the operator do not know how to start. This is one of the biggest obstacles in the implementation process of the standard.

The entries of standard (the latest revision) vary widely with respect to the standard (2006), but are closer to the specific requirements of LEED. Such as in the aspect of energy-saving, both new versions standard and LEED require the use of renewable energy and optimization of energy efficiency. In terms of water saving, both are required to reduce water consumption, innovate wastewater technology, and reduce surface water erosion. As to material saving, both require building reuse, material recycling, and waste management. Considering the land, both pay attention to the ecosystem of the area and the heat island effect. Sound insulation, heat insulation, reducing harmful substances emissions, thermal comfort and view requirements, and other indoor environment requirements must be meet in both of the standard (2014) and LEED (Hu 2010).

2.6 Evaluation Methods

Both LEED and new version green standard use quantified scoring method which gives scores depend on the degree of the implementation and effects of the measures, but they are not exactly the same: LEED uses the total score as the final result, while the standard (the latest revision) evaluation grade is determined by the total score rate; standard (2006) adopts counting the number of provisions as evaluation methods.

The method of counting the provisions number in the standard (2006) has certain defects: Many of these measures are qualitative, so their accuracy and authority are not ideal. In terms of the evaluation results, only "pass" and "not pass," there is no intermediate state of the two, so the standard conditions are more demanding (if there is a requirement that is not met, the result is "not pass"). To quantify the score point is the basic requirement to guarantee the evaluation result as an objective result, therefore the standard (the latest revision) improves and establishes a quantifiable evaluation.

In contrast, the standard (the latest revision) uses the score counting method to determine the level, which is a major update element of the standard. The determined level keeps uniformity and consistency with LEED which is the international popular green building evaluation criteria. It should be said that those measures reflect that domestic green building designers absorb and inherit the international green building standard's essence and strengths. The biggest advantage of the score counting method is that it increases the flexible of space, providing a richer selection of space for green building design. The biggest advantage of the score counting method is that it increases the flexibility of space, providing a richer selection of space for green building design.

At the same time, the standard (the latest revision) also continued to a certain extent of the advantages of the standard (2006), namely control the lowest total score points rate and prevent building having "short board" in certain aspects of performance.

2.7 Evaluation Results

According to the final grades, LEED has four rating levels: certification, silver, gold, and platinum. In the standard (2006), according to the number of meeting the general and preferred items, evaluation results can be divided into three levels: one star, two star, and three star. Besides the control items should be fully met, all of the three levels should meet the relevant request: number of provisions and general items; standard (the latest revision) green building rating is determined by the total score rate, besides to meet all of the control items, the minimum score rate of every index is 50 % in order to avoid the buckets effect.

Table 2 is the comparison of evaluation results among the three standards. As can be seen from table, American standard (with LEED-NC for example) is more detailed than the Chinese standard overall, but the American standard certification's starting level is low; standard (the latest revision) (with residential building for example) certification level is slightly higher than standard (2006) (with residential building for example), especially one-star certification. Besides, China's standard is a little higher than LEED, one-star level certification in China is between certification and silver level in LEED, two-star level is between gold and platinum level of LEED, and three-star level slightly higher than the LEED platinum level.

Table 2 Comparison of certification level, score, and proportion in LEED and China standard

USA		China		
LEED			Standard (2006)	Standard (the latest revision)
Level	Total score (%)	Level	The total number of compliance (%)	The total scoring rate (%)
Certification	40–49 score (36.4–46.5 %)	One star	18–29(36.7–59.2 %)	50–65 %
Silver	50–59 score (45.5–53.6 %)	Two star	30–39(61.2–79.6 %)	65–80 %
Gold	60–79 score (54.5–71.8 %)	Three star	40–49(81.6–100 %)	80–100 %
Platinum	80–110 score (72.7–100 %)			

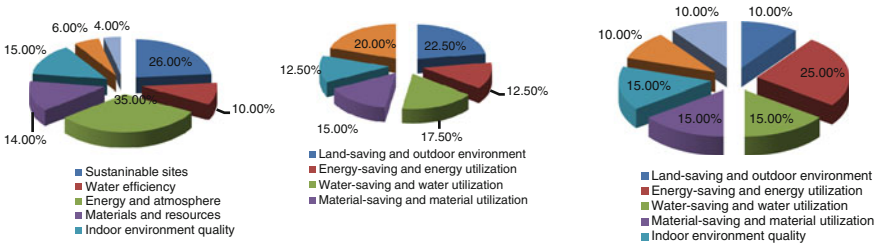

Fig. 1 Index weight distribution of USA LEED and China Standard

2.8 The Index Weight Distribution

Figure 1 is a comparison of index weight distribution of various categories of LEED and China standards. As shown in the Fig. 1, energy, atmosphere, and sustainable areas account a large proportion of weight distribution in LEED, reflecting the important consideration of energy reduction in LEED. China standard's weight distribution is more equal and does not reflect the focus on certain indicators.

3 Improvement of the New Evaluation Standard for Green Building

Table 3 is a general comparison of LEED and China green building standards. Through the above description and Table 3, it can be seen that the standard (the latest revision) has greatly improved in many ways, which are mainly shown in

Table 3 General comparison of USA LEED and China Standard (2006, 2014)

	The assessment phase	The evaluation objects	The index categories	The refined indicators	The scoring points	The evaluation methods	The evaluation results	The weight distribution
China Standard (2006)	Operation phase	Residential buildings and public buildings	1. Energy, resources and environment load and indoor environment quality	Control, general, and preferences items	No perfect	Counting the number of provisions	One star, two star, three star	Slightly balanced
			2. Operation management					
China Standard (the latest revision)	Design phase Operation phase	Civil construction	1. Energy, resources, and environment load and indoor environment quality	Control and score items	Not so perfect	Total score rate	One star, two star, and three star	Slightly balanced
			2. Operation management					
			3. Construction management					
LEED	Design, procurement, and construction phase	LEED family products	1. Energy, resources, and environment load and indoor environment quality	Required item and score item	Perfect	Total score	Certification, silver, gold, and platinum	Energy and atmosphere and sustainable areas account a large proportion
			2. Innovation in design					
			3. Regional priority					

following aspects: (1) Increase the assessment phase, the standard (the latest revision) are not just for the operation evaluation of a building, but also adds design evaluation. (2) The applicable scope is broader; the new national standard will extend the applicable scope to all kinds of civil construction. (3) The system structure of the standard (2014) is more compact; the standard maintains the original control item unchanged, merges the general and preferential items into a score item, adds a new construction management item, and improves the innovation item. (4) The provisions are more quantitative and qualitative; the applicability is clearer and more flexible, and the provisions adopt the method of dynamic updating. (5) Evaluation method upgrades: Standard (the latest revision) with scores counting method replaces the standard (2006) with the number counting method. (6) Modify the part of the evaluation provisions and distribute scores for all score and innovation items.

4 The Shortcomings Existing in China Standard

Compared with LEED and other more mature green building rating system in the world, China's green building standard still needs some improvements.

(1) Evaluation Standard for Green Building should increase building classification and formulate the corresponding standards.
In China, although the standard (the latest revision) will extend the applied scope to all civil building types, it does not mention new construction, expansion building, and retrofitting building. By contrast, the core products of LEED are subdivided into eight categories according to the different stages and different types of buildings and have a very comprehensive coverage. In addition, such divisions of LEED facilitate a variety of users. This is also the reason why LEED is widely accepted in the USA and around the world.

(2) Incomplete assessment phase
According to the project's process, buildings adopting the evaluation criterion of LEED can be divided into 3 phases, such as designing, procurement, and construction. Although design evaluation was included within the scope of the assessment in the standard (the latest revision) of our country and made up the lack of evaluation in the operation phase, but it does not consider ground controlling at construction stage and reusing of materials at procurement phase.

(3) Lower the threshold of evaluation system access
Reducing the threshold of evaluation system access is very important for the development of green building market and relatively easy to do. On the other hand, the mutual compensation of the indicators among energy, resources, and environment load can exist to avoid some buildings with high performance failing to participate in the evaluation.

(4) Strengthen advertisement power
The transformation of the whole society will be the most effective power to promote the concept of green building, which has been confirmed in European–American Nation. At present, we are only in "shout" stage for green building. So, we could use the network, television, newspapers, magazines, and other media to carry out rich energy saving and green building propaganda diverse forms and to improve the social awareness of the importance of the promotion of energy saving and green building.
(5) Optimize process of green building certification
LEED evaluation system has been able to achieve great success and so widely used, because of its underlying set of compact and concise reporting processes. Comparing with the relatively complicated process for green buildings in China, LEED is more mature and highly efficient. Green Building Council of America chooses their own review of the green building; that is, all of the results are from the same review team, which are more fairer and persuasive. In addition, LEED has specific provision to apply for certification for the time of each step period, and the evaluation architecture is open in the LEED information platform, which are more just and open. This is worthy of our study.

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