New Development of China's National Evaluation Standard for Green Building (ESGB-2014)

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NEW DEVELOPMENT OF CHINA'S NATIONAL EVALUATION STANDARD FOR GREEN BUILDING (ESGB 2014): A COMPARISON OF ESGB 2014 TO ESGB 2006

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Abstract

In 2006, China published the first National Evaluation Standard for Green Building (ESGB), which soon became the most widely spread evaluation system in the country. With the fast growth of urbanization, ESGB 2006 version no longer meets the current needs and requires an update. Based on the implementation outcomes of ESGB 2006 and expert opinions, the Ministry of Housing and Urban-rural Development published a new version of ESGB in 2014 (ESGB 2014). This research reviews the previous cases of buildings accredited with ESGB 2006 and collects the facts and data to explain the implementation results and identifies its weakness of the ESGB 2006. A comparative analysis of the ESGB 2014 with ESGB 2006 is based on an in-depth overview of both ESGB 2014 and ESGB 2006. The comparison results shows the improvement of the current ESGB 2014 in details, i.e., evaluated object, stage partition, weighted value, structure, indicators, etc. A case study is followed by choosing one building project to evaluate and calculate the green building accreditation according to both ESGB 2014 and ESGB 2006, and demonstrate the differences and development of ESGB 2014.

1 Introduction: Green Building Assessment in China

Green building is an important embodiment of sustainable development strategy, and evaluation system is a significant tool to guide the construction and operation of green building. Since 1990s, many countries have developed a number of green building assessment tools, such as LEED in the USA, BREEAM in the UK, CASBEE in Japan and SBTool, etc. With the rapid process of urbanization in China, the development of green building has been progressing steadily. The first green building standard system in China – Evaluation Standard for Green Building (GB/T 50378-2006) was established in 2006. The compile of the ESGB 2006

learnt from the experience of the international best practice in GB tools, and adjusted its structure and contents to suit for the local situations of China. The establishment of ESGB 2006 set the most important basis of green building design and evaluation in China, and the theoretical foundation local standard. However, with the fast growth of urbanization, the ESGB 2006 version no longer meets the current needs and therefore requires an update. Based on the implementation outcomes of ESGB 2006 and expert consulations, the Ministry of Housing and Urban-rural Development published a new version of ESGB in 2014 (GB/T 50378-2014, ESGB 2014).

This paper first gives a detailed overview of ESGB 2006 and collects the facts and data to explain the implementation results and identifies its weakness of the ESGB 2006. It then compares the ESGB 2014 with ESGB 2006, based on an in-depth overview of both ESGB 2014 and ESGB 2006 application to a selected case study building.

2 ESGB 2006overview

Up to December 31st, 2014, there had been 2,538 projects apply for the Green Building Evaluation Label (ESGB 2006), including Design Label (93.7%) and Operation Label (6.3%), and the total area reached 290,000,000 square meters. Compared to the data of 2008, the amount of applicants had grown over 100 times. Most of the projects applied for 1-star or 2-star level, and the types of building were mainly residential building and other building typology including office building, commercial building and hotel building. Only 0.9% of the applicant projects were industrial building. (Figure 1 and Figure 2)

Figure 1 Applicant numbers of different levels from 2008-2014 in China

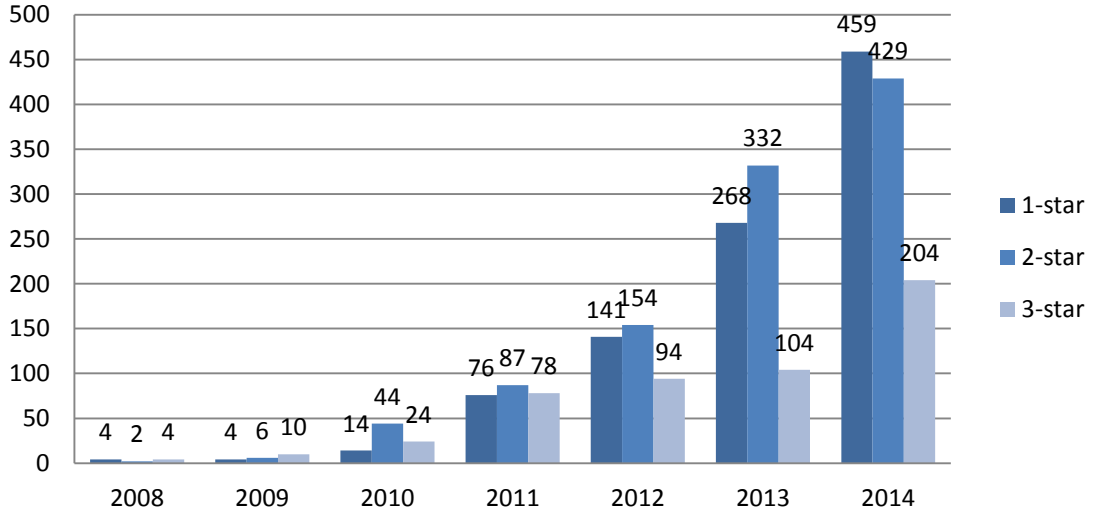
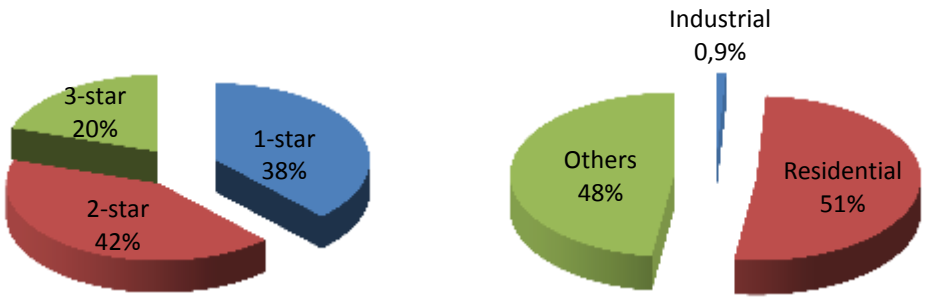


Figure 2 Applicant proportion sorted by levels and building types

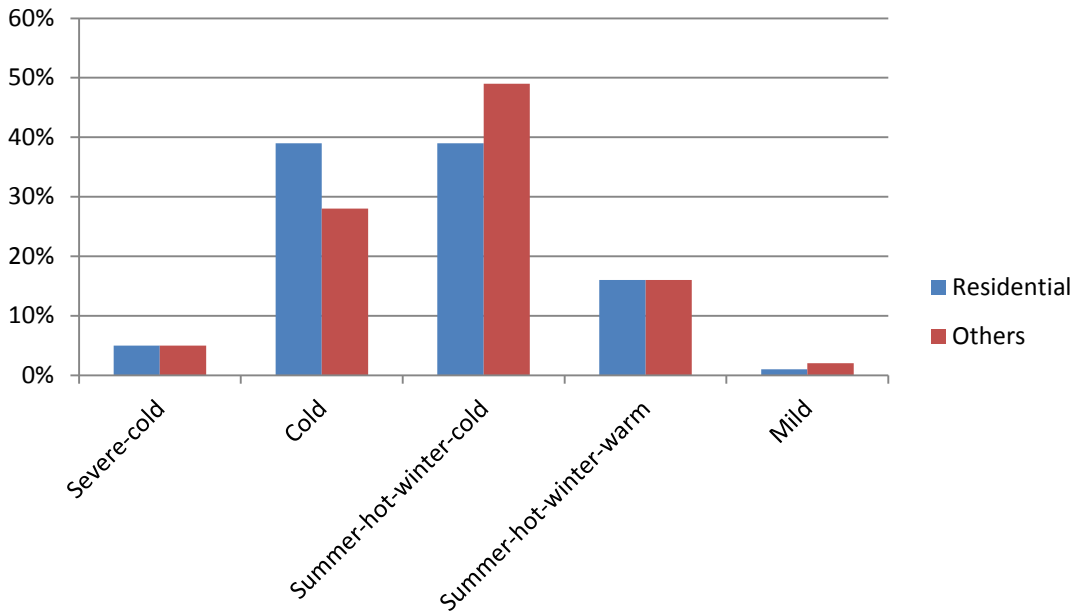


Among the 655 other building typology (including office buildings, commercial buildings and hotel buildings) applicant projects, there are 448 1-star level (42,560,000 square meters), 454 2-star level (34,646,000 square meters), 310 3-star level (18,855,000 square meters). 48% of them are office buildings. The balance of the 3 levels might because most office buildings are self-funding by developers, who will also be the beneficiary, making the incremental cost more acceptable.

Among the 655 residential building applicant projects, there are 426 1-star level (83,568,000 square meters), 583 2-star level (83,501,000 square meters), and 156 3-star level (27,768,000 square meters). Compared to the data of other building typology (including office buildings, commercial buildings and hotel buildings), the percentage of 3-star level residential projects is much lower. It is the consequence of comprehensive consideration of both local policy and incremental cost. In big cities of China such as Beijing and Shenzhen, all the new-constructed building must reach the standard of 1-star level. If the incremental cost is acceptable, some developers would choose to apply for 2-star level. But when it comes to 3-star level, the incremental cost would be a heaven burden. Hence only some top real estate agencies would achieve 3-star level as high-quality demonstration projects.

The penetration of green building also differs according to climate regions. As shown in Figure 3, an amount of 1,120 applicant projects are in hot-summer-cold-winter region, followed by cold region (852) and hot-summer-warm-winter region (405). Only 6% (161) of the projects are in severe-cold region and mild region. Due to lack of policy and financial support, the development of green building in the 2 regions had fallen behind southeast coastal area.

Figure 3 Proportion of applicant projects in different climate regions and building types



The evaluation system of ESGB 2006 consists of building typologies, categories, evaluation methods, weighting factors, rating system, etc. In ESGB 2006, green building is defined as eco-friendly, resources saving, low impact building which provides healthy, suitable and efficient space. The evaluation object of ESGB 2006 could either be a group of buildings or individual building, and the typology buildings including residential buildings, office buildings, hotel buildings and commercial buildings. Applicants should submit life-cycle technical and economic analysis report to show the project scale, construction process and materials

selection. Supporting files such as daily construction logs are also demanded to show the process monitoring.

The credits fall into 6 categories –intensive land use and outdoor environment, energy-saving and utilization, water-saving and utilization, material-saving and utilization, indoor environmental quality and operations management. See the following Table 1.

Table 1 Categories and main contents in ESGB 2006

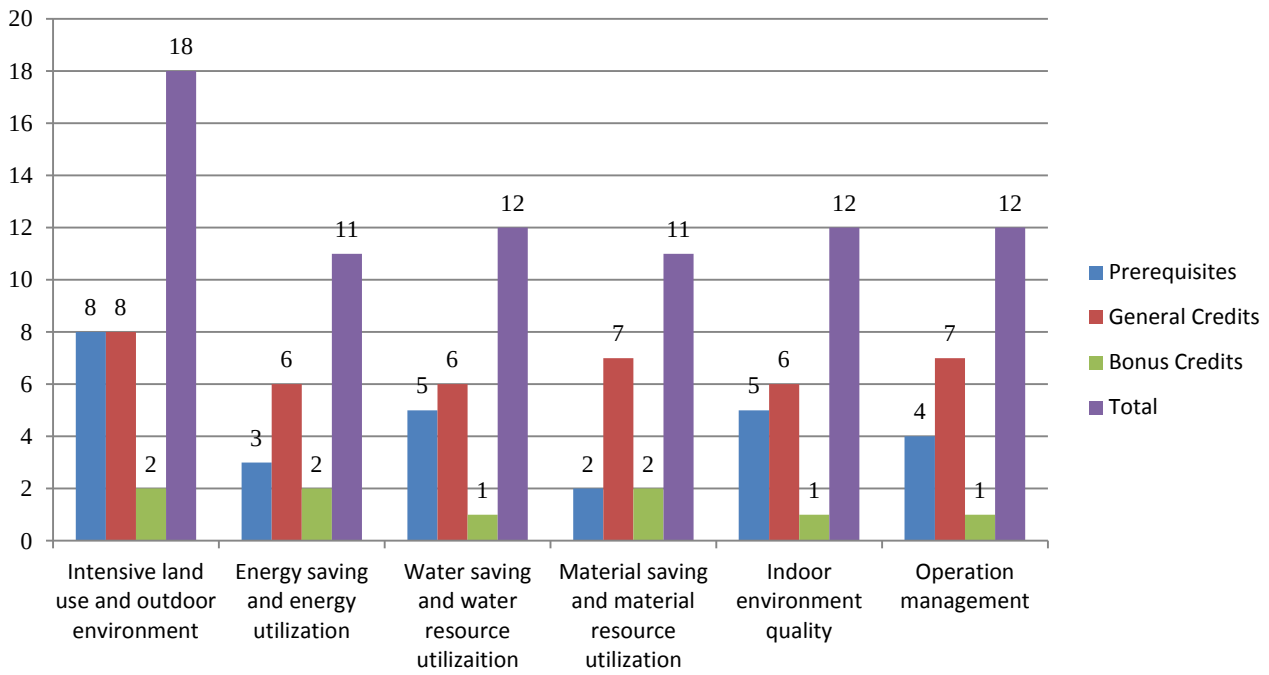
Categories	**Main contents**
Intensive land use and outdoor environment	Site selection and protection; Residential land per capita indicator; Green ratio and vegetation choice; Infrastructure construction; Reuse of existing buildings; Site environment; Heat island intensity; Pervious surface; Underground space utilization.
Energy saving and energy utilization	Active energy efficiency design; Passive energy efficiency design; Illumination energy-saving design; Renewable energy utilization.
Water saving and water resource utilization	Nontraditional water source utilization; Avoid pipeline leakage; Water saving plumbing fixtures; Surface runoff; Landscape water; Rainwater collection and reuse.
Material saving and material resource utilization	Material selection; Solid waste disposal; Recyclable material; Integration of construction and decoration; Structure selection.
Indoor environment quality	Sunshine and lighting; Indoor environment and pollution concentration; Sight view; Non-condensate; Indoor temperature control and outdoor shade; Dedicated outdoor air system.
Operation management	Green management system; Household metering management; Waste discharge; Intellectualized system; Equipment maintenance.

Every category includes 3 sub-categories–prerequisites, general credits and bonus credits. The projects applied must satisfy all prerequisites. The total score of the project is calculated by the scoring of each category and its bonus. The overall score will determine the project to be rated as 1-star level, 2-star level,

3-star level (given 3-star is the highest). Some credits are not applicable for all applicant projects, for example, projects in hot regions do not need to take heat preservation into consideration. In that case, those credits could be ignored in the project, and the actual full score is less than the theoretical full score, then the score it gets shall be adjusted pro rata. For example, if a project is in hot region, it does not fit the items about heat preservation. Then those items could be deleted in this project. If there are 7 such items and the score of the project is 85, then the final score will be 85/93*100=91.

However, there is no weighting system in ESGB 2006. The score of a category is simply defined by how many numbers of the credits it fulfills. For example, figure 4 below, the amount of credits that 'intensive land use and outdoor environment' is significantly larger than the others, followed by water-saving. In China, there are shortage problems of land and water supply, to increase the credits weight of these 2 categories could attract applicants' attention to those problems.

Figure 4 Indicators distribution in ESGB 2006



To conclude, ESGB 2006 has a straightforward framework, making it easy to understand. However, some problems had been found during the implementation process. Firstly, the calculation method was too simple. ESGB 2006 does not have a weight distribution. The difficulty and importance of the credits could not be reflected by the scores, which resulted in mark trade-off. Therefore, the applicants would be more likely to choose some measures which are easier to achieve, yet proved to be inefficiency after construction. The system was also not applicable for various building typologies, neither is it flexible for different climatic regions. Besides, without accompanying software tools, applicants had to submit a lot of paper documents, which makes the application procedure complicated and time consuming.

As a guidance of green building development, ESGB 2006 also have some disadvantages. Green building evaluation should be a combination of environment, society and economy, but ESGB 2006 did not take economic efficiency into consideration. Also it did not show concern for the public engagement.

3. ESGB 2014 overview

With the steady economic development in China recent years, people start to pay more attention to building quality and its impact to their health. Green building, which provides a comfortable, healthy and efficient living environment, will be a preferable choice in the future.

During the implementation process of ESGB 2006, some defects had been identified. For example, the calculation method is too simple as explained before. Many developers in China prefer to apply LEED certificate, due to its transparent, simple, fair evaluation process, and its global recognition. However, there is a concern of the local suitability of LEED program, which may not fit the local characteristics directly. Therefore, it gives rise to the demand of a new national green building evaluation system - ESGB 2014.

In 2011, National Ministry of Housing and Urban-Rural Development (MOHURD) published an official document, clearly announced that ESGB 2006 would soon be replaced by a new version. On the basis of the implementation condition of ESGB 2006, an exposure draft of ESGB 2014 was announced for consultation. The lead organizations include China Academy of Building Research and Shanghai Research Institute of Building Science. Other research institutes and design organizations are actively involved, such as China Green Building Council, China Academy of Urban Planning & Design, Tsinghua University, China State Construction Engineering Corporation, etc., with experts from different areas such as green building, urban planning, energy consumption and construction technology. In the process, the committee summarized recent practical experience and research results, applications from international best practice as references, and solicited opinions from different relevant identities–government agents, developers, suppliers, counselors, constructors, architects, real estate agents, and NGO, etc.

There are 11 chapters in ESGB 2014: general provisions, terms, basic requirements, intensive land use 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, operation management, promotion and innovation. Comparing to ESGB 2006, ‘construction management’ is a new category. Each category consists of ‘prerequisite credits’ and ‘scoring credits’. The criteria credits are sorted by 7 categories. See the Table 2 below.

Table 2 Categories and Contents in ESGB 2014

Categories	**Contents**
Intensive land use and outdoor environment	Land utilization; Outdoor environment; Transport facilities and public service; Site planning and ecological.
Energy saving and energy utilization	Architectural design and building envelope; HVAC; Lighting and electrical; Energy utilization.
Water saving and water resource utilization	Water saving system; Water saving implements and equipment; Non-traditional water source utilization.
Material saving and material resource utilization	Material saving design; Material selection.
Indoor environment quality	Indoor acoustic environment;

	Indoor lighting environment and vision; Indoor thermal environment; Indoor air quality.
Construction management (Newly-added category)	**Resource conservation;** **Process management.**
Operation management	Management system; Technical management; Environment management.

In order to quantify level of projects applied and refine the score, some credits have requirements in different levels, either progressive or paratactic. The illustrations are as following. If a credit has progressive requirements, applicant fit only one level according to its performance. For example, credit No.7.2.7 (Noted: the numbering of the credit): Use local-produced materials (within 500 miles from construction site), 10 points: $60\% \leq R_{lm} < 70\%$, 6 points; $70\% \leq R_{lm} < 90\%$, 8 points; $R_{lm} > 90\%$, 10 points. If a credit has paratactic requirements, there are several separated scored requirements. If the project satisfies more than one requirement, the score will be summed. For example, credit No.6.2.5: Take water saving measures in public bathrooms, 4 points: a. use shower with thermostatic controller and temperature display screen, 2 points; b. use user-reimbursement facilities, 2 points.

4 Comparison of ESGB 2014 to ESGB 2006

In the comparative study, we take a project as case study to demonstrate some significant changes in the revision. No.1 teaching building of Tianjin University's new campus is certified 3-star level green teaching building by ESGB 2006. It has attempted and explored methods in energy-saving and green technology. In the design, appropriate technology was properly applied to according to the demand of site condition and indoor environment.

- **Evaluate Object and Phase**

The environmental impact of buildings differs from the type. Based on the condition of construction market, the evaluation object of ESGB 2006 focuses on residential building, office building, commercial building and hotel building. In ESGB 2014, the range of building typology is broadened to all kinds of buildings, to meet the demand of green building practice and evaluate work.

In ESGB 2006, the evaluate work takes place as late as 1 year after the project is in use. It can efficiently supervise the implement of the green building measures, yet not good to motivate the applicants. Thus MOHURD published 'Green Building Evaluation Rules (trail version)' in 2008 as a supplementary instruction to ESGB 2006, in which the evaluate process was divided in two phases: design phase and operate phase. ESGB 2014 follows the rule. Design phase focuses on 'green measure' and expected effect, while operation phase focuses on green footprint and operation management as well.

- **Rating Method**

One of the most significant changes in the new version is the rating method. In ESGB 2006, scores of applicant projects are calculated by counting the number of credits reached. Although the method is simple, it did not show concern about the weight value. According to the method, all the credits are of the equal importance, which is obviously inappropriate. Many of these measures are qualitative, so their accuracy and authority are not ideal. The evaluation results are either 'pass' or 'not pass', which could not reflect the how

effective the measures are.

In the revision of ESGB 2014, a mixed methodology of AHP and Delphi was used to make a new weight value system. Scores of all the 7 categories are weighted and summed (Noted: As the highlighted sentence above, the weights are decided by experts, and the author of ESGB 2014 did not give a detailed method.).When an applicant project only applies for design evaluate, 'construction management' and 'operation management' would not be scored. Besides the 7 categories, there is 'promotion and innovation' category at the end of the assessment, including general requirements and bonus credits, to encourage creative methods in technique, products and management in the life cycle of the building. The maximum score of 'promotion and innovation' is 10.

The weight value of the 7 category in the new ESGB 2014 is shown in Table 3:

Table 3 Weight value in ESGB 2014

Evaluate object		w_1	w_2	w_3	w_4	w_5	w_6	w_7
Design phase	Residential	0.21	0.24	0.20	0.17	0.18	N/A	N/A
	Others	0.16	0.28	0.18	0.19	0.19	N/A	N/A
Operate phase	Residential	0.17	0.19	0.16	0.14	0.14	0.10	0.10
	Others	0.13	0.23	0.14	0.15	0.15	0.10	0.10

$$\sum Q = w_1Q_1 + w_2Q_2 + w_3Q_3 + w_4Q_4 + w_5Q_5 + w_6Q_6 + w_7Q_7$$

w_1: Intensive land use and Outdoor Environment
w_2: Energy Saving and Energy Utilization
w_3: Water Saving and Water Resource Utilization
w_4: Material Saving and Material Resource Utilization
w_5: Indoor Environment Quality
w_6: Construction Management
w_7: Operation Management

Besides prerequisite credits as necessary conditions, every category has a minimum required scoring rate (40%) to avoid shortcomings. On this premise, applicant project will be rated by the total scoring rate – 50% to get 1-star level, 65% to get 2-star level, and 80% to get 3-star level.

China has a large territory, leading to the diversity in climate, resource, environment and economy condition. Not every credit would fit all types of building in all regions, thus the theoretical full score of applicant projects are not the same, which is unfair**.** Using scoring rate in evaluation is therefore more suitable.

- **Indicator Credits**

ESGB 2014 has a total of 126 credits, including prerequisite credits, scoring credits and bonus credits, while the number of ESGB 2006 is 159. Though the number is larger, most credits in ESGB 2006 could be merged. So the credits are increased in the revision.

Case study of No.1 teaching building of Tianjin University in both ESGB 2006 and 2014 (Figure 5 and Figure 6)

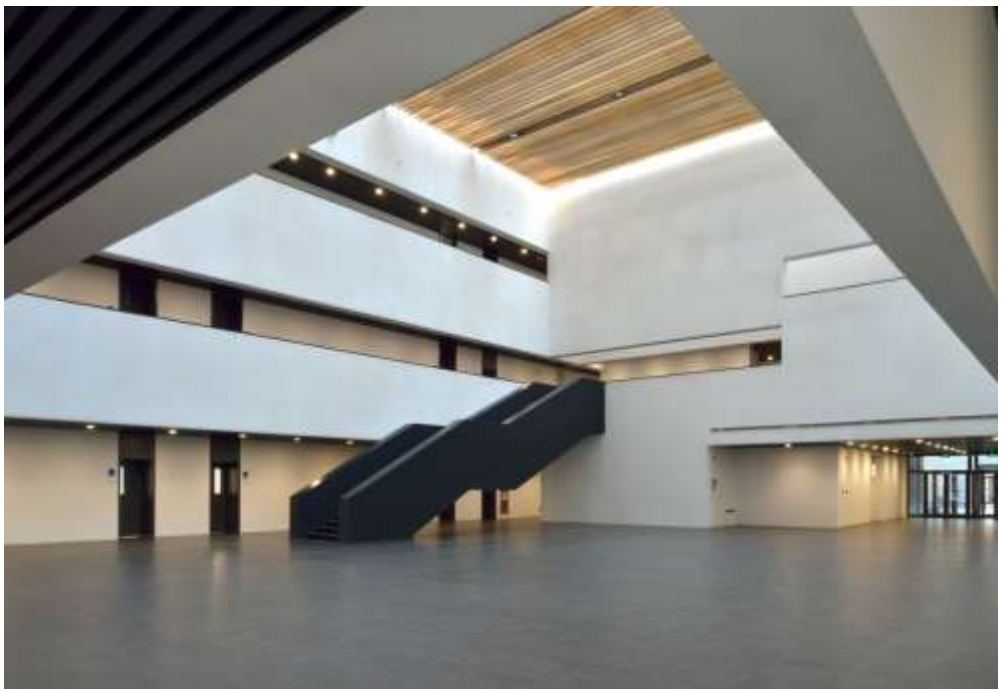
No.1 teaching building (Figure 5) is in the central area of the campus, on the north of an artificial river, surrounded by student dormitories, library and dining hall. The gross floor area is 10708.8m^2, and the

maximum capacity is 3366. Several technologies are used in the design to ensure low energy consumption and comfort level, such as proper site location, reasonable plan layout, envelope heat preservation and renewable energy sources.

Figure 5 Perspective view of No.1 Teaching Building

The building (Figure 6) has 2 internal atriums surrounded by classrooms, and 1 courtyard as a connection of dormitories and library, which is convenient for students to pass through. The designers use energy simulation software to analyze the physical environment of the building, and to optimize the design.

Figure 6 Use interior atrium and automatic sunroof to adjust the indoor light environment



When evaluated by ESGB 2006, No.1 teaching building satisfied 41 scoring credits and 11 bonus credits, and gets a 3-star level green building label. There are mainly 3 forms of revision in statement: newly-added, quantified and improved. According to the feedback of applicants, the difficulty of ESGB 2014 is higher than the former version. It is more difficult to acquire the 3-star level in ESGB 2014 than 2006. The increasing of difficulty shows an overall consideration of building quality and feasibility. With a moderate difficulty and reasonable incremental cost, developers would be more likely to achieve 1-star or 2-star level. It is because the importance of building energy efficiency and living quality has been a social consensus in China, and end-users are more likely to choose green buildings despite of a higher price. Meanwhile it is relatively harder to achieve 3-star level, which would encourage the development of green building technique.

However, when we evaluate the same case study building with ESGB 2014, it shows the different results. The reasons are the following: since there is some newly-added or improved contents in the new version that No.1 Teaching Building did not considered in the design, it will lose marks when evaluated by ESGB 2014. In the following Table 4 and 5, it lists out the credits that No.1 Building lost marks. It can also demonstrate the revision of credits in both requirements and statements.

Table 4 Case study building failed to satisfy the following newly-added contents in ESGB 2014

	Newly-added credits in ESGB 2014
5.2.11	Rationally select elevators and escalators, and take measures like group control and automatic start-stop control.
6.2.11	Use nontraditional water source in make-up cooling water system.
8.2.4	Specialized design in rooms with acoustic requirements, such as multi-functional hall, reception hall and large conference room.
9.1.3	Construction management department should have occupational health and safety policy for constructors.
9.2.1	Take measures to avoid construction dust.
9.2.6	Take measures to avoid loss of ready-mixed concrete.
10.2.2	Have contingency plan in energy saving, water saving, material saving and greening project. Clearly label the operating instruction of equipment and devices.
10.2.4	Put mechanisms to explain the idea of green building. Provide instruction manual of green devices to users.
10.2.9	Use information technology in estate management, and establish profiles of construction engineering, facilities, components and energy consumption.

Table 5 Case study building failed to satisfy the quantified or improved credits in ESGB 2014

Quantified or improved credits	**ESGB 2006**	**ESGB 2014**
4.2.4	Avoid light pollution towards nearby residential areas and traffic roads.	Avoid light pollution in illumination design, 4 points: 1. Visible light reflectance of glass walls less than 0.2, 2 points. and 2. Nightscape lighting design certifies ‘Code for

		lighting design of urban nightscape' (JGJ/T 163), 2 points.
5.2.2-2	No less than 30% of external windows are operable.	No less than 30% of external windows are operable, 4 points. No less than 35% of external windows are operable, 6 points.
6.2.7	Use water saving irrigation scheme and reach 10% saving rate.	Use water saving irrigation scheme, 10 points: 1. Use water saving irrigation system, 7 points. On this basis, use controlling devices like soil moisture sensors and rainy day automatic closing device, 3 points. or 2. Use non-permanent irrigation plants, 10 points.
7.2.7	More than 70% of materials are produced within 500 miles from construction site.	Use local-produced materials (within 500 miles from construction site), 10 points: $60\% \leq R_{lm} < 70\%$, 6 points; $70\% \leq R_{lm} < 90\%$, 8 points; $R_{lm} > 90\%$, 10 points.
7.2.12	On the premise of performance, use recycled materials in preference.	Use renewable or recyclable materials, 10 points: 1. For residential buildings, not less than 6%, 8 points; not less than 10%, 10 points. or 2. For other building typology (including office buildings, commercial buildings and hotel buildings), not less than 10%, 8 points; not less than 15%, 10 points.
8.2.8	Use adjustable shading to avoid solar radiation.	For external windows and transparent curtain walls, use adjustable shading to avoid solar radiation, 12 points: not less than 25%, 6 points; not less than 50%, 12 points.

It can be concluded that credits about pervious technology are easier to satisfy, while credits about construction management and operation maintenance have a lower implementation rate. It is mainly because those credits need long-term investment cost, which is not profitable for the developers. Also, some credits are qualitative in ESGB 2006, and were quantified in the revision, which increases the difficulty to the applicant. To achieve 3-star label in ESGB 2014, developers must concern more about the effects of the green measures.

5 Conclusion: Develop Tendency of Green Building Assessment in China

This paper gives detailed analysis and comparison between ESGB 2006 and ESGB 2014, including the following inscapes: evaluation phase, evaluation objects, credits, evaluation methods, weighting system and evaluation results. The comparison results shows the improvement of the current ESGB 2014 in details, i.e., evaluated object, stage partition, weighted value, structure, indicators, etc. A case study is selected to evaluate and calculate the green building accreditation according to both ESGB 2014 and ESGB 2006, and demonstrate the differences and development of ESGB 2014. This paper concludes the following on the development tendency of green building in China:

- **Stakeholders Involvement**

The experience from overseas proves that the successful promotion is market-oriented. However, currently the development of green building in China mainly relies on government intervention and incentive policy. Lacking of knowledge also influence the enthusiasm of architects, developers and real estate towards green building. To break the situation, the government should properly guide the market and plan more promotional events, and multi-stakeholders should move towards new forms of cooperation, to realize the implement of the evaluation system.

- **Integrated Design Process**

In the traditional design process, problems like high-cost excessive technology will occur and consequently have negative effects on the building. Previously some of the applicant projects applied for the green building label only for the promotional effect. After ESGB 2014 was published, green building team must involve in the design process earlier and participate in the whole process to guarantee the implement of green measures, and thus make a multi-disciplinarily integrated design process.

- **Contents Extension**

From the study of worldwide green building evaluation systems, we can learn that the contents of green building is always been extended. This trend can also be founded in ESGB 2014. When an evaluation system is firstly published, it pays more attention to some certain perspectives such as environmental load and indoor air quality, as well as some critical issues in the area, such as intensive land use, natural lighting and premixed concrete. With its development, it will start to expand the focuses to some widely concerned issues, including frontier technology, society and economics. Examples are building information modeling, techno-economic analysis, carbon emission, heritage conservation, etc.

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