

# Research on the Current Situation and Prospect of Green Building Technology in China

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**Abstract.** In view of the series effects by global warming, green building has become one of the key parts to solving this problem, as green buildings are in line with the strategic goal of sustainable development and can play a significant role in reducing energy consumption. This paper first introduces the basic concept of green building, as well as the green building-related policies and the green building certificate in China. The latest environmental protection production standard for building issued by the Chinese government is also expounded. Then, the American Green building standard named Leadership in Energy and Environmental Design (LEED) is briefly introduced and compared with the green building standard of China. At the same time, the problems affecting the development of green building technology in China and the improvement measures are introduced. Finally, the overall trend of green building development of China in the future is analyzed.

**Keywords:** Green buildings, LEED, energy-saving.

## 1. Introduction

Nowadays, the global warming effect is one of the main challenges that human beings may need to face. According to Proceedings of the National Academy of Sciences of the United States of America, by 2100, sea levels might rise by 127 cm as a result of global warming, submerging 1,400 US communities. To stop global warming, the Paris Climate Change Agreement was ratified in 2015. To achieve this goal, humanity will need to promote net zero greenhouse gas emissions lifestyles as much as possible. Over these years, China's economy grew to be the second-largest in the world, and China's total carbon dioxide emissions reached the top of the world's ranking. Therefore, it is necessary for Chinese people to research the current situation and prospects of green building technology.

In the 1990s, green construction became a popular idea in China. In 2006, the relevant departments issued "Green building Evaluation Standards" (GB/T 50378-2006) [1]. The standard refers to the international advanced experience and the practical experience and research results of the relevant aspects of green building in China. Residential structures as well as commercial buildings including offices, malls, and hotels are assessed using this criterion. It is divided into six sections: land conservation, the natural environment, energy efficiency, The use and conservation of materials, and the quality, operation, and administration of the interior environment. Construction of buildings in China has advanced significantly in recent years thanks to the development of green buildings, most of which adopt steel structures and make full use of renewable building components. At the end of 2021, there were 742 green building projects in China, with 75.84 million square meters of buildings receiving the green building designation. Since 2006, 127 houses have received green construction certification., accounting for 52.3% of the total. A total of 116 public buildings, accounted for 47.7 per cent of the total. During the two cycles of 2006-2010 and 2011-2015, the government set mandatory targets for reducing energy consumption per unit of GDP and planned to cut carbon emissions per unit of GDP by 40%-45% between 2010 and 2020. Recently, green buildings become a pretty popular topic in China, most real estate projects want to obtain some certificate to show their buildings are environmentally friendly in some way. Take the world's tallest office building, Shenzhen Ping An Financial Center, for example. This building has obtained LEED (Leadership in Energy and Environmental Design) platinum certification and China Green Building three-star certification. This means this building both receives a Chinese green building certificate and an

American green building certificate [2]. Recently, some people point out that Green building is just an expensive environmental gimmick. A LEED certification costs millions. According to the data provided by the construction company, if a project in China applies for LEED certification, it needs to pay the consulting company a total fee ranging from 400,000 Yuan to 600,000 Yuan and another LEED project registration fee ranging from 15,000 US dollars to 45,000 US dollars. Therefore, it is important to analyze green building technology and its necessity.

This paper introduces the basic concept of green building and compares the Leadership in Energy and Environmental Design (LEED) in the United States with the green building standard in China. Then, The issues limiting the advancement of green building technology in China are discussed, as well as the solutions.

## **2. Green Building Technology**

### **2.1. The Basic Idea of Green Buildings**

Since the first industrial revolution, the construction industry was committed to conserving energy and reducing the emission of waste. The term "sustainable development" was first used in 1980 by the International Union for Conservation of Nature. In 1987, United Nations Environment Program published a report and established the policy of sustainable development again. That is the origin of sustainable buildings. Chinese authorities also define a green building. The goals of green buildings may include maximizing resource conservation, environmental protection, pollution reduction, providing livable, useful, and efficient space for people, and living in harmony with the surrounding environment. As urbanization continues to advance, more buildings will be built generally, increasing building energy consumption and its share of total energy consumption. Therefore, one significant strategy for achieving China's targets of energy conservation and emission reduction is to continue to promote green buildings, low-energy consumption buildings, and zero-energy consumption buildings throughout a wide range of the entire societal scope. China's rapid urbanization brings both development opportunities and environmental pressures, and the consequences of extensive urban and rural construction, which has long focused on scale rather than efficiency, will become more pronounced in the next 10 or 20 years. In terms of the present development situation, 27.5 per cent of the total energy consumed by social terminals comes from Chinese buildings. The difference with the developed countries is 12.5 percentage points, and the building of more than 2 billion square meters of terminal energy consumption has been close to 30% of the whole use of energy by society. Building construction will continue to grow overall while building energy consumption and its share will grow due to the growth of urbanization.

Green building, also known as ecological building, has the following three main purposes. First, It can decrease resource waste and conserve energy. Second, it may save the environment by lowering pollution levels and carbon dioxide emissions. Third, it can satisfy consumers' demands and give them a comfortable atmosphere.

#### **2.2.1 Analysis of Green Building Status in China**

At present, the development of green buildings in China is still in its infancy. However, there is still a ton of room for future green building growth. Through the development of new materials, and new energy-saving technology to optimize the design of buildings, and further improve the function of green buildings, to successfully combine the creation of economic, social, and environmental advantages. China is also gradually developing its green building evaluation system, norms, and regulations. First, a series of laws and norms on energy conservation was introduced, such as "the Energy Conservation Law of the People's Republic of China" and "the Energy Conservation Design Standards for Public Buildings". There have also introduced several green building evaluation standards. "The China Eco-Housing Technology Assessment Manual", published in 2001, was employed to encourage the construction of environmentally friendly homes. "The Green Olympic Building Evaluation System" was published in 2003 to guide the green construction of Olympic

venues. After that, “Green Building Technology Guidelines”, “Green Building evaluation”, “Green building evaluation technical rules”, and “Green building evaluation technical rules” symbolize that our country's green building development has been on the right track [3]. To encourage the widespread construction of green structures, “the Evaluation Criteria for Green Small Towns” was published in 2012. The scientific system on green small towns released in 2015 also makes comprehensive and specific deployment from various aspects, such as planning, resource utilization, energy utilization, water utilization, site utilization, publicity, and protection. This year's 13th Five-Year Plan has set a target for the development of green buildings: By 2020, all city buildings will meet energy-saving standards and half will be green buildings. Fortunately, many buildings in our country have received LEED Gold certification internationally, which has to be said to be great progress. Some well-known real estate enterprises in China have gradually given up the traditional extensive real estate development model and begun to transform it into a green and sustainable model. They are increasingly taking on corporate responsibility to protect the environment. Such as Vanke, China Resources Land, Country Garden, and other enterprises into the top 10 green residential. In a word, under the vigorous promotion of the country, the concept of green building is being paid attention to by more and more real estate developers [4].

A total of 2,538 green building project signs covering 290 million square meters had been submitted for review as of December 31, 2014. 2,379 of the total involved logo design work, making up 93.7% of the total applications. A total of 159 operational identification projects, or 6.3% of all proposals, were submitted. The overall number of applications for green building signs has multiplied 109-fold since 2008. As visible in our current development of green building social consensus has been gradually formed. By the end of 2016, China has awarded green building assessment marks to 7,235 construction sites with a combined floor area of more than 800 million square meters. About 95 per cent of the projects were labelled green buildings. Promotion of green building, not only caused an unprecedented shock for the traditional construction industry but also promote the related industry backwards in technology updates, and product generation, together with the construction industry towards a new era of the green industry. Green building is particularly obvious for the promotion of the renewable energy industry. In China, renewable energy sources including solar energy, wind energy, water energy, and geothermal energy are in plentiful supply. Renewable energy development started late but has developed rapidly, and now has significant scale and economic advantages. In technology innovation, our country is close to the leading level of the high-end technology research field. In 2004, Shanghai Eco-Building Demonstration Building was completed, which brought together 104 industrial, academic, and research complexes at home and abroad, involved 12 cross-disciplines, and integrated the most advanced green building technologies and products at home and abroad. It strives to achieve "the comprehensive energy consumption is 25% of that of ordinary buildings, Solar, wind, water, and geothermal energy are all readily available renewable resources in China. The indoor comprehensive environment has reached the indicators of health and comfort, and the utilization rate of renewable resources has reached 60% ". It has ten technical characteristics, such as resource reuse, intelligent control, natural lighting, healthy air conditioning, renewable energy, natural ventilation, ultra-low energy use, and a comfortable atmosphere. Through the follow-up measurement of the implemented technology system and the follow-up application research of new technologies and new products, Shanghai eco-building Demonstration Building has been built into a green building technology promotion platform and education demonstration base. Based on technical independent innovation, our country is also comprehensive introduction of international advanced technology experience and moulding products, the annual "international conference on intelligent, green buildings and building energy efficiency and new technologies and products expo" in the display of building energy efficiency, green buildings at home and abroad, intelligent building and green building materials application examples of the latest technological achievements and products at the same time, Also set up the introduction of technology, cooperative research, collaborative development of the exchange platform.

### **2.2.2 Issues of development**

China's progress toward green building construction is also unimpressive. Even though many Chinese structures have received worldwide green building certification, many real estate developers start by inflating and raising the cost of housing, which is a trick. Often, the development price of this kind of green building is quite high, and the later operation cost is also very expensive, which does not achieve its core goal of green building. There is a big deviation in the understanding of green buildings among ordinary people. They believe that creating a green building just involves covering it with more greenery. Populist pricing and strong demand are the dynamics behind the expansion of the market for green buildings. The perception of remoteness that people have toward green buildings is now stifling their development. And the related supporting construction technology is not mature. Many firms interested in building efficiency would be deterred by the high cost of importing foreign technology. Planning, design, construction, and exploration must work together to produce green structures. The burden for designers will likewise drastically expand. Many architects and designers nowadays aren't even sure how to properly make a building "greener."

## **2.2. The Green Buildings Standard Comparison**

### **2.3.1 Basic idea of Chinese green building technology standard**

The first Chinese "Green Building Technical Guidelines" were published in 2005, and this is when the Chinese green building rating system was first established. As a national programmatic and technical document, the course interpretation of green building is provided, including The foundation for the assessment standard framework of green construction is provided by the conservation of land, energy, water, materials, and the environment. The following will briefly introduce GB/T50378 "Green Building Evaluation Standard", which came into effect on August 1, 2019 [5].

The standard was created to put the idea of green development into practice, to encourage the high-quality construction of green structures, to save energy, to protect the environment, and to satiate people's insatiable need for a better standard of life. The climate, ecology, economy, and culture of the project location will all be carefully taken into account when evaluating green buildings, and the effectiveness of safety, robustness, health, and comfort, as well as the ease of life, resource-saving, and livable environment throughout the building's life cycle, will be thoroughly assessed.

"Green Building Standard" focuses on the whole life cycle of buildings, wishing to fully take into account and utilize environmental factors in the planning and design stage, ensuring that the building process has little impact on the environment, and that the operational phase can provide people with a safe, pleasant, low-consumption area, and that the environmental damage after demolition is kept to a minimum. [6]. To meet the relationship between the use function of buildings, resource-saving and environmental protection, it is not advocated to increase consumption too much to achieve a single index. At the same time, it is not advocated to reduce the functional requirements and applicability of the building to reduce the consumption of resources. It is emphasized that the contradictions among energy saving, land saving, water saving, material saving and environmental protection should be considered and handled correctly in the whole life cycle of buildings. The use of information technology, intelligent technology, new technologies, new products, new materials, and new processes for green buildings should also be taken into consideration. Conforming to national laws, regulations and relevant standards is a prerequisite for participating in green building evaluation. "Green Building Evaluation Standard" does not fully cover the functions and performance requirements of common buildings, but focuses on the evaluation of the content related to the performance of green buildings, mainly including energy saving, land saving, water saving, material saving and environmental protection. "Green Building Evaluation Standard" pays attention to the economy of the building, calculates the benefits and costs from the whole building's life cycle, and complies with regional economic demands and market growth objectives. Advocate simple and simple, oppose flashy and ostentatious and realize the unity of economic benefits, social benefits and environmental benefits.

Five types of indicators should make up the assessment index system for green buildings: resource-saving, livable environment, health and comfort, the convenience of living, and safety and durability. Each category of indicators should also include control items and score items. Additionally, extra points are consistently determined by the evaluation index system [7]. For multi-functional integrated single buildings, all evaluation provisions of this standard shall be applied to the area one by one. Conduct evaluation and determine the score of each evaluation clause, as shown in Table 1.

**Table 1.** Green building evaluation score of China [8]

Control item's score	The full score of the evaluation criteria					Improvement and innovation
	Safety and durability	Health and comfort	Convenience	Resources saving	Environmental liability	
Full score	400	100	100	100	200	100

The total score for green building evaluation should be calculated as follows:

$$Q=(Q0+Q1+Q2+Q3+Q4+Q5+QA)/10 \tag{1}$$

Where Q is the total score achieved. Q0 is the basic score of the control item is 400 points when all the requirements of the control item are met. Q1~Q5 are Five indexes of the evaluation index system (safety and durability, health and comfort, convenience, Resource saving, environment livability) score. QA is the improvement and innovation bonus points score.

Four stages should be established for the green building: the basic level, the one-star level, the two-star level, and the three-star level. The green building grade shall be basic if all control criteria have been satisfied. The green building grade must be one star, two stars, and three stars accordingly when the total score exceeds 60 points, 70 points, and 85 points, respectively, and should match the conditions of Table 2 and Table 3.

**Table 2.** Number of items required to classify green buildings (Residential buildings) [8]

Level	General item number (total of 40)						
	Land Saving and Outdoor Environment	Energy conservation and Resource Utilization	Water saving and Water Resources	Material saving resources	Indoor environmental quality	Operations management	Priority item
Items	8	6	6	7	6	7	9
One-star	4	2	3	3	2	4	—
Two-star	5	3	4	4	3	5	3
Three-star	6	4	5	5	4	6	5

**Table 3.** Number of items required to classify green buildings (Public buildings) [8]

Level	General item number (total of 40)						
	Land Saving and Outdoor Environment	Energy conservation and Resource Utilization	Water saving and Water Resources Utilization	Utilization of material-saving resources	Indoor environmental quality	Operations management	Priority item
Items	6	10	6	8	6	7	14
One-star	3	4	3	5	3	4	—
Two-star	4	6	4	6	4	5	6
Three-star	5	8	5	7	5	6	10

Note: Mark the proportion of three stars to show how easy it is for this level to meet the number of terms)

Residential building sound insulation performance is governed by the current national standard for sound insulation design of civil constructions, GB 50118. The main indoor air pollutants are ammonia, formaldehyde, benzene, hydrogen, Inhalable particle matter, total volatile organic chemicals, and others. The applicable criteria of the current national standard "Indoor Air Quality Standard" is the concentration reduction benchmark.

### 2.3.2 Basic idea of America green building evaluation system

In the 1960s and 1970s, the United States experienced an "energy crisis". To make Americans aware of the "limitation" of energy, and publicity, "protecting the earth, energy conservation, and environmental protection became a topic that everyone in the United States paid attention to. The construction industry, according to relevant statistics, accounts for 30 per cent of the country's energy consumption and up to 60 per cent of its electricity use. In the mainstream orientation of society, the construction industry started the process of "green" transformation in the 1980s. The US Green Building Council (USGBC) undertakes the task of regulating Green Building orientation to meet the demand of the Green Building market and Green Building evaluation, improve the economic performance, energy conservation, and environmental protection of buildings. In the nearly 20 years since its birth and development, LEED has been constantly enriching and improving itself. In the time interval when the old and new versions change, new family members will be developed and promulgated to improve and broaden the evaluation object and scope of LEED itself. LEED entered the Chinese construction market in 2003 and has evaluated dozens of projects in Beijing, Shanghai, Shenzhen, Suzhou and other places since 2007, and awarded platinum and gold-grade green buildings respectively. Chinese "green standard" also draws lessons from the LEED standard's part of the advanced experience and summarizes the practice experience and research results of our green building in recent years. Two standard comparisons, you can see many similarities, especially paying attention to improving resource utilization, reducing carbon emissions, being concerned about the environment and health problems reflecting the local characteristics, etc, provide us with more perfect laws and regulations, but there are also many differences, which related to the national conditions, related to the speed of economic growth, and understanding these differences, It is also precisely to better respond to various environmental and social problems and meet the urgent need to create and promote a green building market.

In each investigation, the assessment points are divided into three types of assessment premises. A project cannot be certified if it fails to meet any of the requirements of the assessment premises. The assessment essentials are the various technical measures proposed as described in the previous green building survey. They will assess the building and give them an Innovation score. These scores are awarded when the technical measures adopted by the candidate project significantly exceed the requirements of some of the evaluation points, or when the technical measures adopted by the project achieve significant results in environmental protection and energy conservation areas not mentioned in the evaluation system.

At the same time, the requirements of a variety of evaluation points are elaborated through four aspects: the purpose of evaluation points, evaluation requirements, recommended technical measures, and the requirements of documents to be submitted [9]. An assessment item that meets all the requirements of the assessment premise can be divided into four levels according to the score obtained. The certification meets at least 40% of the key points of the assessment The silver level meets at least 50% of the assessment points The gold grade meets at least 60% of the assessment points Platinum level meets the requirements of at least 80% of the assessment points [10].

In general, the design company usually tries to meet the higher specification certification as much as possible, which is usually the marketing gimmick of the building, but also really promotes the promotion of green building and effectively saves energy recycling, and reduces waste. The categories for the green building grade include three grades from low to high: one star, two stars and three stars. For buildings of the same star level, the score is used to distinguish them, which is reflected in the logo and certificate.

### 2.3.3 The difference between the two criteria

As can be seen from the above table, six different indicator categories are used to group the two standards. The content of the first five categories of indicators is comparable, but the sixth category is distinct. LEED refers to innovation and design, and our green standard refers to operation management, which is also the difference in economic development in different countries shows the difference in standard emphasis. In our country, in the operation and management of energy-saving systems, LEED is the scoring method, and "green standard" is the number of the project achieved and met, according to the arrangement of the fractional proportion and different weights "Green Standard" is, energy saving and energy use 23%. Material saving resources utilization 19%. Operations management 16%. Water saving and water resources consumption and interior air quality, land saving and outdoor environment. LEED is 25% energy and atmosphere; Indoor environment quality is 22%. 20% of site selection for sustainable development; Materials and Resources 19%. Water utilization is 7%, and innovation and design is 7%. The above weight arrangement shows the differences between our "green standard" and the LEED standard.

## 3. Conclusion

This paper draws the following conclusions based on the status quo of China's green standards, LEED in the United States, and green building status in China. First, China's green building has developed rapidly from scratch. By actively learning from other countries' green building standards, China issued its first green building evaluation standards in 2006, and the success of the green building standards has aroused the awareness of building developers to protect the environment. Second, there are also differences in green building standards between China and the United States. The Chinese standard is the operation and management of an energy-saving system, while the American LEED is a scoring system. The weight of various aspects of LEED is also different from that of China's national standard. Finally, there are still some problems with the development of green buildings. For example, builders are deterred by high certification fees, and people do not realize the value of green buildings, so it is difficult to popularize green buildings. These shortcomings could be ameliorated if governments incentivize developers with financial support or tax incentives and promote the benefits of green building.

The design, construction and monitoring of green buildings after they are put into use, as well as how to evaluate their green level, are new concepts and challenges facing the construction industry in China. Although China has done some design work following relevant standards, many problems have been found as soon as it enters the substantive declaration stage.

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