The Green Building Development and Assessment Method – Energy and Cost Analysis in China

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Abstract. With the aggravation of global warming in the world, China is a country that produces a large amount of carbon dioxide every year. The development of green buildings is a primal aspect that the Chinese government has worked for many decades to build a healthy environment. This study explores three major Chinese green building assessment methods and compares the Evaluation Standard for Green buildings (three-star standard) with other countries' representative assessment methods, which indicates that the three-star standard puts more attention on qualitative indicators. So, many buildings which receive that certification does not really have much sustainable equipment or save much energy. Also, this paper researches the status of green buildings in China. There are not many developers investing in green buildings, due to the price of green building construction is much more expensive than conventional buildings. That is because those green buildings equip many sustainable technologies and equipment. To encourage the construction of green buildings, the government can enact regulations and incentives to encourage more companies and developers to build green buildings.

Keywords: Green building assessment standard; regulations; incentives.

1. Introduction

Due to the development of urbanization, there are more and more buildings constructed in the world. Buildings consume a great portion of energy. Therefore, buildings have much potential in saving energy. Green buildings have become the main goal that the government tries to develop and promote for several decades. The Chinese government has enacted many green building assessment standards for buildings to approach and issued many incentives for constructing green buildings. People can receive subsidies if they buy or build those constructions. This paper includes the major green building assessment standards in China and compares them with other countries' or regions' standards. Then, it points out some issues that Chinese green building standards can improve and provides some suggestions for developing green constructions in China. This article covers multiple aspects of green buildings, which can let readers have a more comprehensive understanding of them.

2. Green building assessment methods in China

2.1. Green building assessment methods developed in China.

Due to the rapid development of China during these decades, the emission of carbon dioxide has surged and constantly increases every year. Now, China is the country that produces the most carbon dioxide worldwide. In 2019, China emitted 10.2 billion tons of carbon dioxide. That made China become the largest carbon dioxide emitter in the world [1]. The buildings in China play a dominant role in consuming energy; around 30% of China's total primary energy consumption comes from them [2]. Thus, the development of green buildings can significantly reduce the energy and cost used in China.

In 1992, China began to develop green buildings. In 1996, the Ninth Five-Year Plan of China listed research about the Chinese green construction system as one of its funding aspects. Then, China had many documents and regulations related to green buildings. For instance, Residential Green Building Elements and Technical Guidelines; China's Eco-house Technical Evaluation Handbook; Green Building Technical Guidelines [3].

China's revolution of green building standards can be classified into three stages. The first phase is the Chinese Eco-house Technical Evaluation Handbook, which has 4 editions in total, first published in 2001. The latest edition of it was published in 2007. The content of that handbook is based on the Leadership in Energy and Environmental Design (LEED) standard which was invented by the US, and the situation in China. This is the first guideline for evaluating green buildings in China. However, it can only be used to assess residential buildings, and its use is limited. This handbook includes the construction methods of ecological residential buildings. Also, the rating system in this handbook includes five indicators: energy and environment, site and residential environment, quality of the interior environment, material and source use, and water environment. Meanwhile, the assessment of residential buildings is based on the above five indicators and other three aspects, which are prerequisite assessment, operating and maintenance assessment, and planning and design assessment [4].

The second stage is Green Building Assessment System for Beijing Olympics (GBASBO). Because Beijing was elected to host Olympic Games in 2008, and the Chinese government decided to conduct a green Olympic Games. So, the government began to make an assessment for green buildings in November 2002. That assessment was referenced to the Japanese Comprehensive Assessment System for Built Environment Efficiency (CASBEE). GBASBO considered the reality of China and the conditions of Beijing to constitute that assessment. It was the first green building concept in China. It is comprised of four phases: the planning phase, the design phase, the construction phase, the final inspection phase, and the operation and management phase. This assessment system will estimate those four stages individually and estimate those processes as a whole again. This assessment system is only used to evaluate the venue construction in Beijing. It can't be used to estimate other buildings or other regions [4].

The third stage is the Evaluation Standard for Green buildings. It is the first national standard to access green buildings in China. It was released on 7 March 2006 and implemented on 1 June 2006. Since the Evaluation Standard for Green Building only has three levels, it is also called Three Star Standard. This standard is based on the LEED standard because the LEED standard has few indicators which require buildings to reach to get points but provides many choices for developers to choose from, and the final points will be evaluated. It makes the assessment system become easier to be accepted. Meanwhile, because the LEED standard is recognized by most countries in the world and is reliable, therefore, the Three Star Standard is similar to the LEED standard. This standard considers the life cycle of buildings, and its assessment includes both public and residential constructions. This standard aims to reduce the energy and natural sources used. The regular options for this evaluation standard are composed of six aspects: land saving and outdoor environment; energy conservation and use; water saving and utilization; materials saving and utilization; indoor environmental quality; operation and management. Among those six aspects, there are a total of 76 options for residential buildings and a total of 83 options for public buildings. Those options are divided into 3 parts, which are mandatory, regular, and premium. There are 27 mandatory options, 40 regular options, and 9 premium options for residential buildings. Also, there are 26 required options, 43 regular options, and 14 bonus options for public buildings.

2.2. Green building standards' differences between China and other countries

There are a lot of differences between Chinese green building assessments and other countries. It is mainly caused by the different geography and the distinguishing features of different countries. There is a requirement in Chinese assessment standards, which is the reduction of buildings' land use. However, most other countries do not require that because they do not have such a great population density as China [4]. Also, due to the fact that China's energy is chiefly coming from fossil fuels, much pollution has originated from fossil fuel usage. Thus, Chinese assessment standards emphasize the energy saving of the constructions and the utilization of renewable energy, but the other countries' standards concentrate more on reducing total carbon dioxide emissions, and they have made an indicator for reducing the emissions.

Another difference between Chinese assessment standards and other countries is that the items of the standards have some subtle differences among different regions or provinces in China. Because China has a vast territory, it has various climatic characteristics and temperatures. Therefore, the governments will consider their local environmental factors to assess the green buildings. In addition, in China, the occupants of the buildings need to decorate the inner buildings by themselves after buying them from developers. They will cause indoor pollution and the loss of material consumption. Chinese standards will also evaluate it. In other countries, the interior design and decoration will be done by developers [4].

Chinese green building standards grade the buildings by assessing the energy efficiency of ventilation, air conditioning, heating, elevator, etc. In contrast, the code for Sustainable Homes standard (CHS) from the UK provides certification for the energy efficiency of buildings by controlling the proportion and amount of energy-efficient lamps for indoor and outdoor lighting [5].

Three-star standard of China puts more attention on energy consumption. It has strict requirements for energy saving. LEED standards focus on innovations and green technologies that buildings use [6]. Both Chinese green standards and LEED have requirements about indoor air quality, but LEED has more scoring items about it. LEED also has stricter anti-smoking measures for indoor spaces. Three-star standard even has regulations about the performance of building sound insulation. It has made a minimum limit to protect people from the noisy environment.

LEED suggested reusing or recycling the materials of demolished constructions. Thus, they do not need to produce new materials, which will cause pollution. They set up recycled material storage and collection station to classify and store the waste materials. Chinese green building standards are required to reduce material use. It suggested prefabricating the materials to minimize waste. Chinese standards require that waste from green buildings is recovered at a rate greater than 30% and that living waste should be greater than 90%.

2.3. Green building standards' differences between China and other countries

Chinese green building assessment standard primarily focuses on qualitative indicators, but it neglects the requirement of quantitative indicators. The three-star standard in China listed around 80 options for buildings to choose to get the green building certification. Those options mostly require the building to equip some energy-saving systems or require the buildings have some specific abilities to save energy. However, there are not many options having the number requirements. For example, they do not demand how much water or energy a building should save per year. Besides, if one of the options requires the building to equip energy-saving implements, the building just needs to have one energy-saving air conditioner, then it will fulfill that option and receive a point from it.

Another point is that the LEED Core and Shell system allows construction to get "pre-certification" before it is built [4]. So, they can market the tenants quickly, and get higher rents because they have a green building certificate. That can attract more people to develop green buildings. In contrast, if a construction wants to apply for a three-star standard certification, it must operate for at least one year. That will make the green buildings in China obtain fewer benefits than the countries which use LEED standards.

The three-star standard does not require many innovations in green buildings. Developers do not have the incentive to adopt innovations. There are many options for the developers to choose to do. The cost of different options is different, so some of those developers will choose the options that do not need much money and do not need to be innovative to earn points to get the certification [4].

3. Development of Green buildings in China

3.1. Current status of green buildings in China

Chinese building energy conservation work first began in the 1980s. The country enacted the environmental protection law and provisional regulations on energy conservation management. Thus, people had a clear outline of the building construction that used less energy at that time. Meanwhile,

the government would reward people or enterprises that contributed to the energy saving of buildings. The notion of "four economies and the protection of the environment" began to merge in China. People began to concentrate on the refurbishment and construction of wall materials and resource-saving. In 2005, Beijing held the first international green building conference. That conference emphasized energy saving, increasing sustainable building development, and turning sustainability into the central idea for a low-carbon economy [2].

China has made energy saving and emission reductions a national strategic policy to develop green buildings. The Chinese Ministry of Finance also enacted many policies and documents to encourage other departments to take part in its development of it. In 2012, the "Implementation Opinions on Accelerating the Development of Green Buildings" was issued by the Chinese government. They set a goal that 30% of new buildings should reach the standard of green buildings by 2020 [7]. The first-tier cities' governments have developed economic incentives to encourage the development of green buildings. In 2013, the "green action plan" was officially started in China. In 2018, China built over 2.5 billion square meters of green buildings [7].

3.2. The benefits of green buildings

Because green buildings had spent much money on energy-saving facilities when they were built, the cost saving can be achieved through energy use after it begins to operate. They will have higher occupancy and lower energy consumption. Buildings with LEED certification are 25 to 30 percent more efficient than conventional buildings on average. In addition, they will have a higher selling and rental price. The constructions that have LEED certification in the US can gain rents that are 5 to 17 percent higher than other buildings. Meanwhile, they can be sold for 11 to 25 percent higher than buildings that do not have LEED certification [6]. Green buildings can highly increase people's rent and purchase willingness.

Green buildings also can improve public health by providing better ventilation and cleaner indoor air quality. They can decrease the emission of carbon dioxide. By the end of 2015, the total green buildings produced 1460 billion ¥ of environmental benefits. The underground space utilization produced 48.36% of gross value. It saved 115.76 million square meters of land used. The water-saving appliances in the green buildings saved 407.32 million tons of water in 2015. It helped to alleviate the water shortage in cities. Ground greening saved the use of coal by 326.6 thousand tons and reduced the carbon emission by 747.4 thousand tons. It generated 447.9 thousand tonnes of oxygen [7].

3.3. The difficulties analysis of green building development in China.

The development of green buildings is rapid, but there are still many difficulties that governments meet around the world. In Australia, the lack of motivation and knowledge about green construction restricts its development of it. In England, the high cost of them and inadequate experience become a major barrier. There are also many difficulties that the Chinese government is facing now.

Green buildings cost more money than conventional buildings. The developers of green buildings need to pay an additional 2 to 9 percent money to be certified as green buildings [6]. They need to use that money to purchase green facilities, like ground-source heat pumps and many green technologies. They are also responsible for design and labor costs. However, there is a longer payback period than conventional buildings. So, it becomes a barrier for people to invest in green buildings [6].

Many people do not become aware of the benefits of green buildings or do not have the professional knowledge to judge a green building. It leads to many people neglecting the importance of green buildings in our society. The immature environment of the marketplace is a critical factor that slower the green building development in China. The absence of training and promotion of environmentally friendly buildings let people not have relevant knowledge about that area [8].

3.4. Promotion of green buildings

There are five pivotal factors that can increase the development of green buildings, which can be listed as 'commitment of the project participants,' 'Integrated design,' 'Mandatory requirements,' 'Adequate incentives,' and 'Cooperation between stakeholders' [9].In China and the United States, governments have put in place many policies to encourage developers to build eco-friendly buildings to receive certification. Those policies include lowering tax rates, providing financial subsidies, etc. In 2012, China's government issued a policy based on incentives. It was mainly about the buildings which received a three-star certification could get a subsidy of eighty yuan per square. The governments expect to gain support from citizens by adopting those policies. They think the policies can make the environment more sustainable [6].

The construction cost of eco-friendly buildings should be decreased. The unit price of green buildings should be similar to that of conventional buildings. So, developers will have more willing to construct green buildings. In addition, it should have a good market environment to develop green buildings, like the attitudes of developers, consumers, and architects. Meanwhile, it needs mature green technologies to develop and many social factors to help it, such as people's understanding of green buildings, green buildings' reputation, and standards [10].

Company-related drivers, regulations, standards of government, and incentives support can significantly increase the adoption of green buildings [10]. Mandatory green policies and regulations can make the developers have more pressure, thus they will build green buildings. Meanwhile, those company-related drivers can encourage companies to adopt green building technologies and enhance their public reputation. Having a clear understanding of barriers, incentives, and adoption strategies can let the decision-makers avoid the barricades and know the key benefits of green buildings.

4. Conclusion

China has created many different green building assessment methods. The Evaluation Standard for Green buildings (three-star standard) is accepted by most people more than other methods. Many indicators from the three-star standard are based on the Leadership in Energy and Environmental Design (LEED) which is an assessment method from the US. After comparing the indicators of the three-star standard and the indicators of LEED, the Chinese one has more qualitative indicators which more focuses on the use of varieties of energy-saving technologies, rather than the number of those technologies or the amount of energy that the building has saved.

The Chinese government aims at promoting the development of green buildings, it encourages many departments to pitch in the development of green buildings and enacts the corresponding policies. However, there are still some barriers to developing green buildings in China. It is because it will cost more money for the developers to build a green building than a conventional building. Green buildings need many saving energy systems and equipment. So, it will take developers more money to construct those buildings. Meanwhile, the rent of green buildings is also more expensive than that of conventional buildings. Thus, it is hard to find tenants. As a result, it will cause a longer time for a developer to get profit from building a green building. Besides, most people in China don't have a professional understanding of the benefits of green buildings, which leads them to neglect their development of them. Also, the market for developing green constructions is immature in China. Therefore, there should be more incentives and regulations to promote them.

This article provides overall information about the green buildings in China, from their development history of them to how can people promote them more efficiently. The status of green buildings in China which has been mentioned in the paper shows the efforts that the Chinese government has made in the current decades and encourages people to continually develop green buildings.

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