Research on the Incremental Cost and Benefit of Green Building Based on the Whole Life Cycle

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Abstract: With the continuous development of the global economy, environmental and resource problems have become more and more serious, and sustainable development has become an inevitable trend. Among them, green buildings are a new type of industry in the construction field, which can avoid serious pollution problems. Based on previous work experience, this article summarizes the constituent elements of the incremental benefits of green buildings. The author discusses the incremental cost analysis from the following five aspects. They are the decision-making phase, the design preparation phase, the construction phase, the maintenance operation phase, and the demolition and recovery phase.

1. Introduction

Up to now, the development speed of the global economy has gradually increased, which has caused environmental and resource problems to become more and more serious. In the field of architecture, the extensive traditional buildings have high energy consumption, which can no longer meet people's specific life needs. Besides, green buildings, as a new type of construction, can effectively ensure the development of buildings and the unity of nature, which has become the foundation of the sustainable development of China's construction industry. At this stage, China has also increased its emphasis on the development of green buildings. Researchers proceed from the perspective of the whole life cycle to ensure that people can have a new understanding of green buildings.

2. The Concept and Connotation of Life Cycle and Green Building

2.1. Life Cycle Concept

Beginning in the 1950s, the whole life cycle theory has been gradually applied to economic management theory, and many new theories such as product life cycle and enterprise life cycle have been derived. The so-called full life cycle of a building mainly refers to the whole process of building from decision-making, planning to final scrapping and demolition, that is, the entire time required from the beginning to the final. According to the specific definition of life cycle, people can divide the life cycle of green buildings into the following stages. That is, the decision design phase, the implementation phase, the operation and maintenance phase, and the dismantling and scrapping phase. The specific situation is shown in Figure 1.
2.2. The Concept and Connotation of Green Building

It can be understood from the "Green Building Evaluation Standards" that green buildings mainly refer to truly saving resources, protecting the environment, and reducing the number of pollutants during the entire life cycle of a building. In addition, it provides a healthy and comfortable building space for human beings, so that nature and buildings are in a state of symbiosis. In contrast, green buildings mainly include the following characteristics. First, pay attention to the overall ecological design. Consider economic, social and environmental factors as a whole, and truly achieve the integrated operation of building structure and energy-saving design. Second, it shows the full life cycle of the building. Third, fully consider environmental issues to ensure the harmonious coexistence of people and the environment.

3. Analysis on the Elements of Incremental Benefits of Green Buildings

Through the analysis of the incremental benefits of the whole life cycle in the green functions, we can identify the incremental benefits of green buildings. Among them, the fundamental of incremental benefit analysis in benefit identification. To confirm the incremental benefits of a specific green building throughout its life cycle, the following formula must be used:

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\text{Incremental Benefits} = \text{Incremental Economic Benefits} + \text{Incremental Environmental Benefits} + \text{Incremental Social Benefits}
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3.1. Incremental Economic Benefits

The incremental economic benefits in the life cycle of green buildings are mainly the use of green buildings as the main body of investment, thus presenting new economic benefits. This also includes the economic benefits directly measured by stakeholders. From the perspective of the whole life cycle, the staff can learn from the specific technical indicators in the "Green Building Evaluation Standards" to bring new incremental economic benefits.

3.2. Incremental Environmental Benefits

Among the green buildings, the actual incremental environmental benefits mainly refer to the effective improvement of the indoor and outdoor environmental quality after applying energy-saving, water-saving, and material-saving measures in green buildings. This will not only further reduce resource consumption, but also directly or indirectly reduce air pollutant emissions, and control the incidence of diseases of users. Among them, the most important content is undoubtedly the reduction of carbon dioxide emissions, as well as the improvement of residents' health benefits and building durability.

3.3. Incremental Social Benefits

The social benefits of green buildings mainly refer to the series of contributions that green buildings will make to the living standards of users. From the perspective of developers and users, with the large-scale application of green buildings, the social saving capacity has been greatly improved, which has brought more comprehensive benefits to residents. Among them, the most common ones are the burden reduction benefits of municipal public facilities, the reduction of financial losses, and the improvement of work efficiency.
4. Green Building Incremental Costs and Incremental Benefits

4.1. Incremental Cost Analysis

4.1.1. Decision Stage
Generally speaking, the incremental cost of green building decision-making stage mainly involves the following content. First, the technical analysis and evaluation based on traditional benchmark buildings. Second, economic rationality analysis and evaluation operations. Third, environmental impact and analysis and assessment operations. Fourth, the energy consumption level analysis and evaluation operation. Figure 2 shows the incremental cost of green buildings in China.

![Figure 2 Incremental Cost of Green Buildings in China](image)

4.1.2. Design Preparation Stage
Throughout the entire green building design preparation stage, relevant staff not only need to determine the specific planning and design conditions, but also need to provide and sort out the basic materials for subsequent design, and do a good job in signing the contract. When the design work is over, we will also carry out the star-level evaluation of actual green buildings. The green building evaluation mentioned here mainly involves three levels of one-star, two-star and three-star. Besides, during the actual design preparation stage, incremental costs mainly involve program optimization design and increase costs. As well as the cost of light, sound, and thermal simulation of the design plan, and the registration fee and certification fee when applying for green buildings. In the process of actual work, relevant staff can determine the best project registration fee according to the housing and urban-rural construction regulations. At the same time design certification costs and operating certification costs. After adding these costs together, it is the total cost of the design preparation phase.

4.1.3. Construction Stage
The incremental cost in the construction phase is mainly to strengthen the environmental protection effect by means of green technology and the use of green materials, which in turn generates new cost increases. The incremental cost during the construction phase mainly involves the following aspects. First, the incremental cost of land saving. This type of incremental cost mainly includes waste land used during construction, as well as underground space developed by using old buildings to improve land utilization and incremental land use costs. In addition, with the help of green technology, the impact of the outdoor environment will also be minimized. This also increases the incremental cost of the outdoor environment. In the actual construction process, people also need to comprehensively consider the topographical features, customs, etc. of the construction site. With the help of effective ecological compensation measures, the natural environment such as river vegetation can be avoided...
from being damaged. At the same time, construction workers should also plant some green plants around the site to improve the greening rate of the surrounding environment. Furthermore, the construction personnel should also adopt effective rainwater measures to control the discharge of rainwater. This is also the internal process of increasing the ecological incremental cost of the site.

Second, the incremental cost of energy saving. The cost content mainly involves the cost of technology and materials that need to be consumed in the functional design of maintenance structures such as thermal insulation, the cost of HVAC systems, the cost of professional optical technology and material applications, and so on. In actual work, the staff must also fully consider the surrounding natural environment and humanistic characteristics, and make full use of renewable energy. Simultaneously, with the help of cold storage and heat storage, waste heat and waste heat utilization system, the incremental cost is always in a state of rationalization.

Third, save water quality cost. This type of cost content mainly includes the application of high-quality pipe networks, the installation of water metering devices for buildings, and the use of incremental costs for water-saving systems without overpressure outflow measures. Otherwise, after the actual treatment of wastewater and seawater is completed, it will be applied to road flushing, toilet flushing, and groundwater supplementation. This also consumes a certain cost, so it is called the incremental cost of non-traditional water use.

Fourth, the incremental cost of saving materials. The cost content mainly includes the foundation structure, the design operation of the main building, the integrated operation of civil engineering and decoration, the selection of local materials, and the reasonable division of the construction phase. These all belong to the incremental cost content of the selection of benchmark building materials.

Fifth, the incremental cost of indoor environmental quality. The incremental cost of building indoor environment quality is mainly the new cost increase in the process of adjusting the building indoor environment. Generally speaking, the most common components include the following aspects. That is, the incremental cost caused by the use of soundproof doors and other indoor acoustic environment adjustments, the incremental cost caused by the application of low-radiation materials, the incremental cost caused by the application of HVAC technology and so on.

4.1.4. Maintenance and Operation Phase
The main content involved in the incremental cost of the maintenance and operation stage includes the following aspects. First of all, during the actual operation and maintenance of green buildings, energy-saving and water-saving equipment are generally in normal operation. It will consume more incremental costs compared to the operation of ordinary equipment in the benchmark building. Secondly, in order to ensure that relevant energy-saving and water-saving equipment is in normal application state. The relevant staff should carry out necessary inspections and maintenance operations before the work starts. This is also higher than the incremental cost of ordinary equipment repair and maintenance equipment repair. Finally, it is the cost of waste sorting and disposal of green construction and the cost of recycling resources. These costs together constitute the total cost of the maintenance and operation stage.

4.1.5. Demolition and Recycling Stage
When the green building is used, the related staff will demolish it. This stage is also the dismantling and recycling stage that people often call. At this time, people can also use green technology to effectively demolish and recycle green buildings. This process will produce a difference in the cost of dismantling and recycling with the traditional technology. This difference is called the incremental cost in the recycling phase. During the actual construction of the building, the incremental cost of environmental protection and the incremental cost of classification and recycling of construction waste were also much higher than before. Therefore, relevant staff should pay more attention to it.

4.2. Incremental Benefit Analysis
The incremental benefits of green buildings mentioned in this article mainly refer to the fact that green
buildings need to be based on traditional building content during the construction process to generate corresponding comprehensive benefits. The main contents involved are economic benefits, environmental benefits and social benefits.

4.2.1. Economic Benefit
The overall economic benefits of green buildings are mainly dominated by obvious benefits. Moreover, only when economic benefits are feasible, project investors will become more willing to invest. Generally speaking, the economic benefits of green buildings mainly involve the following two aspects. First, design the government incentive policy in the preparation stage. It can be seen from the "Implementation Opinions on Accelerating the Development of China's Green Buildings" that the two-star award in China's green buildings is 45 yuan/㎡, and the three-star award is 80 yuan/㎡. In order to better strengthen economic benefits, various provinces and cities have also formulated different incentive measures. Second, green technologies will also be applied during the construction and operation and maintenance stages, which will then generate new economic benefits. The source of the entire incremental economic benefits of land saving mainly refers to the application of land saving technology to reduce the original land purchase cost. More importantly, the main components of energy-saving incremental economic benefits include the application of energy-saving HVAC, low-energy-consumption electrical equipment, and maintenance and structural transformation. The specific calculation method is the amount of resource saved multiplied by the unit price of the resource. However, the incremental economic benefits of saving materials are mainly based on recyclable materials, so that material costs can be effectively saved. The specific calculation method is to use the saved amount multiplied by the unit price of the material. The specific situation is shown in Figure 3.

4.2.2. Environmental and Social Benefits
First of all, from the perspective of environmental benefits of green buildings, it is mainly based on invisible benefits, and the content that can quantify environmental benefits mainly involves the following aspects. First, improve the efficiency of reducing air pollutants. Second, increase the service life of building materials and reduce maintenance costs. Third, improve health benefits. Besides, the social benefits of green buildings also belong to the category of invisible benefits. The main content involved is green building rainwater recovery technology, water-saving equipment, etc. These can save part of the sewage cost for the benchmark building. In addition, it also includes the comprehensive social benefits of saving electricity, the welfare of green buildings, and the economic benefits of improving sleep quality.
4.3. Regulation of Economic Externalities of Green Building

It can be seen from the actual green building development process that a part of the production income of the sender will “diverge” to the social income level. This ensures that the equilibrium point of private production is lower than the equilibrium point of social demand. It is precisely because of this situation that some social welfare has suffered serious losses. In addition, affected by externalities, the needs and interests of different entities will produce more conflicts. Therefore, many subjects hold a negative attitude towards the green construction industry. Moreover, the externality of green buildings often requires government departments to formulate corresponding laws, regulations, and clear incentive policies, so that the incremental costs and benefits of green buildings can be effectively regulated. This is also the meaning of full life cycle applications.

5. Conclusion

In summary, at this stage, people are paying more and more attention to global climate change and sustainable development. However, the economical nature of actual green buildings has made some people questioning, which has had some impact on the construction of my country's main ecological civilization. To this end, relevant departments need to strengthen the research on the full life cycle of green buildings and present specific economic advantages. In this way, a reasonable work plan is set and the feasibility of the study is strengthened.

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