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Research on Management and Innovation of Green Building of Real Estate Enterprises under the Concept of "Dual Carbon"

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Abstract: *Since carbon emissions from the construction industry is one of the four major areas of China's carbon emissions, green and low-carbon is the future development trend of building design. The real estate industry, as an important part of the realization of the goal "carbon peak and carbon neutral", faces long-term carbon emissions base, the increasing total amount of carbon emissions and other issues. This paper aims to investigate the innovation path of green building development in real estate enterprises. Specific carbon reduction measures are targeted, while exploratory and exploitative green innovations are introduced to reshape the core competitiveness of real estate enterprises and promote the transformation of the construction sector to the green and low-carbon.*

Keywords: *"dual carbon"; real estate companies; green building development; innovation*

1. Introduction

According to China's "dual carbon" commitment, China will strive to reach peak carbon emissions by 2030 and to achieve carbon neutrality by 2060[1]. This national strategy will not only have a far-reaching impact on the international industrial chain, but will also trigger profound changes in the domestic construction industry, especially in the development mode of the real estate. Construction is one of the four major areas of China's carbon emissions. "Reinventing Energy: China's Roadmap for the Energy Consumption and Production Revolution in 2050 (Volume for Industry)[2]" points out that the energy scenario for 2050, compared with the scenario for reference, the potential construction industry has for carbon and emission reduction is as much as 74%, which is 1.5 times that of the industry and construction industry has the greatest potential among the three major energy-consuming sectors of industry, construction and transportation, so the low-carbon transformation of the building development is the key to achieving "dual-carbon". Therefore, a low-carbon transition in building development is key to realizing the "dual-carbon" goal.(As shown in figure 1)

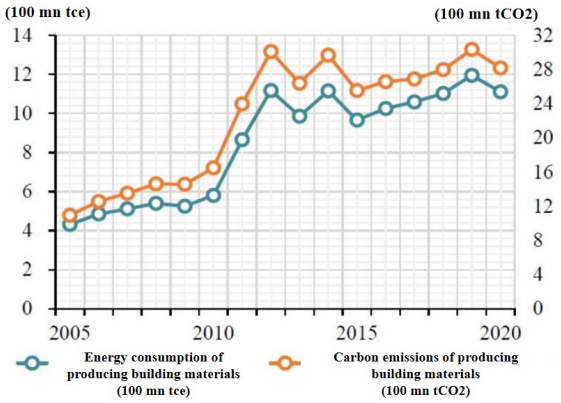

Figure 1. Trends in energy consumption and carbon emissions of producing building materials

2. Overview of the "dual-carbon" concept and green buildings

2.1 Low-carbon economy

Low-carbon economy, as a formal concept, originated from the British white paper on energy "Our

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Energy in Future: Creating a Low-Carbon Economy" in 2003[3]. It refers to an economic development mode which, guided by the idea of sustainable development, cuts the usage of oil, coal, and other high-carbon energy sources as much as possible, reduces greenhouse gas emissions, and achieves a "win-win" situation between economic and social development and ecological and environmental protection through technological innovation, institutional reformation, industrial transformation, and the exploration of new energy sources. (As shown in figure 2)

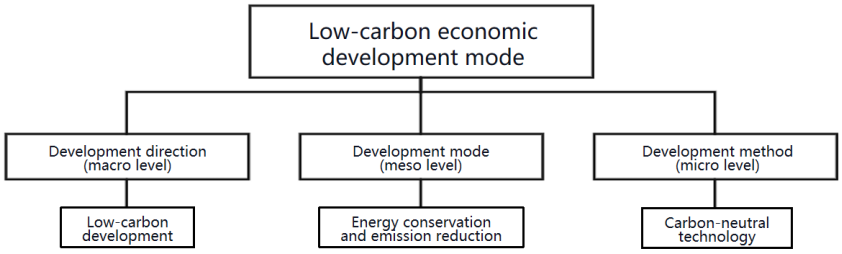

Figure 2. The development mode of low-carbon economy

2.2 Green buildings

Green building derives from the concept of sustainable development, the functional requirements of green buildings guided by the World Green Building Council (WorldGBC) include[4]:

1) Effective utilization of energy, water and other resources;

2) Use renewable energy, such as solar energy;

3) Measures to reduce pollution and waste, and recycle waste;

4) Good indoor air quality;

5) Use non-toxic, ethical and sustainable materials;

6) Consider environmental factors in design, construction and operation;

7) Consider the quality of life of residents in design, construction and operation;

8) A design that can adapt to the changing environment.

2.3 Innovation in the development of green buildings

For real estate enterprises, green building is the development goal and important carrier of enterprise innovation in the low-carbon context, and green technology innovation is the core content of green innovation. In this study, the development and innovation of green building is defined as brand-new activities of utilization and development in which the enterprise applies green sustainable elements around the whole life cycle of the design, construction and operation of the building project, and considers the negative impacts of the enterprise's operation on the environment in the aspects of technology, product, service, process, organization and market.

The development and innovation of green building is characterized by two features: first, the construction technology innovation is characterized by frequency, complexity and risky. Due to the one-time characteristic of construction projects, it is difficult to realize the complete replication of the application of the existing green innovation technology to the construction process of different projects. So, the enterprise needs to tailor to the local conditions, on the basis of the existing technical advantages, continuously form differentiated improvements for green technology. Second, the green innovation of construction enterprises also needs high technology and has urgency. Since the current level of green building technology cannot meet the needs of the "dual-carbon" goal, and the technical level still needs to be upgraded and breakthroughs.

3. The Innovation Path of Real Estate Enterprises' Green Building Development

Both types of activities are needed in the green innovation activities of construction, so both types of innovations, exploratory green innovation and exploitative green innovation, should be considered.[5]

Green innovation in construction firms should be more of a phased, hierarchical, and step-by-step

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approach. De Visser et al (2010) demonstrated that if firms want to achieve better results by improving existing products and developing new ones, they need to focus on a variety of innovative activities[6]. According to the degree and stage of green innovation, construction companies need to carry out both types of green innovation activities at the same time.

3.1 Utilizable green innovation

Utilizable green innovation emphasizes the introduction of mature green building technologies, or the continuous extension of existing technical knowledge through the continuous improvement and adjustment of existing construction processes or outputs (products/services), which effectively reduces the consumption of raw materials, water and energy, as well as reduces the negative impacts of emissions of waste gases, wastewater and hazardous substances on the environment. With the advantages of faster speed, lower cost and lower risk, it is conducive to the expansion of existing products and services, and can increase the utilization rate of existing resources in a short period of time, and thus improve the green image of enterprises.

3.1.1 Improvement of the design standards of green building

The fundamental standard of green building in China, "Green Building Evaluation Standard" GB/T 50378[7], was promulgated and implemented in 2006, and with this standard as the core, a more complete system of green building standard has gradually been formed. In 2022, the Ministry of Housing and Urban-Rural Development (MOHURD) issued GB 55015-2021, "General Specification for Energy Efficiency and Renewable Energy Utilization for Building"[8]. For the first time, the calculation of carbon emissions in building was made a mandatory requirement. With the development of building technology, passive ultra-low-energy, near-zero-energy and zero-energy buildings have emerged. For residential buildings, it is recommended to change the past design method that focuses on façade and appearance effect, and to establish a construction concept that takes low-carbon benefit and green performance as the fundamental. It takes a certain period of time for the standards of energy efficiency of new buildings to be raised, applied, completed in projects and put into practice. At the same time, the iteration and upgrading of energy-using equipment in buildings is rapid, so it is necessary to have a certain degree of foresight in the formulation of the standards, so that they can cope with the development of the future building and the transformation of the energy-using system.

3.1.2 Green innovation in building materials

In terms of accounting for carbon emissions in the whole process of construction, there are three major stages, namely, the production stage of building materials, the construction stage and the operation stage of the building. The carbon emissions from the production stage of building materials refer to the energy consumption and carbon emissions of building materials consumed by the construction industry during the whole production process (including upstream raw materials), including housing construction and infrastructure projects. According to the figure below, the production stage of building materials accounts for 28.2% of carbon emissions. (As shown in figure 3)

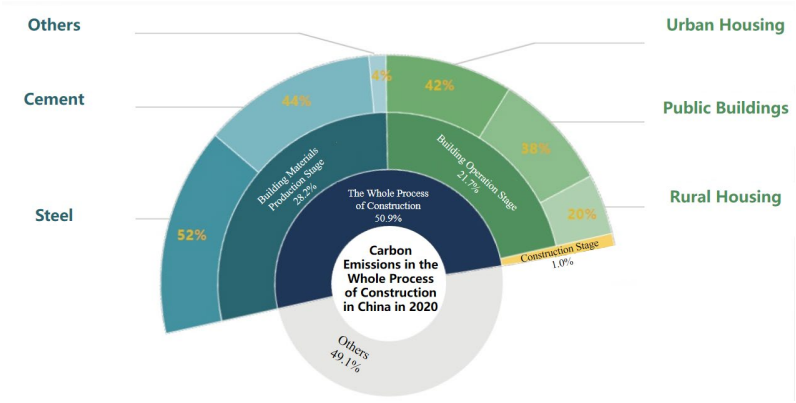

Figure 3. Total energy consumption and share of carbon emissions from the whole building process in China in 2020[9]

At this stage, China's high-rise building construction has a greater demand for concrete, reinforcing steel and other materials. However, reinforced concrete materials are of high pollution. In the process of selecting materials, designers should prioritize the use of recyclable and environmentally friendly

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materials to reduce material waste. For example, in the design process of the main frame, designers can choose reinforced concrete materials, while for non-load-bearing structures, designers can choose some green materials. In addition, in the process of material transportation and construction, powdery materials are easily affected by wind and will spread freely, thus generating dust pollution, which seriously affects the urban environment. It is reasonable to give full consideration to the energy-saving and recyclability of the materials, promote the implementation of low-carbon energy-saving and environmental protection concepts from the root, and combine with the surrounding construction market and raw material market, preferably take materials from the local area to effectively reduce the emission of pollutants.

3.1.3 Making full use of the natural environment to optimize building design

The natural environment has a greater impact on the construction of the project, and the designers need to combine the environmental attributes of the project site and the design requirements of the construction project, adjust the design program, so that the natural environment and the construction will be fully integrated, and a green, environmentally friendly, comfortable place will be created for the residents to live. Therefore, the designers should conduct a field survey of the local ecological environment, understand the local topography and geomorphology, make full use of the terrain, reduce the amount of construction work, and save construction resources. At the same time, the designers should comprehensively analyze the wind direction, light and other factors where the construction project is located, optimize the spatial structure of the building, realize the efficient use of natural wind and sunlight and other natural resources, reduce energy consumption in the process of construction and use of the building, and meet the requirements of people's low-carbon life.

There are many cases of using natural environment to optimize the design of building to achieve the goal of low-carbon design, such as Spain's "Air Tree" building (As shown in figure 4)[10], which fully combines the characteristics of the natural environment in the city, makes great use of renewable energy, designs sprinkler pipes in the internal space of the building and cultivates a large number of plants, so that the carbon dioxide produced in the building can be quickly absorbed, thus improving the air quality inside the building and providing a green living place for the occupants.

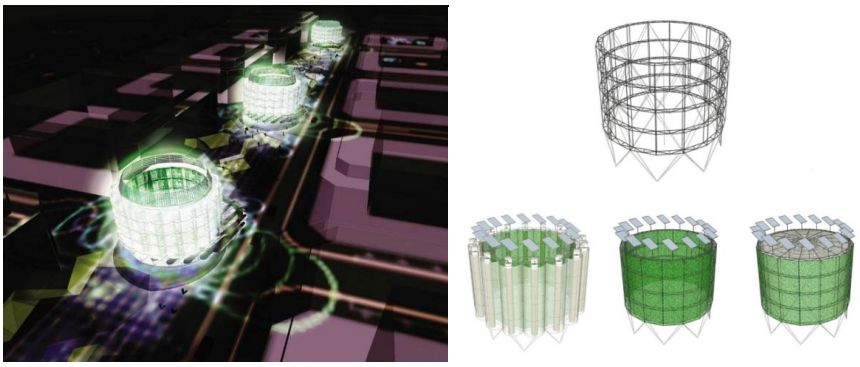

Figure 4. Spain's "Air Tree" building

3.2 Exploratory green innovation

Exploratory green innovation focuses on the development and breakthrough of sustainable designs and solutions based on new concepts, such as launching new environmentally friendly products or services, designing new construction processes for energy saving and emission reduction, and opening up new markets and customers through cross-border cooperation, etc. It usually requires a complex search process and prudent investment management, and is reflected in the process of green design, construction, and operation, which is conducive to enhancing the market share and influence of the enterprise. It helps to increase the market share and influence of the enterprise, and promotes the enterprise to become the leader of green standards in the industry. Once successful, such innovative activities are generally difficult to be imitated and surpassed by competitors in the short term, which helps to consolidate the competitive advantage of the enterprise.

3.2.1 Concrete 3D Printing Technology

Concrete 3D printing construction is a complex and systematical engineering that includes equipment, software, materials, printing, structural design, construction, acceptance and delivery and many other aspects. Relying on the intersection of materials science, computer science, robotics, structural engineering, and architectural design and other disciplines, concrete 3D printing technology has made a

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number of breakthroughs and advances, and is expected to be applied on a large scale in the future of the construction industry.[11]

The traditional construction industry is labor-intensive, and the amount of carbon emissions generated by manual labor on construction sites cannot be ignored. While high-tech intelligent equipment such as digital control systems and construction robots offer higher operational efficiency and lower energy consumption and carbon emissions. The automated construction process of 3D printing reduces the need for labor, which can effectively deal with the global labor shortage while significantly reducing the carbon footprint of the manual labor during the construction phase. In addition, unlike the traditional method from frame support to steel banding to concrete pours, the 3D printed process does not require frame support, which reduces or eliminates the need for formwork during construction and prefabricated component production, reduces the cost and energy consumption of formwork manufacturing, and reduces the amount of construction waste from discarded formwork. For shaped buildings or components, concrete 3D printing technology can reduce the energy consumption and cost of shaped formwork production while reducing construction difficulty and increasing the freedom of architectural design. At the same time, formwork-free construction allows 3D printing to topologically optimize structural design based on component stresses, minimizing the use of construction materials. Studies have shown that 3D printing can reduce construction waste by 30-60%, labor consumption by 50-80%, and construction time by 50-70% compared to traditional construction methods.[12] This is of great significance for the construction industry to realize green, low-carbon and intelligent efficiency.

3.2.2 Building a supply chain system of green building

In order to achieve long-term sustainable development, real estate enterprises must choose partners with capacity for green production and sustainable development strategy to achieve the goal of strategic interoperability and mutual benefit. At the present stage, many real estate enterprises still select suppliers taking achieving short-term economic benefits as the starting point, ignoring the environmental benefits brought by suppliers. They lack of strategic vision for long-term development. In the process of real estate development, the establishment of a perfect supply chain system of green building plays an important role in promoting the sustainable development of green building and the improvement of the level of the construction industry.

The management mode of green building supply chain refers to the management mode that maximizes the resource utilization rate and minimizes the environmental impact of the production and operation of the construction project by coordinating the design companies, construction suppliers, construction companies and construction recyclers in the construction supply chain during the whole process of the construction project's design, material and equipment procurement, construction, marketing and recycling. The green building supply chain emphasizes the implementation of green concepts throughout the construction project cycle, aiming to comprehensively coordinate the economic and environmental benefits for construction enterprises.

4. Conclusion

In summary, real estate enterprises, as the key implementation body of green building development, through the innovation and development of the technology and mode of green building, will realize the design of low carbon, low carbon materials, low carbon construction process, low carbon operation and maintenance, so as to form the whole process of real estate development of low carbon. This paper enriches the related research about the green innovation in terms of the development mode of real estate, which may shed some lights for real estate enterprises on enhancing the ability of green innovation.

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