

Research on Carbon Neutralization Approach and Photovoltaic Energy for Eco-friendly Prefabricated Buildings in Extremely Cold Regions

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Received: 26 September 2024; **Accepted:** 14 October 2024; **Published:** 26 October 2024

Abstract:

Carbon neutrality has become essential in the construction and energy sectors, especially in freezing climates. This study focuses on eco-friendly prefabricated buildings and photovoltaic technologies, exploring their synergistic effects in achieving carbon neutrality. First, the impact of cold environments on building and energy systems and the significance of carbon neutrality are summarized. Second, the working principles and advantages of eco-friendly prefabricated building and photovoltaic energy technologies, along with their critical roles in carbon neutralization, are analyzed. Practical and effective strategies for achieving carbon neutrality in cold regions, based on specific case analyses and data statistics, are discussed. The study found that optimizing green building designs, integrating photovoltaic energy systems, and considering local climate characteristics can significantly reduce carbon emissions. Finally, research results are summarized, and directions for future research are proposed.

Keywords:

Carbon Neutrality, Eco-friendly Prefabricated Building, Photovoltaic Energy Technology, Extremely Cold Climate, Sustainable Development

1. Introduction

As a new building material, prefabricated building materials have attracted worldwide attention. Due to its advantages of energy saving, emission reduction, civilized construction, environmental protection, and its characteristics of improving efficiency, ensuring engineering quality, and reducing indoor pollution during construction, it has attracted wide attention in architecture. Prefabricated building materials have excellent development potential in the global construction market, but their development in the Chinese market faces certain obstacles, especially in cold climate conditions.

From the perspective of economic benefits, the cost of prefabricated buildings is generally higher than that of traditional buildings. However, its advantages in the whole life cycle of buildings must be comprehensively considered. In the context of the new era, actively promoting prefabricated buildings has become an inevitable trend in the development of China's construction industry. It is also the primary way to reform the traditional construction model and improve the level of the industry. Promoting the development of prefabricated buildings plays a vital role in China's green growth and supply-side reform. In addition, it contributes to the stable development of China's economy, realizes technological upgrading, improves production efficiency, guarantees housing quality, and promotes green building [1].

In various regions of China, it is necessary to actively and effectively promote the development of prefabricated buildings according to local characteristics and adopt different development methods according to local conditions. Therefore, this paper will use severe cold climate conditions to study further the collaborative application of eco-friendly prefabricated buildings and photovoltaic energy technology in this unique environment [2].

2. Eco-friendly Prefabricated Buildings in Extremely Cold Regions

Due to global climate change, architectural design faces much more severe challenges under severe cold climate conditions. Therefore, eco-friendly prefabricated buildings have attracted much attention as a new architectural model. This architectural model has become the industry's focus because of its high efficiency, environmental protection, and sustainable characteristics. The characteristics of eco-friendly prefabricated buildings include but are not limited to using environmentally friendly materials, modular design, and efficient energy utilization. In particular, in the severe cold climate, the eco-friendly prefabricated building shows its significance in architecture by emphasizing the specific design strategies of thermal insulation performance and reducing energy consumption.

3. The Advantages of Eco-friendly Prefabricated Building

3.1. Promote the Transformation and Upgrading of the Construction Industry

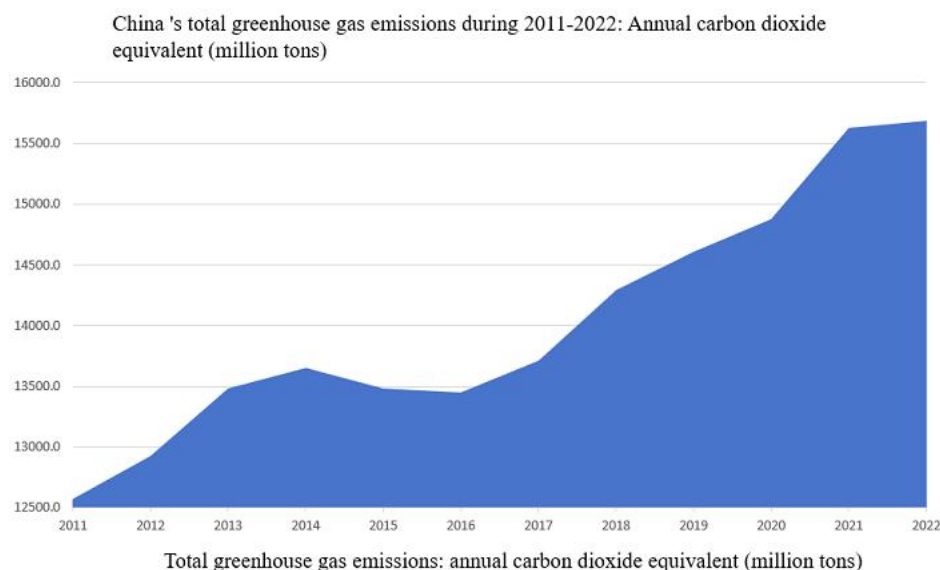
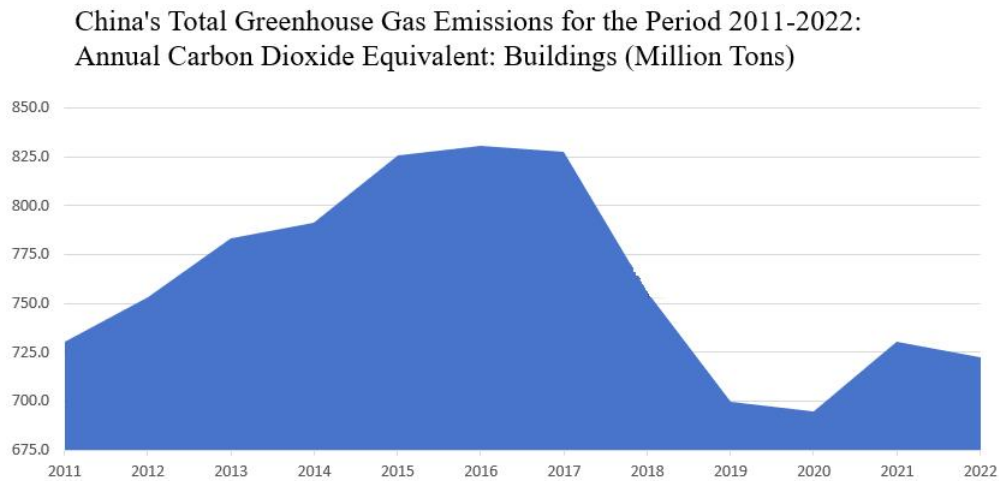


Figure 1. Total greenhouse gas emissions: annual carbon dioxide equivalent.



Total greenhouse gas emissions: Tons of carbon dioxide equivalent per year: Construction 2013

Figure 2. Total greenhouse gas emissions: Tons of carbon dioxide equivalent.

Figure 1 and Figure 2 show that China's total greenhouse gas emissions have been increasing year by year in the past decade, and the emissions of the construction industry have increased significantly during 2011-2017. A few years later, with the advocacy of carbon neutrality, carbon emissions dropped off a cliff. However, carbon dioxide emissions from the construction sector still exceed 700 million tons, accounting for nearly 5% of China's total carbon dioxide emissions. There is a long way to go to achieve the goal of carbon peak and carbon neutrality in the construction field. It is necessary to implement policies comprehensively, popularize green buildings in an all-around way, and promote green construction in depth.

3.2. Promote the Modernization of the Construction Industry

Developing eco-friendly prefabricated buildings will also inject strong impetus into upgrading various new materials and technologies. Eco-friendly prefabricated building is a critical part of the innovation and upgrading of China's construction industry, which is bound to promote the development of upstream and downstream sectors. Prefabricated buildings promote the upgrading of prefabricated buildings towards a high-quality green building industry, thereby achieving a virtuous cycle [3].

3.3. Accelerate the Construction of Low-carbon Communities

Cities are the home of artificial greenhouse gas emissions. To realize carbon neutrality in urban areas, we must not mindlessly follow the traditional path of Western countries but open up a modern road [4]. When promoting the revitalization of aging residential areas and urban renewal, energetic revitalization of the residential regions is carried out. Therefore, the capacity of urban infrastructure will be increased, while the facility structure and energy utilization mode will also be optimized [5].

4. Problems in the Process

4.1. Imperfect Economic Support System

Advanced technology and management methods can effectively guarantee the quality of the building, protect the environment, and save resources. Because the development of eco-friendly prefabricated buildings is in its infancy, and the business

model needs to catch up, it will have a particular impact on the costs. Therefore, long-term incentive policies such as finance and taxation are needed [6].

4.2. Low Technical Level and Professional Skills

The shortcomings of housing industrialization are mainly reflected in the following aspects:

(1) In terms of design, it is essential to make new prefabricated components and refine the design. However, the traditional prefabricated component factories and design institutes need to have a mature and stable ability to deepen the design of modules or consider it, thus producing some substandard editing errors when producing prefabricated components [7].

(2) In terms of quality, there is no uniform standard for the quality of raw materials used in production, resulting in particular differences in the quality of abrasives and accessories, and the quality is low. In addition, the production equipment still needs to form a mature general module, which needs to be improved.

(3) The supply of supporting materials needs to be increased. A large number of supporting materials are required for the production and application of prefabricated buildings. The existing problems are an insufficient supply of these supporting materials and an immature product quality management system [8].

(4) The management and technology could be better. The critical technology of implementing prefabricated building construction is an integral part of improving the project management system. Due to the lack of relevant knowledge reserves, the actual construction efficiency could be higher [9].

4.3. Imperfect Policy Guarantee System

With the continuous development of green buildings, relevant legal norms have been introduced in China, and the policy system is also constantly improving. Nevertheless, the legal system has a narrow scope of constraints, and the management could be more robust, resulting in a lack of constraints and guarantees for green building projects and affecting the overall development of the construction market. There are no clear energy conservation requirements, the legal liability system needs to be more explicit, and there needs to be detailed programs and countermeasures [10].

5. Solutions to Eco-Friendly Prefabricated Building

5.1. Policy Support

The government should improve the relevant support policies and provide support in scientific and technological research and development, as well as cost model research. For example, European and American countries have adopted a variety of preferential policies to develop prefabricated buildings. Therefore, to ensure an open green channel under the entire national system and reduce the approval process, we invest in technology research and development. China should adopt the developing trend of prefabricated buildings. The construction of various types of affordable housing and government infrastructure, such as demolished houses, apartments, low-rent housing, and public toilets, can be led by the government with the participation of construction companies from all parties.

5.2. Technological Innovation and the Establishment of Relevant Standards

With the continuous development of eco-friendly prefabricated buildings, eco-friendly prefabricated buildings must meet more social needs. Technical systems and standards should speed up innovation, improve the technical level of prefabricated buildings, and improve their mechanical properties and structure. They focus on the research and development of new technologies, new materials, and new processes; this is the focus of the current development of China's eco-friendly prefabricated buildings.

5.3. Establish A Sound Management and Control System

A perfect legal system and norms are needed to promote green building project management. Therefore, it is necessary to establish an effective control and guarantee system to lay a good foundation for facilitating the management of green building projects. The following aspects can serve as a starting point:

To begin with, improving the relevant legal norms is essential to protect the rights and interests of stakeholders in green building projects. Simultaneously, it is crucial to establish a comprehensive claims system and an accountability framework.

Additionally, managers should formulate a practical certification and evaluation system. By classifying green buildings under qualification certification and assigning unique building signs, this system can influence market consumption behavior and guide consumers' decisions more effectively.

Moreover, the development of energy-saving technical standards and energy consumption indicators is necessary to strictly control energy use and minimize buildings' environmental impact. It is also important to actively incorporate new technologies, processes, materials, and equipment while phasing out obsolete ones. Managers should enhance the promotion of green technology and materials to ensure the standardization of construction and inspection processes.

5.4. The Implementation of Effective Management Reward and Punishment Mechanism

It is imperative to improve and implement effective reward and punishment measures for construction projects. The government should develop comprehensive financial subsidy measures, particularly during the technology development stage, and ensure the provision of adequate resources and financial support. Moreover, the government should increase its focus on these initiatives to enhance the enthusiasm of technology research and development personnel and stimulate market consumption.

6. Analysis of the Advantages of New Photovoltaic Energy Technology

6.1. Reduce Energy Consumption

Energy consumption has always been a shortcoming of human civilization's development, especially in industrialization [11]. Photovoltaic new energy technology is an effective way to help people reduce energy consumption. Its principle is to use solar energy to generate electricity. It effectively avoids the loss of electric energy in long-distance transmission, maximizes the role of electric energy, and reduces the loss of non-renewable resources in the construction industry to some extent [12]. Therefore, buildings can realize the conversion of solar energy, thus significantly reducing energy consumption. This technology has been widely used at home and

abroad and achieved remarkable results. Take a large commercial center in Germany as an example. After adopting new photovoltaic energy technology, the center reduced energy costs by 20 million euros within one year.

6.2. Safe and Pollution-Free

New photovoltaic energy technology is safe and pollution-free, and it is one of the ideal choices in renewable energy technology. New photovoltaic energy technology provides a sustainable new energy source by converting solar energy into electrical energy [13]. Photovoltaic new energy has the advantages of low cost, renewable, accessible storage, and no pollution. Therefore, it is increasingly favored by people and has attracted wide attention from construction practitioners [14].

7. The Specific Application of New Photovoltaic Energy Technology in Building Electrical Energy Saving

7.1. Photovoltaic Roof

With the increasing attention to the solar power industry in China, the field of photovoltaic roofs is developing rapidly. The overall scale, floor space, and power generation capacity of photovoltaic roof projects are growing continuously.

Since the late 1970s, the United States began to develop solar photovoltaic power generation technology and spread it across the country. The application range of photovoltaic roofs has gradually expanded and is widely used in industry, commerce, and agriculture. China's total purchase of photovoltaic roofs has reached 12 trillion yuan, and state and government procurement accounts for a large proportion. China has built the largest and most advanced photovoltaic roof production base. As the photovoltaic roof gradually enters the public view, more and more people choose to install this new energy equipment.

7.2. Photovoltaic Curtain Wall

As an innovative building material, the photovoltaic curtain wall is attracting more and more attention. It is a kind of solar power generation equipment that can convert solar energy into electric energy. This process can be realized through photovoltaic modules installed on the facades of buildings. Solar photovoltaic curtain walls can significantly improve the appearance of buildings. At the same time, it has excellent air permeability and heat insulation performance. In addition, it can prevent buildings from being damaged by direct sunlight and reduce the heat loss inside the building to achieve good energy savings.

8. Conclusions

Developing prefabricated buildings in extremely cold region will lead to a new trend and become an emerging construction trend in China. By adopting the method of factory manufacturing and on-site assembly, the aim is to achieve the goal of "energy saving, water saving, material saving, time saving and environmental protection." It can reduce the construction site's pollution and noise and the cost of labor and materials. At the same time, researchers shorten the construction period, reduce the impact of seasonal factors, and further reduce costs. With well-equipped equipment and advanced information systems to control the production process, future building components can flow between workshops. Most of the parts and components

will be manufactured in the factory during the project's construction and then delivered to the construction site. From the front-end factory equipment manufacturing and transportation production to building materials technology, it is necessary to build and expand the construction scale of integrated enterprises and promote upgrading the industrial chain. Future research should learn from the installation experience of Western developed countries and support enterprises in perfecting professional and technical facilities. At the same time, it is also crucial to continuously improve the technical level, expand the scale of production, and improve the technical level of workers. From planning and design to factory processing, transportation, and on-site installation, this project is committed to achieving the goals of high energy saving, high environmental protection, and high engineering quality.

The increasing number of electrical equipment in buildings has led to a large increase in energy consumption and huge waste. How to effectively use new energy technologies to reduce energy consumption has become a hot topic in current research. New photovoltaic energy technology is an emerging technology that can convert sunlight into electrical energy. It has been widely used at home and abroad, and achieved remarkable results. Based on the current situation of building electrical energy saving, this paper briefly analyzes the existing problems, and puts forward opinions and suggestions on how to make efficient use of photovoltaic new energy. Dedicated efforts are aimed at enhancing the national standards of building electrical energy conservation and advancing sustainable economic development.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Funding

This work was supported by the Fund support: Key research project on economic and social development in Jiamusi City (Project No. 230031); Jiamusi University Education and Teaching Reform Research Project (Project No. 2023JY4-08); Supported by the Higher Education Research Project of Heilongjiang Higher Education Association (Project No. 23GJYBJ109).

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