Journal of Energy and Power Engineering 16 (2022) 166-174
doi: 10.17265/1934-8975/2022.04.003

Research on the Development of Green Building Technology in Hot Summer and Cold Winter Area under the Background of Carbon Neutrality: A Case Study of Zhuzhou City

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Abstract: Carbon sequestration and emission reduction in the construction industry plays an important role in China's goal of achieving carbon neutrality. Research in Zhuzhou city scored 42 since the assessment of the green building project situation as the research object, in hot summer and cold winter areas of analysis and evaluation on the development of green building technology, and then sums up the carbon neutral background the priority areas and tasks for the development of green building techniques, optimization of the construction industry into a new era under the background of green development to provide the reference.

Key words: Carbon neutrality, hot summer and cold winter area, green building technology.

1. Introduction

Carbon neutrality refers to a state in which the total amount of carbon emitted is less than or equal to the total amount absorbed by a carbon sink. Since entering the era of industrial civilization, mankind has created huge material wealth and accelerated the grab of natural resources. The massive and rapid carbon emissions brought about by industrial civilization have broken the balance of the earth's ecological system, and the deep-seated contradiction between man and nature has become increasingly apparent. In recent years, the increasingly severe climate change has brought great challenges to human survival and future development. On September 22, 2020, during the 75th Session of the United Nations General Assembly, China proposed that it would enhance its nationally determined contribution and adopt more effective policies and measures to strive for the peak of carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060 [1].

"2020 global construction status report" pointed out that in 2019 global construction sector is about 1 billion tons of CO_2 emissions, accounted for 28% of global energy related carbon emissions, with part of the construction industry (the entire industry used in the manufacture of building materials, such as steel, cement and glass (estimate)) of emissions, the proportion will rise to 38% [2]. China is still in the economic growth stage, and is the country with the largest total carbon emission in the world, and its carbon emission per unit GDP is higher than that of developed countries such as Europe and the United States. Therefore, the "China plan" and roadmap are particularly important in achieving the goal of global carbon peak and carbon neutrality. The development trend of green building technology is closely related to the global environment, energy and human settlements, so it is of great importance and urgency to develop

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green building in China [3]. Therefore, it is of great significance to study how the green building industry can effectively cope with carbon neutrality.

Areas with hot summer and cold winter are characterized by hot summer, cold winter and high humidity throughout the year. The climate in hot summer and cold winter areas is worse than that in other areas at the same latitude in the world, and building energy consumption is required to achieve the same thermal comfort conditions. Therefore, it is particularly important to study the development direction of green building technology in hot summer and cold winter areas to achieve the goal of carbon neutrality. As a key driver of green development and carbon neutrality, green technological innovation is becoming an important emerging area in the new round of global industrial revolution and scientific and technological competition [4].

2. Premise and Principle of Carbon Neutrality in Construction Industry in Hot Summer and Cold Winter Region

Under the guidance of the overall political situation promised by the state, the construction industry is brave enough to undertake its mission to achieve carbon neutrality, from the whole life cycle of buildings to become carbon neutrality, such as building construction, operation and maintenance to reduce carbon emissions, the balance of carbon emissions at the same time adoption of strategies to cope with the climate characteristics of different climate area, so as to provide a more healthy and comfortable life for people.

In response to climate change, various green building technologies should take into account both heating in winter and cooling in summer, scientifically and effectively deal with the needs of ventilation, lighting, shading and heat insulation of buildings, improve the basic performance of building itself to regulate the internal environment of buildings, and try to use clean energy. We will promote deep-seated changes in China's economic structure, industrial structure, energy structure and way of life.

3. Current Development Status of Green Building Technology in Zhuzhou

3.1 Research Contents and Methods

Reasonable application of green building technology is the foundation of building energy saving and low carbon. The application data of green building identification can reflect the application situation of corresponding technology in the region from the side. The big data of "four saving and one environmental protection" of civil architecture have economic and scientific value [5]. The study takes 42 green building projects (including 25 residential buildings and 17 public buildings) in Zhuzhou city, a typical city in hot summer and cold winter regions, as samples. The project application period is from 2018 to 2020.

According to the evaluation index system of Green Building Evaluation Standard of Hunan Province (DBJ 43/T 314-2015) (hereinafter referred to as the standard) [6], according to carbon emissions' evaluation score of all green technologies of public buildings and residential buildings, a statistical analysis on scores of different technology is made, the current green building technology application situation of Zhuzhou city is summarized, under the background of carbon neutral in hot summer and cold winter region, the development of green building technology breakthrough is explored.

3.2 Green Building Technology Sorting

The study sorted out 13 carbon neutralization related technology subitems (Table 1) according to the evaluation rules of the relevant provisions of the five major technology systems of energy saving, land saving, water saving, material saving and indoor environmental quality in the Standard.

Table 1 List of green building technologies related to carbon emissions.

Technology system	Technical items	Carbon neutrality
Land saving	The land use	Intensive use of land to reduce hardened areas and preserve more green space to absorb and fix carbon.
	Outdoor environment	Improve the external conditions of the site to reduce heat island intensity and reduce energy requirements to reduce carbon emissions.
	Transportation and public service facilities	Reasonable public transportation and organization of public facilities reduce greenhouse gas emissions.
	Site design and site ecology	Ecosystem richness affects the strength of the carbon cycle.
Energy saving	Building and envelope structure	The high-performance envelope can enhance the thermal insulation effect of the building itself, and reduce energy consumption on the side.
	Heating, ventilation and air conditioning	Distinguish heating, ventilation and air conditioning needs of different spaces to avoid waste.
	Lighting and electricity	Intelligent control, using efficient electrical appliances.
	Comprehensive utilization of energy	Energy recovery and renewable energy use to reduce carbon emissions.
Water saving	Non-traditional water use	The scientific and rational utilization of non-traditional water resources is conducive to the stability of ecosystem and the improvement of biological carbon sequestration.
Saving material	Saving material design	Optimize the design to achieve material saving effect and reduce the difficulty of construction.
	Material selection	Improve repeatable utilization rate and standardized production and treatment rate to effectively reduce carbon emissions.
Indoor environmental quality	Indoor light environment and visual field	Use natural lighting as much as possible to reduce energy consumption.
	Indoor hot and humid environment	Indoor humidity and heat environment independent adjustment, energy saving and carbon reduction.

3.3 Analysis on the Application of Green Building Technology

According to the scores of relevant technical sub-items in self-assessment reports of 42 green building projects, the average scoring rates of public buildings and residential buildings are statistically analyzed, as shown in Fig. 1.

3.3.1 Land Use

With the increasing concentration on greenhouse gases in the atmosphere, carbon emissions caused by land use change have become the second largest source of greenhouse gas emissions. This paper reviews the impact of land use change on carbon emissions from three aspects: the transformation of land use function, the internal land use of agricultural land and the internal land use of non-agricultural land.

The scoring rate of economical and intensive land use for residential buildings is less than 50%, and the scoring rate of rational development and utilization of underground space for public buildings is as low as 32.25%. The development and utilization of underground space still has great development potential.

3.3.2 Outdoor Environment

The outdoor environment in the city including environment, artificial environment and nature in construction of the outdoor environment, not only creates a landscape, but also combines ecological and environmental consideration, the climate characteristics, economic conditions and cultural tradition of content into account, considering its development sustainability, forming the corresponding regional unique outdoor environment.

Taking measures to reduce the intensity of heat island and improving the site ventilation environment by using the aerial form at the bottom of the building to increase the outdoor activity space had the lowest average score, less than 20%. The local heat island effect can be reduced and the living environment can be improved by using permeable pavement, roof greening and concave green space [7]. In addition,

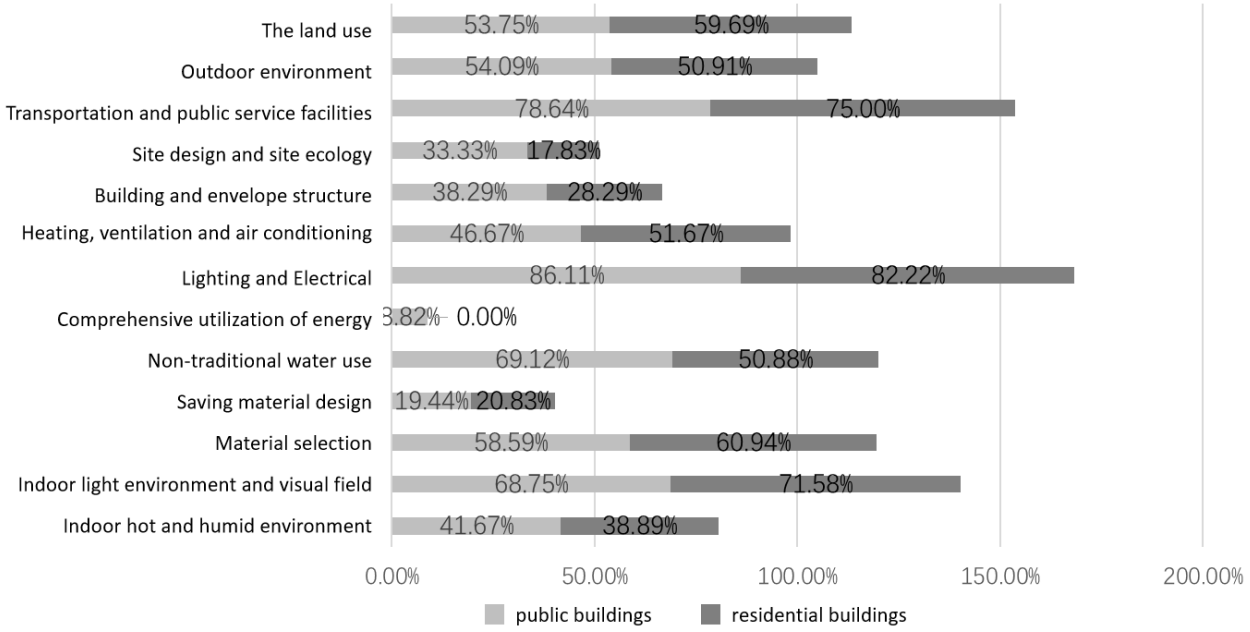

Fig. 1 Statistical analysis chart of scoring rate of green building technology.

natural ventilation is one of the important ways to make full use of environmental greening, and the effective combination of the two can greatly reduce carbon emissions.

3.3.3 Transportation and Public Services

Low-carbon and efficient public transport is the direction and inevitable trend of future urban development, as well as the inevitable requirement to achieve carbon neutrality. Carbon emissions can be effectively reduced by managing traffic demand, rationally organizing transportation modes and improving the energy efficiency of vehicles. Under the macro-control and top-level design of the government, the project can better realize the accessibility of public facilities and services through reasonable layout of import and export.

The technical sub-item scoring rate of transportation facilities and public service facilities technology system is more than 70%, which belongs to relatively mature application level.

3.3.4 Site Design and Site Ecology

In the development of contemporary architecture, attention is paid to exploration of construction technology and architectural aesthetics, but the relationship between low-carbon site design and human activities is rarely discussed. Site design is one of the important elements linking urban design and architectural design. Scientific site design should attach importance to the sustainability of site ecology, respect the original ecological cycle process of the site, and reasonably retain the ecological personality and culture of the site.

It can be seen from the statistical table that the score rates of technical sub-items of site design and site ecological technology system are both less than 60%. Considering the score of reducing heat island effect in 2.3.2, the green building projects in Zhuzhou still have great room for improvement in site design and improvement.

3.3.5 Building and Envelope Structure

Envelope structure is composed of roofing, exterior wall, door, window etc. composition, can reduce the invasion of outside harsh climate to building interior space, have heat insulation, wet, sound effect at the same time, ensure the safe use, comfortableness and privacy.

The scores of thermal performance of building maintenance structure, building shading and roof

design were all lower than 20%. In view of the technical system of building and envelope, the improvement methods can be referred to as: (1) Promote new high-performance building materials for building envelope; (2) Explore a more scientific approach to the envelope structure and optimize its organizational form; (3) Build a complete shading system to improve the organization of building greening.

3.3.6 Heating, Ventilation and Air Conditioning

Due to historical reasons, there is no central heating in hot summer and cold winter areas, so indoor comfort is poor in winter. In recent years, user-type independent heating equipment began to be widely used, which has huge energy consumption in winter heating.

It can be seen from the statistics in the concentrated heating hot water circulating pump power lose heat ratio and fan ventilation air conditioning system of unit volume power consumption evaluation item score is low. In addition, the score of heating, ventilation and air conditioning system optimization technology item serves is also low, less than 30%. The key of optimization lies in boosting heating and air conditioning equipment performance, encouraging innovation and reforming the use of traditional cold and heat sources, so that the equipment has higher energy efficiency.

3.3.7 Lighting and Electricity

At present, the most important energy source for buildings is electricity imported from outside. However, only 30% of China's electricity comes from zero-carbon power such as nuclear power, hydropower, wind power and photoelectric power, while the remaining 70% is "carbon emission" power powered by coal burning gas. We take coal burning thermal power generation as a reference to calculate the benefits of electricity saving and emission reduction. According to expert statistics: 1 kWh of electricity consumes 0.4 kg of standard coal, saving 1 kg of standard coal and reducing 2.493 kg of carbon dioxide emissions.

The scores of all lighting and electrical technology sub-items are good, except for energy-saving electrical equipment for residential buildings, the scoring rate is more than 70%. The choice of energy-saving electrical equipment in residential buildings is closely related to residents' lifestyle and energy saving consciousness.

3.3.8 Comprehensive Utilization of Energy

Electricity, heat and other energy are necessary for human production and life. While saving energy and reducing carbon, it should increase the proportion of useful energy in energy consumption, improve the conversion efficiency and transmission efficiency of each link, reduce energy waste, and then reduce carbon emissions. Comprehensive utilization of existing energy is very important. In recent years, although there are applications such as heat pump water heater and solar water heater, the efficiency is not high, so the use of connected electricity is reduced and the efficiency of heat energy recovery is improved [8], combined with local climate and resource conditions to develop renewable energy, etc. In recent years, with the increase of building operating energy consumption year by year, the energy intensity of renewable energy such as biological energy has slightly decreased. It can be seen from the statistical data that the scoring rate of this technology is low, less than 50%, so there is still a great potential for the development and utilization of renewable energy worth exploring.

3.3.9 Utilization of Non-traditional Water Sources

Non-traditional water sources have great potential. On the one hand, sewage and reclaimed water can be warm in winter and cool in summer, can be used for heating in winter and cooling in summer, and energy recycling can effectively save energy. On the other hand, the effective utilization of non-traditional water sources and the application of water-saving technologies, such as drip irrigation, sprinkler irrigation and other water-saving irrigation methods, are conducive to better growth of plants, so as to better carry out carbon-sequestration related life activities.

The two subitems related to the use of non-traditional water sources, storm water management and surface runoff scored low, below 70%. Among them,

the utilization of non-traditional water sources is closely related to technological innovation, and rainwater control and surface runoff are related to the construction of outdoor sites.

3.3.10 Material Saving Design

For buildings in different climate zones, carbon emission calculation for each life stage can be carried out in the scheme stage, and the scheme selection and optimization can be carried out. More suitable shape, more material saving structure, reusable building components, standardized and industrialized mass production components can be selected to achieve lighter dead weight and lower cost.

It can be seen from the statistical data that the technical sub-items of this technical system of material saving design are all lower than 50%, especially in the use of prefabricated components, integral design hutch and bathroom, structures and facilities inside the site, the main reasons are: (1) The high cost of high-tech components inhibits the market adoption rate; (2) The living standard of residents is improved, but the wealth is uneven, and the personalized requirements for decoration are greatly different; (3) In order to reduce the difficulty of design and construction, the site is mostly fully designed and fully developed, and the crude oil structures and facilities in the site are seldomly reserved and utilized.

3.3.11 Selection of Materials

China's manufacturing industry accounts for 65% of the country's total energy consumption, and building material is one of the three major carbon emission industries. Low-carbon development requires the reform of the construction industry, and the use of new low- or zero-carbon building materials to replace high-carbon emission building materials, such as cement.

According to the statistics, sub-items such as the use of ready-mixed mortar, the use of high-performance materials and old building materials scored low, with a score of less than 30%. On the one hand, due to the historical reasons of the market, the new materials have to take into account the stability of the market in the process of promoting, and on the other hand, the technical system is not mature enough and the system leads to high use cost, which is not favored by various construction subjects.

3.3.12 Indoor Light Environment and Visual Field

A good indoor light environment requires good natural lighting, which not only reduces lighting consumption, but also creates a healthier indoor environment than artificial lighting.

Statistical data show that good indoor natural lighting effect technology sub-item score rate is 54.20%. A good indoor light environment is closely related to the physical and mental health of residents, and the use of light guide tube, reflector and other technical means can properly guide the natural skylight to improve the effect of indoor natural lighting.

3.3.13 Indoor Hot and Humid Environment

Adjustable shading measures are adopted to reduce the heat gain from solar radiation in summer, which reduces the demand for indoor cooling in summer and reduces energy consumption. The end of the heating and air conditioning system can be adjusted independently on site, so that the air conditioning system can be adjusted flexibly to avoid the waste of resources when people leave the room for a long time.

It can be seen from the statistical data that the independent adjustment of Zhuzhou air conditioning system has been implemented in place, but the score of shading measures is low, with a score rate of less than 10%. Shading measures in hot summer and cold winter areas have a great impact on building energy consumption, so we should pay more attention to the use of shading measures in buildings.

3.4 The Conclusion

From the macro point of view of the average scoring rate of the five technical systems, the scoring rate of each system is not high, especially material saving and land saving (as shown in Fig. 2), which are all below 50%. With the increasing material and cultural needs of people, the requirements for architecture and its

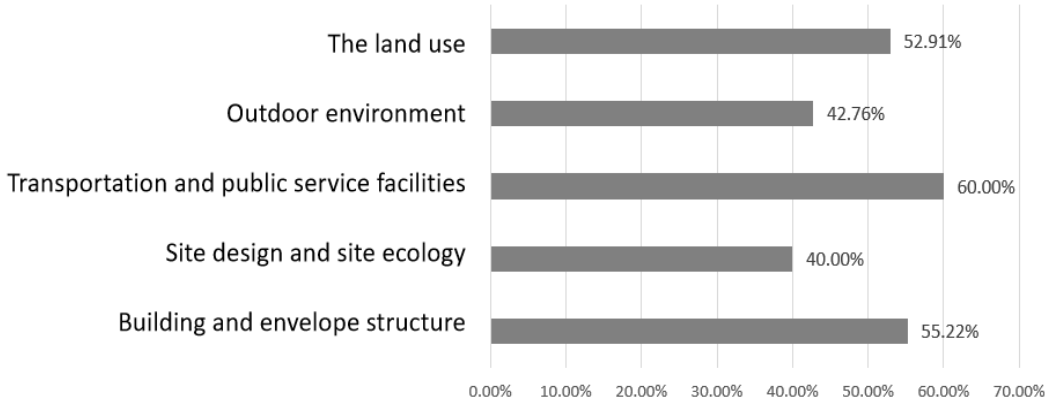

Fig. 2 Statistical chart of average scoring rate of five technical systems.

environment are also higher and higher, and the demand for energy and carbon is also higher and higher. If we want to deal with it from the perspective of green building, we should make up our shortcomings, optimize our strengths and reform the application of innovative technology system.

4. Key Areas and Tasks of Green Building Technology in Hot Summer and Cold Winter Areas under Carbon Neutrality Target

Based on the analysis of the application of various technical systems of green buildings in Zhuzhou, the key fields and tasks of energy saving and carbon reduction are considered from the whole life cycle of buildings so as to explore a green low-carbon road suitable for the climate and cultural characteristics of areas with hot summer and cold winter.

4.1 Key Areas of Green Building Technology

(1) Establishment of a clean energy system

Biomass is the fourth largest energy source after coal, oil and natural gas [9]. Relying on abundant biomass resources to build a clean energy system, such as: biomass power generation, biomass boiler, biomass utilization, and extensive use of zero-carbon energy, including nuclear power, hydropower, wind power, photovoltaics, etc., a clean energy system will be formed, with zero-carbon energy as the main energy source and a small amount of coal-fired gas power as supplement.

(2) Optimization of green and low-carbon building design

Promoting green energy-saving buildings: at the beginning of the design will be considered in the construction of the whole life cycle: maximize resource conservation, environmental protection and reduce carbon emissions, provide people with healthy, comfortable and efficient use of space, and the natural harmonious coexistence, scientifically design exploration, it is best to the whole life cycle of carbon budget.

(3) Resource reuse of building materials

The production of building materials needs to emit a lot of carbon dioxide, and the life of building materials varies. Some of the building materials with short life lead to short service life of the building, and the building materials with long life also become “garbage”. The recycling and reuse of this part of “waste” can greatly reduce the carbon emissions caused by building materials. In addition, exploring new carbon sequestration building materials and avoiding large-scale demolition and construction are also key areas of industry reform.

(4) The promotion of knowledge and awareness of low-carbon life

Designers, builders and users of buildings are all human beings, so the dominance of human beings on buildings is decisive, because knowledge and awareness of low-carbon life are extremely important.

Encourage residents to change their traditional habits of using energy and popularize relevant knowledge. In addition, we should start from the education level to cultivate consciousness from childhood.

(5) Top-level design guidance and institutional guarantee

Clarify the task framework of realizing carbon neutrality in all industries at the national level, accelerate the promotion of legislation and institutional guarantee in all sectors, guide the industry to rapidly reform and innovate and respond correctly from the top down, seize this opportunity, stimulate new market vitality, and work together to achieve carbon neutrality by 2060.

4.2 Main Tasks of Green Building Technology Optimization

(1) Change the type and structure of energy consumption: increase exploration of geothermal energy, air energy and other energy sources, and form an energy consumption structure with electricity as the main energy source and a small amount of other energy as supplement.

(2) Change the way of energy use: improve the conversion rate and transmission rate of energy, promote the use of high-efficiency air source heat pump heating, electric heating and other facilities, deepen the technical reform of energy use equipment.

(3) Change building materials and structures: strengthen research and exploration of carbon sequestration methods, including carbon capture, utilization and storage; low- and zero-carbon building materials instead of high-carbon materials; optimize the building structure and reduce the use of wood.

(4) Change the refrigeration method of air conditioning, strengthen the recovery and treatment of refrigeration working medium, further explore the fluorine-free refrigeration technology or switch to the traditional ammonia refrigeration technology.

5. Conclusions and Prospects

Achieving carbon neutrality is the common goal of a global community with a shared future. China has once again demonstrated its responsibility as a major country. Before reaching the carbon peak, human energy and carbon demand are still increasing. At the same time, with the optimization of artificial carbon sequestration and biological carbon sequestration technology, the low-carbon response of various industries will inevitably lead to the direct "reduction" of carbon emissions. The "elastic" range that fluctuates in the process of achieving carbon neutrality is what makes it reasonably resilient.

Therefore, in order to reasonably control the elasticity and ensure the smooth achievement of the goal of "carbon neutrality", the following suggestions are proposed for the development and innovation of green building technology in hot summer and cold winter areas:

(1) From a macro point of view, carbon neutral strategies for areas with hot summer and cold winter should be determined based on the adoption rate, implementation status and technical weaknesses of various green building technologies, and local green building industry should be guided to actively seek breakthrough points under the premise of safety.

(2) Local departments and organizations actively connect regional development goals and requirements, identify their own positioning, evaluate and promote the shortcomings of existing technology application and high-quality and efficient technology, and encourage the application of low-carbon intelligent technology.

(3) The architectural discipline should cross disciplines and complement each other in different regions, so as to seek the breakthrough point and innovation point of technical shortcomings. Zones with different climate have their corresponding historical characteristics and technological advantages, and most of them seek feasible ways of low-carbon emission reduction from the perspective of technological optimization, laying a solid technological foundation for the realization of carbon neutrality in the green building industry.

With the continuous development and progress of technology and the continuous updating and optimization of materials, the design of green buildings should take these aspects into account as comprehensively as possible: abandon the unchanging conservative design and adopt flexible construction strategies that can cope with the development and update [10]. The construction industry in hot summer and cold winter regions can help carbon neutrality through the optimization and application of green building technology, macro-control, step-by-step implementation, innovation technology, carbon sequestration and emission reduction. Only by fully grasping elasticity and dynamic neutralization can carbon neutrality be better achieved.

Acknowledgements

The work of this paper is financially supported by the Hunan Provincial and Municipal Joint Fund (No. 2022JJ50069).

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