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Research on Identification of Factors Influencing Low Carbon Buildings in Hebei Province

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Abstract

In the context of actively addressing climate change and vigorously advocating energy conservation and emission reduction globally, low-carbon buildings have become an important direction for the sustainable development of the construction industry. This study closely focuses on the theme of low-carbon buildings in Hebei Province, and conducts in-depth and systematic identification of influencing factors. Through extensive literature review and comprehensive integration of relevant research results at home and abroad, combined with multiple representative practical cases for in-depth analysis, we accurately grasp the key links in low-carbon building practice, and conduct in-depth interviews with senior experts in the field of architecture in Hebei Province to fully draw professional insights and practical experience. Through comprehensive research, it has been found that in terms of policies and regulations, the implementation of building energy-saving standards is insufficient, incentive policies are not yet perfect, and there are obvious loopholes in regulatory mechanisms, resulting in a lack of strong institutional guarantees for the development of low-carbon buildings. At the technical level, the promotion and application of energy-saving technologies are relatively low, the ability for technological innovation is seriously insufficient, and the integration and collaboration between various technologies are poor, making it difficult to support the efficient implementation of low-carbon buildings. In terms of economic costs, the high initial investment costs and uncertainty in operation and maintenance costs have brought significant economic pressure to developers and owners, hindering the market promotion of low-carbon buildings. In the field of social cognition, the public's awareness of environmental protection is weak, and their acceptance and recognition of low-carbon buildings are low. At the same time, there is a shortage of professional talents and insufficient demand for the development of the construction industry. These factors interact and constrain each other, forming a complex mechanism of action that seriously hinders the development process of low-carbon buildings in Hebei Province from multiple aspects. This research provides a solid theoretical basis and decision support for the precise formulation of targeted and feasible strategic measures in the future, which helps to break the current development bottleneck, effectively promote the steady progress of the construction industry in Hebei Province towards a low-carbon development track, and contribute key forces to the achievement of energy-saving and emission reduction goals in the province. It has significant value in improving the environmental, economic, and social benefits of buildings in Hebei Province, and also provides useful reference examples and practical inspirations for the development of low-carbon buildings in other regions of China, in order to jointly promote the green and low-carbon transformation and sustainable development of the construction industry in China.

Keywords

Sustainable Development; Low-Carbon Construction Industry; Hebei Province.

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1. Introduction

The construction industry is one of the important areas of energy consumption and carbon emissions, and achieving low-carbon development of buildings is of great significance for addressing climate change and promoting sustainable development. As a major economic and construction province in China, Hebei Province has become increasingly prominent in terms of building energy consumption and carbon emissions during the rapid urbanization process. Therefore, in-depth research on the influencing factors of low-carbon buildings in Hebei Province is urgently needed to promote the green transformation and sustainable development of the construction industry in Hebei Province.

Low carbon buildings emphasize reducing resource consumption throughout the entire lifecycle of the building. By optimizing building design and using efficient insulation materials, the heat loss in winter and heat absorption in summer can be reduced, thereby lowering the energy demand for heating and cooling. This helps to save non renewable energy sources such as coal and natural gas, and improve the sustainability of resource utilization. Low carbon buildings help reduce air pollution. Traditional building energy consumption mainly relies on fossil fuels, which release a large amount of pollutants during the combustion process. Low carbon buildings can reduce the emissions of these pollutants, improve urban air quality, and protect residents' health by using clean energy and improving energy efficiency. In the long run, low-carbon buildings can reduce building operating costs. Although adopting low-carbon technologies and materials may increase investment in the early stages of construction, significant energy and maintenance costs can be saved throughout the building's lifespan through measures such as energy and water conservation. This is cost-effective for building users and also beneficial for the rational allocation of social resources.

Accurately identifying the influencing factors of low-carbon buildings is a prerequisite for quantitative analysis and simulation research. By determining specific factors such as the thermal performance of building materials, the efficiency of renewable energy utilization, and the behavior patterns of building users, researchers can establish more accurate mathematical models and simulation software. Building energy consumption simulation software can set parameters more accurately, quantitatively predict and dynamically simulate the energy consumption, carbon emissions, and indoor environmental quality of buildings. This not only helps deepen the understanding of building physical processes and environmental performance, but also provides powerful scientific tools for optimizing building design schemes and evaluating the effectiveness of low-carbon technologies, transforming building research from qualitative description to quantitative and precise analysis, improving the scientific and rigorous nature of academic research in architecture, providing data support and theoretical basis for formulating scientific and reasonable building energy-saving standards and specifications, and leading the construction industry towards data-driven precision design and management.

For the entire construction industry, identifying the influencing factors of low-carbon buildings is a key step in achieving sustainable development transformation. Government departments and industry associations can formulate more effective industrial policies, technical standards, and regulations based on these influencing factors, guiding the construction industry towards green and low-carbon development. Develop energy-saving design standards and renewable energy application indicators suitable for different regions based on their climate characteristics and resource conditions, and promote the standardization and normalization of the construction industry; Encourage construction enterprises to adopt environmentally friendly materials, energy-saving equipment, and low-carbon technologies, promote the green upgrading of the construction industry chain, drive the coordinated development of upstream and downstream related industries, promote the development of renewable energy and green

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building materials industries, and form new economic growth points. In addition, by studying the behavioral factors of building users, corresponding guidance measures and incentive policies are formulated to enhance their energy-saving awareness and behavior habits, further reduce energy consumption and carbon emissions from the end of building use, comprehensively promote the transformation of the construction industry from traditional high energy consumption mode to low-carbon sustainable mode, and make positive contributions to addressing global climate change and resource scarcity issues, ensuring the sustainability and livability of human living environment.

This study breaks through the limitations of previous single research methods and innovatively combines multiple methods such as literature review, field research, and expert interviews. Through literature research, comprehensively review the existing research results on low-carbon architecture both domestically and internationally, providing a solid theoretical foundation and research ideas for the study; Conduct on-site research on representative construction project sites in Hebei Province, obtain first-hand actual data and case situations, and root the research in practical applications. Expert interviews leverage the rich experience and profound insights of industry experts, scholars, government officials, and business representatives from various fields to provide in-depth interpretation and supplement of research results. The deep integration of this comprehensive and diverse approach not only ensures the richness, authenticity, and reliability of research data, but also enables a comprehensive analysis of the influencing factors of low-carbon buildings from multiple dimensions, providing strong guarantees for the accuracy and scientificity of research conclusions. It also provides new examples and ideas for the selection and application of research methods in similar studies in the future.

Considering the dynamic characteristics of the influencing factors of low-carbon buildings over time, technological development, and changes in the socio-economic environment, this study innovatively introduces a dynamic analysis model. This model can track the changing trends and interactions of various influencing factors at different stages, the promoting effect of gradually improving policies and regulations on technology research and development investment and market demand cultivation, and how the market's acceptance of low-carbon buildings increases with the maturity of technology and cost reduction. Through this dynamic analysis, research can more accurately grasp the inherent laws and evolution mechanisms of low-carbon building development, provide a basis for formulating forward-looking and adaptive development strategies, and also provide an effective quantitative analysis tool and innovative reference for subsequent research in dealing with dynamic complex system problems.

The innovation of this paper in methodology and identification of influencing factors aims to provide more in-depth, comprehensive, and targeted theoretical support and practical guidance for the development of low-carbon buildings in Hebei Province. At the same time, it is expected to open up new paths and research ideas for related follow-up research in the field of architecture, promote the continuous development of low-carbon building research, and contribute more academic value and practical wisdom to the global response to climate change and the realization of sustainable development in the construction industry.

2. Analysis of the Current Status of Low Carbon Buildings in Hebei Province

The Hebei Provincial Government has actively responded to the national call for energy conservation, emission reduction, and the development of green buildings, and has introduced a series of policies and regulations to promote the development of low-carbon buildings. We have established building energy-saving standards and specifications, clarified energy-saving

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goals and technical requirements for new buildings, and proposed specific energy-saving indicators for building envelope structures, energy systems, and other aspects, providing technical basis for the construction of low-carbon buildings. At the same time, management measures for green building evaluation labels have been introduced, encouraging construction projects to apply for green building certification, and providing certain rewards and policy support to projects that obtain high star green building certification, which has increased the enthusiasm of construction enterprises to develop low-carbon buildings.

Local governments are also actively implementing provincial-level policies, and have formulated corresponding implementation rules and action plans based on local conditions. Some cities provide policy support such as preferential land transfer fees and plot ratio rewards for projects that construct low-carbon buildings in the land transfer process, guiding developers to actively participate in the construction of low-carbon buildings. Shijiazhuang City has piloted the construction of green building demonstration zones in some areas, giving priority support to building projects within the demonstration zones in terms of planning approval, construction funds, etc., promoting the concentrated development of low-carbon buildings in the region and forming a good demonstration effect.

Hebei Province has made certain progress in the field of low-carbon construction. In terms of policies, provincial governments have actively responded to the national call and introduced a series of policies and regulations to promote the development of low-carbon buildings, such as formulating energy-saving standards and specifications for buildings, clarifying energy-saving goals and technical requirements for new buildings, and issuing management measures for green building evaluation labels, giving rewards and policy support to projects that meet the standards; Local governments have also implemented relevant policies based on actual conditions, providing preferential treatment and rewards for low-carbon building projects in the land transfer process, promoting the construction of green building demonstration zones and forming a good demonstration effect. From the perspective of construction practice results, the development trend of green buildings is good, with the proportion of newly built green buildings increasing year by year, covering various types of buildings. By optimizing design, energy consumption can be reduced and indoor environmental quality can be improved; Passive ultra-low energy buildings have also been actively promoted, with multiple demonstration projects distributed in various places, using efficient insulation materials and other technologies to reduce energy consumption, and constantly exploring technology integration and standardized construction. At the level of technological application, building energy-saving technology is widely used, with technologies such as exterior wall insulation, solar water heaters, and ground source heat pumps commonly found in buildings. Intelligent lighting control systems and high-efficiency energy-saving doors and windows are also gradually being promoted; The utilization of renewable energy is highly valued, and solar photovoltaic power generation and small-scale wind power generation systems are being applied in some projects. Biomass and geothermal energy utilization technologies are also in the research and pilot stage. In terms of market awareness and participation, consumers' awareness and acceptance of low-carbon buildings have improved. Some homebuyers are concerned about factors such as building energy efficiency and are willing to pay a premium for low-carbon buildings, but there are still some consumers with insufficient awareness; Some large construction and material production enterprises actively participate to enhance their own capabilities and competitiveness, but small and medium-sized enterprises have low enthusiasm due to technological and financial limitations.

However, the development of low-carbon buildings in Hebei Province also faces challenges. Insufficient technological research and innovation, compared with advanced regions in China, there is less investment in research and development in areas such as efficient energy conservation and integrated application of renewable energy, and a lack of core technologies

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and innovative achievements. The economic cost constraint is obvious, and the initial investment cost of low-carbon buildings is high. Although the long-term operating cost is low, it still affects market demand and promotion speed. The problem of talent shortage is prominent, with insufficient talent reserves in the low-carbon construction field, an imperfect training system, and the need to expand the establishment and enrollment scale of relevant majors in universities. There are few opportunities for continuing education for in-service personnel, which affects the quality and technical level of project construction. Overall, although there have been achievements in low-carbon construction in Hebei Province, it still requires joint efforts from all parties to overcome difficulties and achieve further development.

3. Identification of Factors Affecting Low-Carbon Buildings in Hebei Province

3.1. Technical Factor Analysis

After the low-carbon building is put into use, there is a lack of regular maintenance and performance monitoring of the technical system. For example, after running for a period of time, the fresh air system of a building may suffer from insufficient fresh air volume and decreased air quality due to delayed replacement of filters and failure to repair fans. This not only affects indoor environmental comfort but also increases energy consumption. This is because the building property management personnel lack knowledge and skills in maintaining low-carbon technology systems, and have not established a comprehensive equipment maintenance plan and file.

In terms of post optimization of technological applications, there is a lack of ability to analyze and utilize actual operational data of buildings. Building owners and operation managers often fail to establish effective building energy consumption monitoring systems, making it difficult to accurately obtain operational data from various building systems. This makes it difficult to optimize and adjust low-carbon technologies based on actual situations, fully tap into the energy-saving potential of technologies, and reduce the long-term operating costs of buildings.

3.2. Economic Factor Analysis

Economic factors play a crucial role in the development of low-carbon buildings in Hebei Province. From the perspective of initial investment cost, advanced technologies and materials used in low-carbon buildings are expensive, such as high-efficiency insulation materials, solar photovoltaic power generation systems, ground source heat pumps, etc. Compared with traditional building materials and equipment, the cost has significantly increased, resulting in a significant increase in construction cost per square meter. At the same time, its design requirements are complex, requiring a professional team and higher design costs. Due to the complex process and high technical requirements for personnel during construction, labor and management costs increase, and the construction period may be extended, indirectly increasing costs.

In terms of operation and maintenance costs, although it can save energy and reduce consumption in the long run, the maintenance costs of some low-carbon technologies and equipment in the early stage are relatively high, such as ground source heat pumps, solar photovoltaic power generation systems, etc., which require professional maintenance. The maintenance and replacement costs of new energy-saving lamps and intelligent control systems are also not low. Moreover, low-carbon buildings have strict requirements for energy management and monitoring, and the establishment of energy management systems and the deployment of professional personnel have increased labor and technical costs. In addition, fluctuations in energy prices can also affect the operating costs of low-carbon buildings. Regions with incomplete economic development levels and industrial structures have a low

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tolerance for operating costs of low-carbon buildings, and poor industrial support can increase the cost of equipment and material maintenance and replacement. These economic factors are constraining the development of low-carbon buildings in Hebei Province, and it is urgent for all parties to work together to reduce costs and enhance competitiveness.

3.3. Analysis of Policy and Regulatory Factors

Although Hebei Province has taken certain measures in terms of policies and regulations for low-carbon buildings, there are still many problems. The existing policy support is insufficient, and financial subsidies are difficult to meet actual needs. For example, for construction projects that adopt new energy-saving technologies and materials, subsidy funds are limited and cannot effectively compensate for the increase in construction costs, which has dampened the enthusiasm of enterprises. The tax preferential policies are also not comprehensive enough, lacking specificity and attractiveness, making it difficult to motivate more enterprises to enter the low-carbon construction field. Moreover, the coherence of policies is poor, and construction projects involve multiple links and departments. Due to poor coordination among departments, there is a disconnect in the implementation of policies, which makes it difficult for some originally good policies to take root and sustainably promote the development of low-carbon buildings.

There are many imperfections in the standard specification system. The current building standards and specifications lack detailed and precise requirements for low carbonization, and there is a lack of clear and detailed regulations on energy-saving indicators for different climate regions and building types, resulting in a lack of clear guidance in the design and construction of buildings, which can easily lead to inadequate implementation of energy-saving measures. At the same time, the update of standards and specifications lags behind the development of low-carbon technologies. New building materials, energy-saving equipment, and technologies continue to emerge, but relevant standards have not been included in a timely manner, which makes some advanced low-carbon technologies have no basis for promotion and hinders their widespread application in the construction industry, thereby affecting the overall development pace of low-carbon buildings in Hebei Province.

3.4. Analysis of Social and Cultural Factors

The development of low-carbon buildings in Hebei Province is significantly influenced by social and cultural factors. The traditional concepts of residents largely constrain their promotion, and the long-term formed living habits and aesthetic concepts have led to some misunderstandings and rejection of low-carbon buildings. Many people tend to prefer large-scale housing, neglecting energy efficiency, and have fixed traditional aesthetic patterns for building appearance. The unique appearance and structure designed to achieve low-carbon goals are often difficult to recognize, hindering the implementation of low-carbon building design concepts.

Meanwhile, differences in social environmental awareness have also had varying impacts. In big cities and economically developed areas, there is a lot of environmental protection promotion, and some residents have a certain understanding of the value of low-carbon buildings. They are willing to support low-carbon concepts in purchasing or living, or pay additional fees for them, or actively practice energy-saving behaviors, providing a certain market momentum for the development of low-carbon buildings. However, in small and medium-sized cities and rural areas, environmental awareness is relatively weak, and residents pay more attention to the initial cost and traditional functions of buildings. They lack sufficient understanding of the long-term environmental benefits and energy advantages of low-carbon buildings, resulting in low market demand for low-carbon buildings in these areas and facing great difficulties in promotion. It is difficult to form a good cultural atmosphere for the whole society to support the development of low-carbon buildings, which in turn affects the overall

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development process and popularity of low-carbon buildings in Hebei Province.The multidimensional evaluation weights of low-carbon buildings are shown in Figure 1.

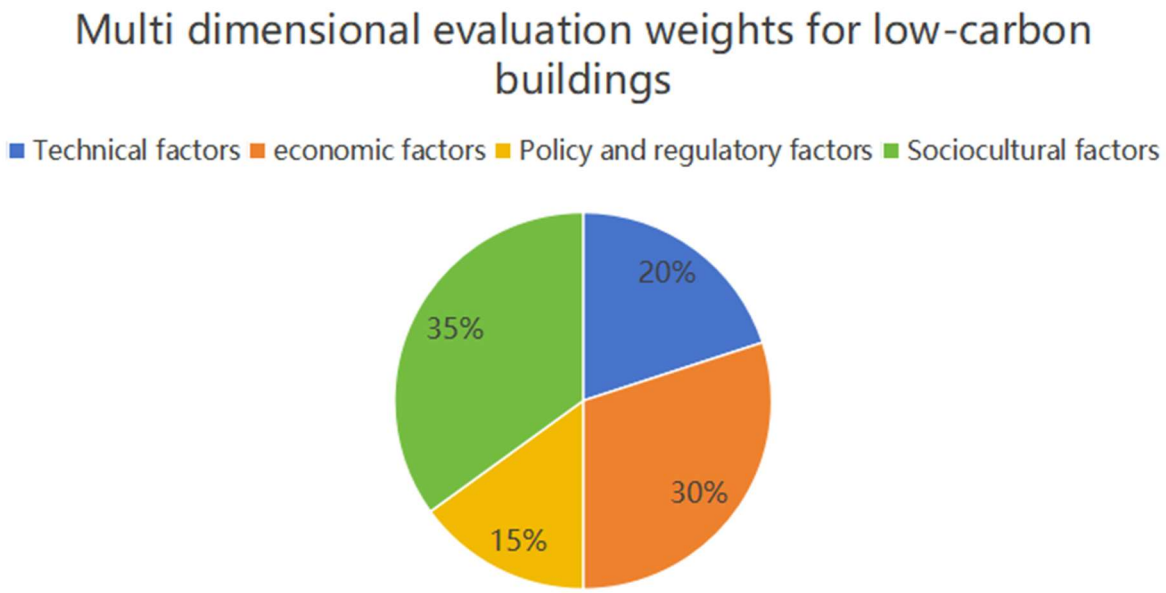

Figure 1. Multi dimensional evaluation weights for low-carbon buildings

4. Design of Evaluation Index System

Table 1. Evaluation index system for low-carbon transformation throughout the entire life cycle of buildings

First level indicator	Secondary indicators	unit	Indicator attribute
Technical factors	Solar coverage rate (c1)	%	forward direction
	Efficient insulation efficiency (c2)	%	forward direction
	Rainwater collection coverage rate (c3)	%	forward direction
	The proportion of recycling of building materials (c4)	%	forward direction
economic factors	Operation and maintenance costs (c5)	Ten thousand yuan	forward direction
	Cost of purchasing energy-saving equipment (c6)	Ten thousand yuan	forward direction
Policy and regulatory factors	Financial subsidies (c7)	Ten thousand yuan	forward direction
	Building Energy Efficiency Regulations (C8)	strip	forward direction
	Environmental Protection Regulations (c9)	strip	forward direction
Sociocultural factors	Public Environmental Awareness Public Welfare Conference (c10)	strip	forward direction
	Acceptance of energy-saving and water-saving lifestyle (c11)	%	forward direction

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Based on the connotation of low-carbon transformation throughout the entire life cycle of buildings and referring to relevant existing research results, an evaluation index system for low-carbon transformation throughout the entire life cycle of buildings is established, consisting of 4 primary indicators and 11 secondary indicators.

Using the established evaluation index system and entropy weight TOPSIS analysis method, evaluate the degree of low-carbon transformation of buildings in Hebei Province throughout their entire lifecycle from initial planning to final demolition. Due to space constraints, the author of this article only lists some relevant calculation data and the final results obtained. Among them, the standardization of indicator data is achieved using the extremum method.

In terms of architectural design, it is necessary to optimize the orientation based on local climate conditions to ensure that the building can maximize the use of natural lighting and ventilation. For example, designing the position, size, and opening method of doors and windows reasonably can promote natural indoor air circulation, reduce reliance on mechanical ventilation, and lower energy consumption. Control the building form factor to ensure that the ratio of external surface area to volume is within a reasonable range, reduce heat loss in winter and heat absorption in summer, and improve the insulation performance of the building. At the same time, improving the utilization rate of building space, avoiding idle or wasted space, adopting flexible and variable space design to adapt to functional changes, and reducing carbon emissions caused by renovation and demolition.

In the selection of building materials, priority should be given to locally produced low-carbon, environmentally friendly, and renewable materials, such as new wall materials and low VOC decorative materials, to reduce carbon emissions during material transportation and minimize environmental pollution. Minimize the use of traditional materials with high energy consumption and carbon emissions, such as clay bricks, as much as possible. Pay attention to the recycling of materials, improve the recycling rate of building materials during the construction and demolition process, actively use recycled materials such as recycled aggregates and steel, and properly dismantle and store reusable building components such as doors, windows, prefabricated components, etc. for reuse in other projects, saving resources and energy. In terms of water resource utilization, water-saving appliances and equipment such as water-saving toilets and induction faucets are adopted, and rainwater collection and reclaimed water reuse systems are designed. The collected rainwater and treated reclaimed water are used for non potable purposes such as building flushing, green irrigation, road flushing, etc., improving the recycling rate of water resources, reducing water waste and energy consumption caused by water treatment and supply.

The design of energy systems is crucial, and efficient and energy-saving HVAC systems, lighting systems, elevators, and other equipment should be selected. For example, high-efficiency air conditioning units, LED lighting fixtures, etc. should be used, and intelligent control systems should be equipped to automatically adjust the operating status of equipment according to actual needs, avoiding unnecessary waste of energy. Reasonably allocate renewable energy utilization facilities such as solar photovoltaic power generation systems, solar water heaters, and ground source heat pumps based on actual building conditions and local resource conditions, increase the proportion of renewable energy in building energy supply, gradually reduce dependence on traditional fossil fuels, and lower carbon emissions. At the same time, establish a comprehensive building energy management system, monitor and analyze the energy consumption of buildings in real time, identify energy waste points through data analysis, and take timely optimization measures to continuously improve energy utilization efficiency.

During the operation, management, and maintenance phase of a building, regular statistics and analysis of the building's energy consumption data should be conducted, and energy consumption records should be established. Based on this, energy-saving goals and

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corresponding measures should be formulated, and energy-saving effects should be evaluated and assessed to motivate operation and management personnel to actively adopt effective energy-saving measures. Develop a reasonable equipment maintenance plan to ensure the normal operation of building equipment, regularly maintain, debug, and optimize equipment, improve equipment efficiency, timely eliminate old and high energy consuming equipment, replace with high-efficiency and energy-saving new equipment, and reduce energy consumption during equipment operation. On the premise of ensuring indoor comfort, reasonable control of indoor temperature, humidity, fresh air volume and other parameters is necessary to avoid excessive pursuit of comfort and energy waste. At the same time, environmentally friendly and pollution-free indoor decoration materials are used to ensure that indoor air quality meets health standards and reduce the increase in energy consumption caused by indoor environmental pollution.

5. Conclusion and Recommendations

The development of low-carbon buildings in Hebei Province is influenced by multiple factors, and the current situation is not optimistic. Although policies and regulations have been involved, there are many shortcomings that have not effectively promoted their development; The technical level is limited, and both research and application capabilities need to be improved; The high economic costs have deterred construction companies and consumers; Weak market demand, low consumer awareness, and unfavorable competitive environment; The social and cultural atmosphere is also not conducive to the promotion of low-carbon architecture, and traditional concepts and weak environmental awareness have become obstacles. These factors constrain each other and seriously hinder the development process of low-carbon buildings in Hebei Province. It is urgent to take comprehensive and targeted measures to break through the difficulties and achieve breakthrough development.The correlation degree is shown in Figure 2.

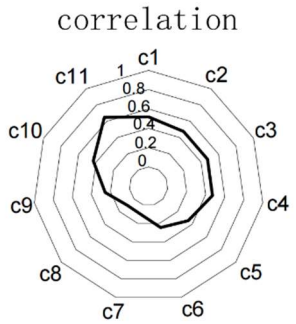

Figure 2. correlation

Hebei Province should make every effort to strengthen policy and regulatory guarantees, significantly increase financial subsidies for low-carbon buildings, broaden the scope of subsidies, increase subsidy amounts, optimize tax incentives, reduce the burden on enterprises, and provide clear policy support in land transfer and planning approval to stimulate enterprise enthusiasm. Accelerate the improvement of the standard specification system for low-carbon buildings, clarify detailed indicators and technical requirements for various types of buildings, and establish a dynamic update mechanism to ensure that standards keep pace with the times. Increase investment in technology research and development, cultivate professional talents, build a close bridge of industry university research cooperation, and promote the transformation and application of technological achievements. Actively exploring methods to reduce economic costs, such as encouraging technological innovation to lower material and

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equipment costs, expanding financing channels, optimizing operational management, improving energy efficiency, reducing waste, and enhancing economic benefits. Strengthen market cultivation, popularize low-carbon building knowledge through various channels, enhance consumer awareness, and encourage enterprises to innovate business models, improve the cost-effectiveness and competitiveness of low-carbon buildings, and expand market share. We also need to pay attention to social and cultural guidance, use various media to promote low-carbon concepts, change traditional ideas, enhance public environmental awareness, and create a good cultural atmosphere that supports the development of low-carbon buildings throughout society. Only in this way can we gradually promote the healthy and rapid development of low-carbon buildings in Hebei Province.

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References

[1] Dong Chaoyang, Shao Yafei, Zhu Xiangling, etc Research progress and development direction of low-carbon construction in buildings [J/OL]. Construction Technology (in Chinese and English), 1-8 [2024 December 26].

[2] Zhang Tongrui, Geng Liming, Na Yonglin, etc Research on the influencing factors of carbon emissions in prefabricated buildings based on a three-dimensional perspective [J]. Brick and Tile, 2024, (12):136-138+141.

[3] Yao Yuan Construction and Empirical Study of Low Carbon Transformation Evaluation Index System for the Whole Life Cycle of Buildings [J]. Inner Mongolia Science and Technology and Economy, 2024, (08):36-39.

[4] Jiang Xinran, Cui Tong, Wang Yijun A review of research hotspots in scientific architecture in the past five years: low carbonization, public space, and integration [J]. Contemporary Architecture, 2024, (02):14-19.

[5] Huang Liying Research on Low Carbon Transformation of Existing Residential Buildings in Cold Regions Based on Active Passive Coupling [D]. Hebei University of Technology, 2023.

[6] An Yandong Exploration of the Application of Low Carbon Building Design Concept in Building Planning and Design [J]. Bulk Cement, 2024, (03):14-16+21.

[7] Liu Heng, Xu Feng, Huang Jianzhao Renovation of existing office spaces under the goal of low-carbon development throughout the entire lifecycle - Low carbon construction of the "Green House" [J]. Architectural Techniques (Chinese and English), 2024, 30 (06): 81-85.

[8] Mou Gaohui, Gao Hong Research on the Driving Factors and Countermeasures of Low carbonization in the Construction Industry under the Dual Carbon Background [J]. Journal of Hebei University of Architecture and Technology, 2023, 41 (01): 213-219.

[9] Wang Sha, Shen Liangfeng, Zeng Qian, etc Research on the Effect of Low Carbon Management Behavior of Contractors in Prefabricated Construction Projects [J]. Science and Industry, 2023, 23 (02): 197-203.

[10] Li Bing, Li Xun, Du Hailong, Dong Cheng, Sun Gang, Zhu Lin, etc Research on Low Carbon Strategy of Architecture Based on Ecological City Concept [J]. Jiangxi Building Materials, 2022, (11):100-101+106.

ISSN: 2688-9323

[11] Song Yuechao, Zhao Yanhua Research on the Restrictive Factors and Countermeasures of Low Carbon Transformation of Construction Enterprises under the Background of Dual Carbon [J]. Tianjin Science and Technology, 2022, 49 (S1): 99-102.

[12] Zhai Jiren, Lin Minmin Research on Improving Low Carbon Development in Urban Areas of China [J]. Low Carbon World, 2020, 10 (12): 7-8.

[13] Zhang Wuxian, Yang Yuanyuan, Fan Xin Analysis of Factors Influencing Low carbonization of Building Supply Chain Based on DEMATEL-ISM [J]. Practice and Understanding of Mathematics, 2019, 49 (19): 18-27.

[14] Wang Fuqiang The Application of Green Building Design Concept in Architectural Design [J]. Sichuan Cement, 2019, (03):48.

[15] Focusing on low-carbon new life, building a low-carbon science popularization museum and low-carbon exhibition hall construction. From low-carbon exhibition content to low-carbon technology and exhibition hall building development. Environmental Protection, 2016, 44 (19): 85.

[16] Chen Lijian Construction and Empirical Study of Evaluation Standards for Low carbonization of Urban Economy [J]. Business Economics Research, 2015, (14):32-34.

[17] Li Zhentao Realizing Low Carbon Building Technologies in Architecture [J]. China Building Materials Science and Technology, 2014, (S2):75.