

Research on the Strategy for Constructing a Green and Low-Carbon Urban Ecosystem under the Dual-Carbon Strategy: A Case Study of Wenzhou, Zhejiang

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Abstract: Against the backdrop of global climate change and increasing environmental pressures, the dual-carbon strategy has become a significant national policy driving China's green transformation. This paper begins by emphasizing the importance of building a green and low-carbon urban ecosystem under the dual-carbon strategy and addresses key challenges such as immature green and low-carbon technologies, underdeveloped policies and legal frameworks, and a lack of human resources. Strategies proposed include strengthening the research and innovation of green and low-carbon technologies, improving relevant policies and regulations, and accelerating talent cultivation and recruitment. These strategies are validated through the case study of the urban ecosystem construction in Wenzhou, Zhejiang, providing a reference for the low-carbon transition of modern cities in China.

Keywords: Dual-Carbon Strategy; Green and Low-Carbon; Urban Ecosystem Construction

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Introduction

The large-scale use of fossil fuels has led to a sharp increase in greenhouse gas emissions, such as carbon dioxide, accelerating global climate warming ^[1]. In response to this global challenge, China, as the world's second-largest economy and a major carbon emitter, has proposed the "carbon peak and carbon neutrality" strategy (hereinafter referred to as the "dual-carbon strategy"), which is a key step in global climate action ^[2]. The dual-carbon strategy aims for China to reach peak carbon emissions by 2030 and achieve carbon neutrality by 2060. This strategy not only addresses the urgent need for climate action but also offers a crucial opportunity for optimizing domestic economic structures and promoting green transformation.

As the main carrier of economic and social activities, cities play a critical role in achieving carbon reduction and sustainable development goals. Urban activities such as energy consumption, transportation, and industrial production are significant sources of carbon emissions, making the construction of green and low-carbon cities crucial to achieving dual-carbon goals ^[3]. The green and low-carbon urban ecosystem seeks to reduce urban carbon emissions through technological innovation, policy guidance, and social participation, while simultaneously improving the quality of the ecological environment and residents' quality of life. This system emphasizes the coordinated development of the economy, society, and ecology by transforming urban management, infrastructure, and governance ^[4].

This paper discusses the current state and challenges in urban ecosystem construction under the green and low-carbon context, proposes corresponding solutions, and explores the case of Wenzhou, Zhejiang, to provide insights for building eco-friendly,

low-carbon cities.

1. Significance of Constructing a Green and Low-Carbon Urban Ecosystem under the Dual-Carbon Strategy

1.1 Improving Urban Ecological Environmental Quality

Building a green and low-carbon urban ecosystem helps significantly reduce urban pollutant emissions, particularly carbon dioxide, nitrogen oxides, and sulfur oxides, which are closely related to air pollution. The dual-carbon strategy promotes the transformation of urban energy structures by encouraging the extensive use of clean and renewable energy, thereby reducing pollution at its source. The adoption of solar, wind, and hydropower not only reduces dependence on fossil fuels but also significantly lowers carbon emissions from energy consumption, improving air quality. Enhanced air quality will reduce health problems caused by air pollution, such as respiratory diseases, directly improving the quality of life for urban residents ^[5].

Moreover, the construction of a green and low-carbon urban ecosystem can effectively mitigate the urban heat island effect. By expanding green spaces, promoting low-carbon buildings, and restoring ecosystems, cities can enhance their ability to regulate climate and alleviate the accumulation of heat. Urban greenery can absorb carbon dioxide and other harmful gases, purifying air quality, while providing more habitats for biodiversity restoration, leading to improved urban ecosystems and ecological balance.

1.2 Promoting Green Technological Innovation and Industrial Development

The green and low-carbon urban ecosystem requires economic and industrial structures to transition towards low-carbon models, which in turn depend on technological innovation. The dual-carbon goals have spurred the demand for green technological innovation across various fields, promoting the development of technologies such as clean energy, energy conservation, low-carbon transportation, and the circular economy. These technologies have vast experimental and application potential within green urban ecosystems, accelerating innovation and application.

Green technological innovation also plays a transformative role in traditional industries. The development of the green and low-carbon urban ecosystem is driving the transition of traditional high-pollution, high-energy industries into low-carbon, environmentally friendly sectors. Clean energy and renewable technologies, for example, not only mitigate the negative environmental impacts of conventional energy but also foster the growth of new green industries such as renewable energy equipment manufacturing, energy storage technology, and smart grids.

1.3 Promoting Integrated Modern Urban Development ("Five-in-One")

The "Five-in-One" concept refers to the coordinated development of economic, political, cultural, social, and ecological aspects of urban construction, which is the overall framework and goal for China's modern cities. Constructing a green and low-carbon urban ecosystem not only helps achieve the dual-carbon targets but also comprehensively advances urban development in all dimensions.

In economic development, the green and low-carbon ecosystem promotes structural adjustments in energy, industry, and technology, fostering the rise of the green economy and reducing reliance on high-pollution industries ^[6]. In political development, the government plays a leading role in policy formulation and legal oversight, ensuring coordinated participation

from all sectors of society. In cultural development, the promotion of environmentally friendly practices fosters a culture of respect for nature and sustainable living. Social development is enhanced by addressing environmental inequality and improving resource distribution. Finally, in ecological development, the green and low-carbon ecosystem transforms urban energy, resource, and environmental systems, reducing reliance on natural resources and restoring ecological balance.

2. Current Challenges in Building Green and Low-Carbon Urban Ecosystems

2.1 Underdeveloped Green and Low-Carbon Technologies

In the field of clean energy technology, although renewable energy sources such as solar and wind power are gaining attention and promotion, their efficiency, stability, and storage technologies have yet to reach an ideal level for widespread use. Solar and wind power are constrained by natural conditions, which result in insufficient stability and continuity in energy supply, making it challenging to fully replace traditional fossil fuels in the short term. Additionally, bottlenecks in energy storage technology further restrict the practical application of renewable energy. Current battery technology faces challenges such as low storage density, high costs, and short lifespans, making it difficult to meet the long-term stable supply needs of large-scale urban energy consumption.

In the construction sector, the development of green and low-carbon building technologies is also immature. Novel materials used in green buildings, such as energy-saving insulation materials and renewable building materials, are hindered by high costs and unstable performance, limiting their widespread application. Additionally, design standards and construction techniques for green buildings require further improvement. The current system of green building technologies has yet to establish industry-wide standards, and the application of low-carbon construction techniques remains at an early stage, making it challenging to achieve large-scale, standardized implementation.

2.2 Incomplete Development Policies and Legal Frameworks

Existing green and low-carbon development policies show a lack of coordination between different levels of government. While the central government has clearly outlined the overall goals of carbon peaking and carbon neutrality, local governments often face challenges in policy implementation due to regional disparities, uneven resource distribution, and insufficient enforcement. Local governments may encounter conflicts between higher-level policies and local economic realities, resulting in diminished effectiveness during implementation. Additionally, the absence of effective oversight and accountability mechanisms in some regions weakens the impact of green and low-carbon policies. The fragmentation and discontinuity of policies further highlight the difficulties in policy coordination and alignment across different sectors and regions.

Although the dual-carbon strategy provides a top-level design for green and low-carbon development, relevant laws and regulations in fields such as energy, construction, and transportation are still lacking. The current legal framework is insufficient in coverage and enforcement, failing to provide strong legal support for the promotion of green and low-carbon technologies and the construction of urban ecosystems. This legal gap further limits the large-scale application of green building technologies.

2.3 Insufficient Talent Resources

The development and application of green and low-carbon technologies require a large number of high-level professionals with cutting-edge scientific knowledge and innovation capabilities. However, in key fields such as energy, environment, and

transportation, there is a severe shortage of professionals capable of driving advanced green technology innovation and research. The lack of high-end talent hampers technological innovation and limits the overall development of green and low-carbon cities. As the demand for technological breakthroughs grows, the current talent supply falls short of meeting the rapid development and innovation needs in the green and low-carbon field, significantly impacting the speed and effectiveness of technological iterations and applications.

3. Strategies for Constructing a Green and Low-Carbon Urban Ecosystem under the Dual-Carbon Strategy

3.1 Strengthening Research and Innovation in Green and Low-Carbon Technologies

To strengthen research and development in green and low-carbon technologies, increased investment in R&D funding is essential, alongside the establishment of a stable and diversified funding support mechanism. The government should set up special funds and provide tax incentives to attract enterprises, research institutions, and private capital to participate in green and low-carbon technology R&D projects. Financial institutions should also be encouraged to develop green financial products, providing long-term, low-cost financial support for green technology innovation and industrialization. Stable financial investment ensures the continuity of related R&D projects and the possibility of transforming R&D results into practical applications.

Promoting collaboration between research institutions and enterprises is crucial for building a collaborative innovation mechanism. In the process of green and low-carbon technology development, the theoretical research capabilities of research institutions must be closely integrated with the market demands of enterprises to form a complete chain of technological innovation. Research institutions should focus on basic research in frontier technologies, providing a scientific basis for the technological development of enterprises. Enterprises, on the other hand, should increase investment in independent R&D of green technologies and actively promote technological trials and industrialization. By establishing a technology-sharing platform, research findings can be rapidly transferred to enterprises. The government should play a guiding role by creating platforms for cooperation between the government, industry, academia, and research institutions, optimizing the allocation of technological resources and improving the efficiency of technology R&D.

3.2 Improving Relevant Policies and Legal Frameworks

A comprehensive policy framework covering all areas of green and low-carbon development should be established to ensure the systemic and coordinated nature of policies. The government needs to focus on top-level design, formulating clear policy directions and specific implementation guidelines based on the long-term strategic goals of green and low-carbon development. This requires the formation of a unified green and low-carbon policy program at the national level, covering key sectors such as energy, transportation, construction, and industry, with clearly defined emission reduction targets and timelines. Additionally, policy coherence and consistency must be ensured to avoid confusion and inefficiency caused by fragmented policies. A systemic policy design can provide clear guidance for green and low-carbon development across different sectors and regions. Strengthening the leading role of local governments in implementing green and low-carbon policies and formulating policy guidelines tailored to local conditions is also important. Given the significant differences in resources, economic structures, and

ecological environments across regions, local governments should formulate specific implementation rules and incentive measures based on national policy frameworks and local realities. For regions with different resource endowments, differentiated strategies for green and low-carbon development should be adopted, with flexible adjustments to policies supporting green industries, resource use, and tax systems to ensure effective policy implementation. Performance evaluations for local governments should be enhanced, especially in terms of evaluating the effectiveness of green and low-carbon policies, and by implementing a thorough evaluation system, local governments can be encouraged to actively fulfill their responsibilities for green and low-carbon development.

3.3 Accelerating Talent Cultivation and Recruitment

Higher education institutions should adjust their curriculum based on the demand for green and low-carbon development by adding courses related to environmental science, clean energy, and ecological management to cultivate interdisciplinary professionals. This requires close cooperation between educational institutions, enterprises, and research institutions to regularly update the curriculum, ensuring that students are learning the latest advancements in green technologies. Educational institutions should promote integration between academia, industry, and research by establishing university-enterprise collaboration programs and practical training bases, which will bridge the gap between academic knowledge and real-world application. Graduate education should focus on cultivating innovative talent, encouraging students to engage in cutting-edge research in green technologies and driving technological breakthroughs.

Governments and enterprises should also intensify efforts to attract talent, particularly by implementing flexible policies to recruit top-tier international experts in green technologies and management. Through international collaboration projects, technology exchanges, and global recruitment efforts, experts with global perspectives can be brought in to foster innovation in the green and low-carbon technology field. The government should provide incentives in taxation, residency, and research funding to ensure that international high-end talent can smoothly integrate into local research institutions and enterprises. Additionally, it is important to create a conducive environment for innovation by providing advanced research facilities, stable financial support, and academic freedom to increase the retention rate of high-end talent. The recruitment of international talent not only fills gaps in certain cutting-edge technological fields but also brings advanced international experience, enhancing the overall capacity for innovation in domestic research teams.

4. Case Study: Wenzhou, Zhejiang

Under the dual-carbon strategy, Wenzhou has actively promoted the construction of a green and low-carbon urban ecosystem by implementing a series of targeted and innovative measures aimed at achieving carbon peaking and carbon neutrality.

Wenzhou has adjusted its energy structure by vigorously developing clean and renewable energy sources to reduce its reliance on traditional fossil fuels. The city leverages its geographical advantages to promote the development and application of solar, wind, and hydropower, creating a distributed energy system that gradually transitions to a clean energy-dominated supply structure. Through the adoption of smart grid technology, Wenzhou optimizes energy distribution while improving energy efficiency and reducing the carbon emission intensity of urban energy consumption.

Given the prominent role of Wenzhou's manufacturing industry, the government has guided enterprises to adopt advanced energy-saving and emission-reducing technologies, increasing energy efficiency in production processes and reducing

emissions of pollutants such as waste gas and wastewater. Through policy guidance and financial support, Wenzhou's manufacturing enterprises are phasing out outdated production capacities and shifting towards more energy-efficient and environmentally friendly production models. At the same time, the city is actively fostering the development of emerging green industries such as new energy, new materials, and intelligent manufacturing, forming a modern industrial system centered on green technology.

Wenzhou has also integrated low-carbon concepts into urban planning and construction, enhancing the city's capacity for sustainable development. In the construction sector, Wenzhou has implemented stringent green building standards, encouraging new buildings to use energy-saving materials and technologies to reduce building energy consumption. For existing buildings, the city has promoted energy efficiency retrofits to improve energy use efficiency. Meanwhile, urban green space planning and ecological restoration projects have been rolled out throughout Wenzhou. The city's green area has expanded, not only improving residents' living environments but also effectively mitigating the urban heat island effect and increasing the resilience of the urban ecosystem. Wenzhou has also actively promoted the concept of a "sponge city," using rainwater collection and recycling technologies to enhance the city's ability to adapt to extreme climate events, further improving the urban ecological environment.

In terms of policy and legal guarantees, Wenzhou has formulated local policies and regulations that systematically support green and low-carbon development. Clear targets and measures for carbon reduction at different stages have been defined, providing a policy foundation for the construction of a green and low-carbon city. The Wenzhou government has also strengthened supervision and management of green and low-carbon policies, establishing comprehensive evaluation and accountability mechanisms to ensure effective policy implementation. Wenzhou has explored carbon trading market mechanisms, promoting carbon emission rights trading and carbon finance innovations to incentivize enterprises to reduce emissions. By using a variety of policy tools, the local government has guided social capital and corporate investments toward green industries and technological innovation, providing ample financial support for the city's green and low-carbon development.

In terms of talent cultivation and recruitment, Wenzhou has taken systematic measures to ensure the research, development, and innovation of green and low-carbon technologies are supported by a strong talent base. The government has worked closely with universities, research institutions, and enterprises to establish industry-academia-research collaboration platforms for green and low-carbon technology, promoting joint training of technical professionals between universities and enterprises. At the same time, Wenzhou has actively recruited domestic and international high-level talent in the green and low-carbon fields. By offering favorable policies and a high-quality research environment, Wenzhou has attracted more professionals to engage in the research and application of green technologies.

Under the guidance of the dual-carbon strategy, Wenzhou has built a green and low-carbon urban ecosystem through comprehensive measures, including energy structure adjustments, industrial transformation and upgrading, green urban planning, policy and legal frameworks, talent recruitment and cultivation, and international cooperation. This has provided a solid foundation for the sustainable development of Wenzhou and offers valuable experience and models for other cities aiming for green and low-carbon transformation.

5. Conclusion

As global efforts to achieve carbon neutrality continue to advance, green and low-carbon cities will move from pilot projects to widespread implementation and play a more active role in global climate action. China's experience in this process not only provides valuable lessons for domestic cities but also contributes ideas and solutions for global green and low-carbon urban development. The transition to low-carbon cities is a long-term and systematic endeavor. In the future, continuous exploration, innovation, and adjustment will be required to gradually achieve harmonious coexistence between humans and nature.

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