Research on the Transformation of China's Low-Carbon Economic Development Model

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ABSTRACT

With the increasingly severe issue of global climate change, low-carbon economy has become a crucial approach for countries worldwide to drive economic transformation, reducing greenhouse gas emissions and achieving sustainable development. As the world's largest developing country, China faces the dual pressure of transformation and development. Balancing economic growth while reducing environmental pollution and resource consumption to smoothly transition from a traditional high-carbon economy to a low-carbon economy is a significant challenge for China's current economic development. Against this backdrop, this paper explores the transformation path of China's low-carbon economic development model from both theoretical and practical perspectives. First, it reviews the theoretical foundations of the low-carbon economy and provides an overview of its development status in China. It then analyses transformation paths in areas such as low-carbon city construction, regional cooperation, industry cultivation, and technological innovation. Next, it examines the implementation effectiveness and deficiencies of current low-carbon economic policies in China and proposes directions for policy adjustments and improvements. Finally, it forecasts and prospects the future development trends of China's low-carbon economy, identifying opportunities and challenges in a globalized context. Through comprehensive analysis and systematic research, this paper aims to provide theoretical support and policy recommendations for the development of China's low-carbon economy, contributing wisdom and strength to achieve green and sustainable development goals.

1. Introduction

1.1 The Necessity of a Low-Carbon Economy in China

1.1.1 Global Climate Change and the Development Trend of Low-Carbon Economy

With the ongoing impact of global warming, attention to climate change is increasing. According to the IPCC report, the Earth's average temperature has risen by 0.74 degrees Celsius over the past century, and this trend is expected to continue in the coming decades. This sustained warming has greatly impacted the global climate system, increasing the frequency and intensity of extreme weather events, degrading natural ecosystems, and having profound effects on human society. Consequently, the international community has reached a consensus on the need to address climate change and promote the development of a low-carbon economy. The low-carbon economy, as a vital means to tackle climate change, involves not only reducing greenhouse gas emissions but also promoting efficient energy use, the rise of green industries, and sustainable lifestyles. Through international agreements like the United Nations Framework Convention on Climate Change and climate summits, a framework and mechanism for promoting a low-carbon economy globally have been established. As one of the world's largest greenhouse gas emitters, China plays a key role in the global development of a low-carbon economy. The Chinese government has committed to peaking carbon emissions by 2030 and achieving carbon neutrality by 2060. To realize this vision, China must transform its development model and explore more efficient low-carbon economic transition paths. This requires adjusting the economic structure, accelerating the application and promotion of new energy technologies, and establishing a sound energy efficiency standards system. Prioritizing investments in clean energy is also necessary. The global response to climate change and the flourishing development of the low-carbon economy have provided strategic direction and policy framework for China's low-carbon economic development (Liu, 2023; Zhu, 2023; Wei, 2023).

1.1.2 Environmental Pressures and the Demand for Low-Carbon Transformation in China

With China's rapid economic growth, environmental pressures and the demand for low-carbon transformation are becoming increasingly prominent. In 2019, China's carbon dioxide emissions were about 10 billion tons, accounting for nearly 30% of the global total, making it the world's largest carbon emitter. This situation poses a severe threat to China's own environmental quality and ecological security and brings immense pressure internationally. China's heavy reliance on coal energy during large-scale industrialization and urbanization has led to severe air pollution and greenhouse gas emissions. Pollutants like PM2.5 have increasingly impacted public health and ecosystems. China faces pressure from the international community regarding climate change and emission reduction commitments and accelerates low-carbon transformation in pursuit of high-quality economic development. Transitioning to a low-carbon economy has become an inevitable choice for China. The low-carbon economy is closely linked with sustainable development, which can drive economic restructuring and industrial upgrading in China, providing effective methods to resolve conflicts between environmental pollution, resource constraints, and economic growth. To achieve low-carbon transformation, China needs to deepen energy structure reforms, reduce dependence on coal, and vigorously develop clean and non-fossil energy sources. Currently, coal consumption accounts for over 57% of China's primary energy consumption, while clean and non-fossil energy consumption remains relatively low. Therefore, China must revolutionize energy production and consumption, increasing the proportion of non-fossil energy and promoting energy system transformation. Technological innovation plays a crucial role in low-carbon transformation. Improving energy efficiency and developing new and renewable energy sources are key to achieving a low-carbon economy. China has made significant progress in new energy technology, intelligent manufacturing, and low-carbon transportation, providing technological support and an innovative foundation for low-carbon development. The environmental pressures and low-carbon transformation demands China faces stem from international environmental governance appeals and China's internal requirements for promoting high-quality economic development and accelerating structural adjustment. China needs to develop low-carbon strategies tailored to its national conditions, promoting diverse mechanisms such as policy guidance, technological innovation, and market incentives to accelerate the low-carbon economic transition and sustainable development. Achieving low-carbon transformation will provide a solid foundation for improving China's environmental quality, resource conservation, and economic growth, demonstrating China's leadership and responsibility in addressing climate change and promoting sustainable development to the world (Yang, 2022; Guo, 2021).

1.2 Research Objectives and Content

1.2.1 Research Objectives

This study aims to comprehensively explore and analyse the multi-dimensional issues of China's low-carbon economic development model transformation in the context of global climate change challenges and national sustainable development needs, and to investigate its inherent development drivers. By identifying key factors in the transformation process, evaluating the effectiveness of existing policies and mechanisms, and establishing a low-carbon economic development model suitable for China's national conditions, this study seeks to provide theoretical and practical foundations for China's sustainable development. Specifically, this study will deeply analyse the interaction between China's macroeconomic and environmental policies, explore how to promote economic structure optimization and upgrading, accelerate the research and application of emerging low-carbon technologies, and drive the growth of low-carbon industries and services. By systematically reviewing the theoretical and practical foundations of low-carbon economy both domestically and internationally, this study will adopt a combination of qualitative and quantitative methods to propose feasible low-carbon transformation paths based on China's national conditions and provide actionable strategies and recommendations for policymaking and practice. Through systematic analysis, this study aims to fill the gap in domestic low-carbon economy research and assist China in gaining a leading position in global low-carbon economic development (Wang, 2021; Ma, 2021; Du, 2020).

1.2.2 Research Content and Framework

As global climate change issues become increasingly severe, it is particularly important for China, one of the world's largest carbon dioxide emitters, to transition its economy towards low-carbon development. To deeply understand the transformation of China's low-carbon economic development model, this study will focus on four main dimensions: policy formulation and implementation, industrial structure adjustment, technological innovation and promotion, and social awareness and behaviour change. These dimensions interact and complement each other, providing a comprehensive and systematic perspective for promoting low-carbon economic development transformation. This section of the study will evaluate the actual impact and effectiveness of China's low-carbon economy-related policies in the economic transformation and low-carbonization process, providing references for future policy formulation. Simultaneously, this study will deeply analyse the paths and models of industrial structure adjustment, exploring key factors in industrial upgrading and structure optimization by comparing the development trends of traditional and emerging low-carbon industries and how to use policy guidance to promote the proportion of low-carbon industries in the national economy. Technological development is the core driving force of the low-carbon economy, so this study will focus on the trends and prospects of low-carbon technologies such as energy efficiency improvement, clean energy development, and carbon capture and storage technologies. By comprehensively evaluating domestic and international technological research, market applications, and policy support, it can provide valuable conclusions on China's competitiveness and innovation potential in the low-carbon technology field. Lastly, social awareness change and individual behaviour support are indispensable elements for any economic model transformation. Therefore, this study will also focus on the improvement of public environmental awareness and the adoption of low-carbon lifestyles. Through methods such as surveys and in-depth interviews, this study will evaluate the social influence of current low-carbon initiatives and analyse factors influencing public participation in low-carbon activities, providing strong support for proposing more effective public participation strategies in the low-carbon economy. This study fully considers classic socio-economic models and international low-carbon economy research progress in constructing its research framework, aiming to ensure the research's depth, operability, and practicality. Through comprehensive analysis and in-depth discussion, the goal of this study is to provide scientific and reasonable strategies and policy recommendations for promoting the transformation of China's low-carbon economic development model.

2. Literature Review

2.1 Theories and Practices of Low-Carbon Economy

2.1.1 International Theoretical Research on Low-Carbon Economy

International theoretical research on the low-carbon economy primarily involves several aspects. Researchers widely discuss and recognize the necessity and urgency of low-carbon development. As global climate change gains widespread attention from the international community, countries have realized the importance of reducing greenhouse gas emissions. International agreements such as the Kyoto Protocol and the Paris Agreement have committed the international community to act against climate change, making the development of a low-carbon economy more urgent. In international theoretical research on the low-carbon economy, technological innovation and promotion are seen as key to achieving a low-carbon economy. The continuous development and application of new energy technologies, such as wind and solar energy, provide essential support for the transition to a low-carbon economy. For instance, according to the International Energy Agency (IEA), the global share of renewable energy has been increasing yearly, becoming a significant part of the energy market. Market mechanisms also play a crucial role in the low-carbon economy. The introduction of economic measures, including carbon trading markets and carbon taxes, can adjust the industrial structure through market mechanisms, directing capital flows toward low-carbon sectors. Lastly, the support of policy and legal frameworks is vital for the development of a low-carbon economy. Governments worldwide have introduced a series of policies and plans, such as setting energy-saving and emission reduction targets and promoting new energy vehicles, providing essential guidance and assurance for the development of a low-carbon economy. International theoretical research on the low-carbon economy explores the necessity of low-carbon development,

technological innovation, market mechanisms, and policy support from various angles. These studies offer valuable experiences and lessons for China's low-carbon economic transition. In promoting low-carbon development, China can absorb these international theories and practices' essence, combining them with its national conditions to actively build a low-carbon economic model suitable for its development (Yang, 2020).

2.1.2 Theoretical Exploration of China's Low-Carbon Economy

In recent years, with the increasing emphasis on climate change and environmental protection globally, the level of China's low-carbon economic development, as the world's largest developing country, has garnered widespread attention both domestically and internationally. The theoretical exploration of China's low-carbon economy began in the early 21st century when China faced increasingly severe environmental pollution and resource constraints, urgently needing to construct a low-carbon economic development model suitable for its national conditions. In 2007, the Chinese government first proposed the strategic goal of building a resource-saving and environmentally friendly society at the national level, explicitly defining the direction of low-carbon development in its policies. The theoretical framework of China's low-carbon economy is built on the foundation of sustainable development, combining environmental protection with economic growth to achieve a green transformation of economic and social development. In exploring the practice of a low-carbon economy, Chinese experts and scholars have proposed a series of guiding theoretical achievements. The core view is that a low-carbon economy is not only a mode of economic development but also a new model of economic growth and national development strategy. The theoretical exploration of China's low-carbon economy emphasizes principles such as energy conservation, emission reduction, clean production, and green consumption, aiming to promote the optimization and upgrading of the economic structure through reform and innovation. Industrial structure adjustment is critical, with a focus on the role of policy guidance and market mechanisms to promote the development of strategic emerging industries such as new energy, energy conservation, environmental protection, and new materials, while phasing out outdated capacity and excessive resource consumption in traditional industries. At the enterprise level, theoretical research on China's low-carbon economy focuses on the low-carbon transformation of enterprises, encouraging technological innovation and management improvement to enhance energy efficiency and reduce greenhouse gas emissions. Scholars have also explored the relationship between enterprise size and green technology development, advocating that large enterprises should take on more responsibility for researching and developing new energy and clean technologies, while small and medium-sized enterprises can achieve their low-carbon transformation by participating in green supply chains. In terms of policy support, China's theoretical exploration of a low-carbon economy has proposed a series of specific measures, such as establishing pilot low-carbon cities, implementing carbon trading markets, optimizing tax incentive policies, and strengthening international cooperation. The carbon trading market, as one of the market-based mechanisms, has been successful in regions such as Europe. Since 2011, China has been piloting carbon emission trading in several cities, actively promoting the establishment of a national carbon market. According to the National Bureau of Statistics of China, in 2019, China's energy consumption per unit of GDP decreased by 13.2% compared to 2015, and CO2 emission intensity decreased by 18.8%, demonstrating the initial success of China's low-carbon economic development model. However, Chinese researchers also recognize that there are still significant gaps compared to developed countries in low-carbon technology research, application, and industrialization. Therefore, there is a need for in-depth research on how to construct effective incentive mechanisms and balance regional development disparities. The theoretical exploration of China's low-carbon economy has achieved significant results, but further improvement is needed in theory and policy practice. Looking ahead, China should deepen the theoretical research on a low-carbon economy, promote low-carbon technological innovation, and actively participate in global climate governance while ensuring national energy security and sustainable economic development. This will allow China to contribute its wisdom and strength to the global low-carbon transition (Wang, 2023; Sun, 2023).

2.2 Development Status of China's Low-Carbon Economy

2.2.1 Overview of China's Low-Carbon Industry Development

Amid the global wave of the low-carbon economy, China, as one of the world's largest carbon emitters, has made the development of the low-carbon industry a strategic focus for national transformation. Guided by national policies and driven by market demand, China's low-carbon industry has made significant progress in energy structure adjustment, low-carbon technological innovation, and the development of the environmental protection industry. In the energy sector, China's investment in new energy industries such as wind and solar power has increased annually. By 2020, China's installed capacity of renewable energy reached 800 million kilowatts, accounting for 42% of the total installed capacity of power sources nationwide, an increase of 9.5% year-on-year. This has not only made China a leader in the global renewable energy field but also provided a solid foundation for China's energy structure adjustment and carbon emission reduction. In terms of low-carbon technological innovation, China has also achieved significant breakthroughs. The application of emerging low-carbon technologies, such as electric vehicles, energy-saving and environmentally friendly materials, and smart grids, is becoming increasingly widespread, driving the development of related industrial chains. Statistics show that by the end of 2020, China's electric vehicle ownership exceeded 4 million, accounting for more than half of the global total. The development and popularization of these emerging low-carbon technologies provide a solid foundation for economic green transformation and offer new growth momentum for China's low-carbon industry. To promote the development of the low-carbon industry, the Chinese government has formulated a series of policy measures. Financial and tax incentives, green credit, and carbon trading markets effectively incentivize the green upgrade of industrial structures. The government has also promoted the establishment of national low-carbon city demonstration projects to guide urban low-carbon economic development and promote the low-carbon industry. However, the development of China's low-carbon industry still faces some challenges. The level of technological research and development is relatively lagging, requiring increased investment in scientific and technological innovation and enhanced independent research and development capabilities. The market mechanism is not perfect, needing further improvement in mechanisms such as carbon emission trading to effectively guide enterprises to increase the application and innovation of low-carbon technologies. Opportunities and challenges coexist in international cooperation and experience exchange, requiring China to strengthen cooperation with other countries to jointly promote the global low-carbon economy. After years of development, China's low-carbon industry has achieved significant results. However, continuous efforts are needed to deepen institutional innovation, enhance independent research and development capabilities, and improve market competitiveness. Only through domestic and international cooperation can China's low-carbon industry continue to develop and contribute more to promoting the global low-carbon economy (Luo, Zhang & Zhou, 2023; Wang & Lin, 2022; Zhang & Fan, 2023).

2.2.2 Progress and Challenges of China's Low-Carbon Technology

With the global effort to address climate change, the development of low-carbon technology in China has faced unprecedented opportunities and challenges. In recent years, the Chinese government has actively introduced a series of policy measures to promote the research and industrial application of low-carbon technologies. In renewable energy technologies, China has made significant progress in the large-scale application of wind and solar power generation technologies. According to statistics, China has become one of the world's leading countries, with rapid growth in the total installation of wind and solar power facilities. However, China's low-carbon technology development still faces several challenges. The maturity of technology varies, with some technologies needing further improvement and refinement. Initial costs are relatively high, requiring further cost reduction through economies of scale and technological advancements to enhance market competitiveness. The market operation mechanism is not yet fully developed, requiring further improvement in policies and market incentive mechanisms to promote the commercial application of low-carbon technologies. The uncertainty of the external economic environment is also a challenge, necessitating strengthened international cooperation to promote the global development of low-carbon technologies. To overcome these challenges, China needs to accelerate the innovation speed and quality of low-carbon technologies, increase investment in scientific and technological research and development, cultivate and introduce high-end talents, and improve technological levels. Meanwhile, under the dual action of policy guidance and market incentives, it is necessary to promote the commercialization of low-carbon technologies and cross-regional collaborative progress. For example, establishing research and industrialization alliances for low-carbon technologies, promoting technology

exchange and cooperation, and accelerating technology transformation and application. Additionally, increasing support for innovative low-carbon enterprises, providing funding, policy, and market access support, and creating a favourable policy environment and market opportunities for enterprise development. In summary, the progress and challenges of China's low-carbon technology lie in accelerating technological innovation and market promotion, enhancing technology maturity and competitiveness, improving market mechanisms and policy support, and strengthening international cooperation. Only in this way can China maintain a leading position in the global low-carbon technology competition and contribute more to global climate governance (Liu, 2022; Wu, 2021).

3. Transformation Pathways for China's Low-Carbon Economic Development Model

3.1 Low-Carbon City and Regional Economic Development Models

3.1.1 Development Strategies for Low-Carbon Cities

The goal of development strategies for low-carbon cities is to reduce urban carbon emissions, enhance energy efficiency, and promote sustainable urban development through a series of policies and technical measures. China has adopted several initiatives in developing low-carbon cities to achieve this goal. Urban planning optimization is a crucial step, focusing on rationally planning urban spatial layouts to improve land use efficiency and reduce energy consumption. A key aspect of this is establishing green spaces to absorb carbon dioxide and mitigate the urban heat island effect. The promotion of green buildings is an essential aspect of low-carbon city development. This involves formulating and implementing building energy-saving design standards and promoting the research and application of new energy-saving building materials. By establishing efficient building systems, cities can reduce energy consumption and lower carbon emissions. The application of renewable energy is also a key area in developing low-carbon cities. Besides utilizing traditional energy forms such as solar and wind energy, China is actively developing unconventional renewable energies such as biomass and waste-to-energy. These measures reduce dependence on traditional energy sources and lower carbon emissions. Energy-saving and emission-reduction technology transformation plays a crucial role in promoting low-carbon city development. Advanced energy management systems and equipment can improve energy efficiency in industries and households. This includes using high-efficiency energy equipment and improving energy utilization efficiency. Building low-carbon transportation systems is also a focus. This includes promoting public transportation prioritization strategies, developing new energy vehicles, and designing non-motorized roads. By reducing the use of private vehicles and encouraging green travel modes, cities can reduce transportation-related carbon emissions. However, implementing low-carbon city development strategies faces challenges such as insufficient funding and the difficulty of technological research and development. To address these issues, the government can incentivize the development and application of low-carbon technologies through financial subsidies and tax incentives. Urban sustainability assessment systems are also important tools for promoting low-carbon city planning. This involves using indicators such as carbon emission accounting and environmental impact assessments to evaluate the sustainability and low-carbon development levels of cities. The development of low-carbon cities positively impacts China's comprehensive construction of a moderately prosperous society and the achievement of sustainable development goals. Through measures such as urban planning optimization, green building promotion, renewable energy application, energy-saving and emission-reduction technology transformation, and low-carbon transportation system construction, China is actively promoting low-carbon economic development and striving to achieve the goal of environmentally friendly cities (Li, 2021; Jiang, Jiang & Yang, 2021).

3.1.2 Low-Carbon Regional Economic Cooperation Model

In the development process of China's low-carbon economy, the low-carbon regional economic cooperation model plays an important role. This model relies on optimized resource allocation and industrial complementarity between regions, mobilizing local governments, industry enterprises, and research institutions to form distinctive low-carbon cooperation networks. It aims to achieve overall regional carbon emission reduction and green growth. Research shows that the low-carbon cooperation model encompasses several aspects, with the core being constructing a cooperation

framework based on low-carbon industrial chains. Within this framework, regions can promote mutual recognition and exchange of low-carbon technologies and products by establishing unified low-carbon standards and certification systems. For example, the Yangtze River Delta region, leveraging its industrial and scientific research advantages, has formed a relatively mature low-carbon technology exchange platform, effectively promoting the collaborative development of low-carbon industries such as new energy vehicles and green buildings within the region. Besides policy support at the government level, the low-carbon regional economic cooperation model also focuses on forming a closed-loop system of scientific research, industry, and market. By establishing regional low-carbon technology research and development centres and introducing international cooperation, China can quickly capture the cutting-edge trends of global low-carbon development and achieve high-quality transformation within the regional industrial chain. This model has been validated in the Beijing-Tianjin-Hebei coordinated development strategy, where the creation of low-carbon industrial parks has promoted economic transformation while effectively controlling regional carbon emissions. The low-carbon regional economic cooperation model is significant for China to achieve green development and construct a low-carbon economic system. In practice, this model requires cooperation and joint improvement from all aspects to promote the deep integration of low-carbon technologies and industries, supporting high-quality sustainable development of the Chinese economy (Liu & Zhu, 2020; Chen & Liu, 2019).

3.2 Low-Carbon Industry and Technological Innovation Pathways

3.2.1 Cultivation and Development of New Low-Carbon Industries

In today's world, where economic globalization and climate change threats are increasingly prominent, the cultivation of new low-carbon industries is crucial for addressing climate change and a necessary choice for sustainable economic development. As the world's largest developing country, China is gradually showcasing the growing proportion of new low-carbon industries in the national economy and the reduction of external environmental impacts in promoting the low-carbon economic transition. Policy orientation is one of the critical factors driving the development of new low-carbon industries. In its 13th Five-Year Plan, the Chinese government explicitly proposed constructing a modern energy system and promoting an energy production and consumption revolution, laying the policy foundation for developing new low-carbon industries. Government policy support and guidance have provided ample market space and growth momentum for low-carbon industries such as new energy, energy conservation, environmental protection, and new energy vehicles. According to data from the National Bureau of Statistics, the total output value of China's energy conservation and environmental protection industry exceeded 6 trillion RMB in 2020, maintaining an annual growth rate of over 15%, demonstrating strong development momentum. Industrial structure adjustment is an important pathway for the robust development of new low-carbon industries. China is gradually eliminating high-energy-consuming and high-emission traditional industries and actively developing new energy industries such as wind, solar, and biomass energy, becoming an important trend in China's low-carbon economic development. With technological advances and cost reductions, the competitiveness of new energy is continually increasing. For example, through technological innovation and large-scale production, China's photovoltaic industry has transformed from a manufacturing powerhouse to a manufacturing leader, becoming the global leader in the photovoltaic industry. Data show that China's photovoltaic product export value exceeded 200 billion RMB in 2020, with a global market share of over 70%. Technological innovation and R&D investment are crucial factors driving the development of new low-carbon industries. The Chinese government encourages enterprises to increase R&D investment to enhance the core competitiveness of new low-carbon industries. Increased R&D investment has led to the birth of new technologies and products, accelerating the commercialization of low-carbon technologies. Statistics indicate that R&D investment in China's new energy vehicle industry has grown at an average annual rate of over 20% in the past five years, and market ownership has accounted for more than 50% of the global new energy vehicle market. International cooperation is vital for promoting the development of new low-carbon industries. China actively participates in global climate governance and promotes the global layout of new low-carbon industries through technology transfer and capital export. International cooperation helps share resources, complement advantages, and promote the unification of global low-carbon technology standards. This strategy further expands the international influence of China's new low-carbon industries and adds new momentum for their long-term development. The cultivation and development of new low-

carbon industries rely on comprehensive measures, including policy guidance, industrial upgrading, technological innovation, and international cooperation. Through continuous efforts, new low-carbon industries are expected to become important drivers for China's economic restructuring and low-carbon transformation (Chen & Ji, 2019; Yan, 2019).

3.2.2 Innovation and Application of Low-Carbon Technologies

Innovating and applying low-carbon technologies is a key pathway to achieving green development in promoting the low-carbon economic transition. As the world's largest carbon dioxide emitter, China urgently needs to explore new energy-saving and emission-reduction technologies and promote the application of existing technologies to achieve sustainable development at national and regional levels. Innovation in low-carbon technologies primarily revolves around improving energy efficiency, renewable energy technologies, carbon capture and storage (CCS) technologies, and new materials. For example, China has achieved world-leading status in solar photovoltaic technology. According to statistics, as of [specific year], China's installed capacity of photovoltaic power generation reached [specific number] gigawatts, accounting for [specific percentage] of the global total. In the field of wind energy, China is actively deploying large-scale wind farms and adopting intelligent dispatch systems to improve wind farm efficiency. Technological innovation is also evident in the research and development of electric vehicles (EVs) and efficient energy storage systems. According to data, in [specific year], China's electric vehicle sales reached [specific number], accounting for [specific percentage] of the global market share. With breakthroughs in lithium battery technology, storage costs have continuously decreased, providing feasible solutions for grid peak shaving. For example, in the industrial sector, some steel enterprises have significantly reduced energy consumption by introducing high-efficiency motors and optimizing heating processes. According to a report published by [research institute], in [specific year], some leading steel enterprises in China achieved a reduction in energy consumption per unit product by [specific percentage] through technological innovation. In applying low-carbon technologies, promoting precise monitoring and data analysis platforms is key. China is optimizing carbon emission management by establishing a national carbon emission trading market and corresponding monitoring systems. According to data provided by [institution], as of the fourth quarter of [specific year], more than [specific number] enterprises participated in China's carbon trading market, with a total trading volume of [specific number] tons and a total trading amount exceeding [specific amount] billion RMB. The government has also introduced policies and subsidy programs to encourage enterprises and consumers to adopt low-carbon technologies. For example, the [specific year] issued "xx Guidance" and "xx Action Plan" provided financial support and tax incentives for low-carbon technology innovation. China also actively engages in international cooperation, accelerating local innovation by introducing advanced international low-carbon technologies. In [specific year], China signed the "xx Technology Transfer Agreement" with country, promoting academic and commercial exchanges in clean energy technologies. Overall, the innovation and application of low-carbon technologies require support from government policies, market mechanisms, and public awareness. Looking to the future, with increased R&D investment, an optimized policy environment, and growing market demand, low-carbon technology innovation and application are expected to play a more critical role in China's low-carbon economic transition (Jiao & Zhao, 2021).

4. Policy Recommendations and Prospects for China's Low-Carbon Economic Transition

4.1 Analysis of Policies Related to the Low-Carbon Economy

4.1.1 Evaluation of Current Low-Carbon Economy Policies

A comprehensive evaluation of China's current low-carbon economy policies reveals that while significant progress has been made, challenges remain. At the macro-policy level, the Chinese government has set the target of peaking carbon dioxide emissions by 2030 and achieving carbon neutrality by 2060. This policy commitment demonstrates the country's high priority on the low-carbon economic transition and provides a macro framework for low-carbon development. Establishing a carbon emission trading market is also a key policy measure. By controlling and managing the carbon emission limits of major emitters, the market mechanism has played a certain role in the low-carbon

transition. In terms of industrial policy, the government actively promotes the research and application of low-carbon technologies and optimizes industrial structures. The new energy sector, especially wind and solar energy, has received substantial support. Simultaneously, the government has implemented stringent environmental standards for traditional high-pollution industries like steel and cement, encouraging these industries to move towards green and low-carbon directions. Regarding technological innovation, the government encourages enterprises to increase R&D investment, support green technology innovation, and foster cross-industry and cross-sector technological cooperation. These policy measures have positively contributed to promoting the development of a low-carbon economy. However, evaluating current policies also uncovers some issues and challenges. The implementation of policies faces regional development disparities, unbalanced economic structures, and industrial bases, leading to varying policy effects across different regions. Although the carbon trading market has been established, its trading activity is low, market institutions are not fully developed, and the role of carbon price signals needs to be strengthened. While the government has provided substantial support for technological innovation policies, the R&D capabilities of enterprises still need improvement, and there is a lack of independent intellectual property rights for core technologies. Specific data for policy evaluation include, but are not limited to, carbon trading volumes and prices, investment in the new energy industry, emissions from high-energy-consuming industries, and the number of green technology innovation patent applications. According to 2020 statistics, China's carbon emission trading market volume was about 300 million tons, with the power industry accounting for the highest trading volume. In 2021, China's R&D investment reached 2.4% of GDP, doubling from ten years ago, but still lagging developed countries. China's current low-carbon economy policies have made significant achievements in promoting the low-carbon transition, but challenges remain. To further promote the low-carbon economic transition, it is necessary to improve related policies, strengthen policy implementation, and enhance the enthusiasm of the market and enterprises in the low-carbon transition. Additionally, attention should be paid to regional balance and industrial synergy, continuously boosting the momentum for technological innovation and industrial upgrading (Yu, 2018; Zhuang & Zhou, 2018).

4.1.2 Directions for Policy Adjustment and Improvement

Based on evaluating current low-carbon economy policies in China, it is necessary to propose targeted adjustments and improvements. To enhance policy effectiveness and strengthen the driving force of China's low-carbon economic transition, policies should emphasize the role of market mechanisms. Currently, the Chinese government plays a leading role in promoting the low-carbon economy but needs to encourage market mechanisms through policies to stimulate more private sector investment in low-carbon technologies and industries. Developing a comprehensive carbon emission trading market should be considered, using market-based approaches to make carbon pricing a crucial factor in enterprise decision-making. According to a 2020 World Bank report, 45 countries and 25 regions worldwide have implemented or plan to implement carbon pricing mechanisms, covering 20% of global carbon dioxide emissions. China should systematically study these practices and formulate a suitable policy framework based on domestic conditions. Policy formulation should focus more on operability and detailed refinement. Some low-carbon policies have macro-level guidance but lack clear action guidelines and specific implementation standards, making execution difficult and less effective. Future policies need to be more detailed, clearly specifying responsible entities, operational steps, monitoring mechanisms, and evaluation methods. Enhancing policy coordination across departments and local governments is essential. Low-carbon economic transition involves multiple departments such as environmental protection, energy, industry, and transportation, as well as cooperation from local governments. At the national level, unified policy directions should be formulated, reinforcing the division of responsibilities among different departments and local governments, and establishing coordination mechanisms to ensure consistent and effective policy implementation. Lastly, improving policies should also emphasize public participation and social supervision mechanisms. Public awareness and behavioural change are key factors in the development of a low-carbon economy. By promoting education, media publicity, and social activities, public awareness of low-carbon lifestyles can be raised, encouraging, and guiding public participation in low-carbon actions. Establishing social supervision systems ensures widespread social oversight and support for policy implementation. Specific data shows that China's carbon emission trading pilots cover over 3,000 enterprises, with a trading volume exceeding 200 million tons and a trading amount

over 5 billion RMB. These data indicate that regulating carbon emissions through market mechanisms is feasible. However, this proportion is still relatively small compared to the total carbon emissions. Therefore, strengthening market-based approaches, especially enhancing the active role of market mechanisms in the low-carbon economic transition, is particularly needed in policy adjustments and improvements. Through these measures, future low-carbon policies in China will be more effective, which is crucial for achieving national low-carbon transition and sustainable development goals (Han, 2017; Xiao, 2016).

4.2 Future Prospects of Low-Carbon Economic Transition

4.2.1 Opportunities and Challenges in Low-Carbon Economic Development

With the increasing global focus on climate change, the development of a low-carbon economy has become an important direction for world economic development. As the world's largest developing country and carbon dioxide emitter, China has a significant responsibility to promote the low-carbon economic transition. The Chinese government has clearly stated in several official documents that by 2030, China aims to peak its carbon dioxide emissions and achieve carbon neutrality by 2060. This ambitious goal brings unprecedented opportunities and challenges for China's low-carbon economic development. In terms of opportunities, international cooperation is a significant one. China has actively participated in international climate negotiations, and through international cooperation, it can gain technical support and experience exchange, promoting the development and application of domestic low-carbon technologies. Green finance also offers opportunities for the low-carbon economy. The introduction of financial instruments such as green bonds and green credit provides financing channels for low-carbon projects, attracting private investment in the low-carbon economic transition. In terms of challenges, the energy structure transition is a significant one. Although China has made progress in renewable energy, coal remains the mainstay of China's energy structure, requiring an accelerated transition. Industrial upgrading is another challenge. While emerging low-carbon industries are developing rapidly, the transformation of traditional high-pollution and high-energy-consuming industries remains difficult. Socioeconomic development imbalances also pose challenges to the low-carbon economic transition, requiring integration with regional coordinated development. Improving the policy and legal framework is a key challenge, needing the enhancement of market mechanisms and policy regulations to support low-carbon economic development. China's low-carbon economic development faces both opportunities and challenges. Strengthening international cooperation, promoting economic structural transformation, innovating green finance mechanisms, accelerating energy structure transition, fostering industrial upgrading, and improving policy and legal support are necessary measures to effectively respond to challenges and seize opportunities, driving low-carbon economic development to new heights (Song & Zhang, 2012).

4.2.2 Long-Term Development Trends of China's Low-Carbon Economy

As the global economic landscape evolves, China, as the world's second-largest economy, plays a crucial role in promoting low-carbon economic development. The long-term development trends of China's low-carbon economy will be reflected in several key areas. Under national policy guidance, China will continue to increase the research and application of green low-carbon technologies. According to national plans, by 2030, China aims to peak its carbon emissions and strive to achieve carbon neutrality by 2060. To achieve this ambitious goal, China needs to continually improve energy efficiency and promote the widespread application of clean energy. Data shows that by 2020, China's installed capacity for wind and solar power generation had exceeded 210 million kilowatts and 250 million kilowatts, respectively, leading the global clean energy market. The development of China's low-carbon economy will deepen market mechanisms. By establishing a carbon emission trading market, the government can effectively incentivize enterprises to reduce emissions. In July 2021, China officially launched its national carbon market, covering over 2,000 large emission enterprises in the power sector. In the future, the carbon market is expected to expand to industries such as steel, building materials, and non-ferrous metals, promoting more industries to achieve low-carbon transformation through market mechanisms. The development of China's low-carbon economy will depend on optimizing and adjusting the industrial structure. By developing low-carbon industrial parks and circular economies, traditional

industries can be green-upgraded. Data indicates that the national circular economy output value exceeded 4.5 trillion RMB in 2019, with the comprehensive utilization of resources industry output value growing by 6.7%. In the long run, public awareness and acceptance of low-carbon lifestyles will significantly improve, providing a solid social foundation for the sustainable development of the low-carbon economy. With the spread of low-carbon awareness and increased green consumption behaviour, the low-carbon economy will integrate into daily life. It is expected that by 2035, China's urbanization rate will reach 70%, further accelerating the construction of low-carbon civilized cities and promoting low-carbon development in housing, transportation, and waste disposal. The long-term development trend of China's low-carbon economy will be multifaceted and systematic, including policy guidance, technological innovation, industrial upgrading, market mechanism optimization, and changes in social consumption patterns. Facing future challenges, China should further improve relevant policies and regulations, strengthen international cooperation, and cultivate low-carbon industry talent to support the long-term goals of low-carbon economic development (Liu & Wang, 2010).

5. Conclusion

The transformation towards a low-carbon economy is a pivotal challenge and opportunity for China, requiring a multifaceted and systemic approach. As the world's largest developing country and a major emitter of greenhouse gases, China bears a significant responsibility in addressing global climate change. This conclusion synthesizes the key insights and future directions for China's low-carbon economic transition, emphasizing policy effectiveness, technological innovation, and international cooperation. Evaluating China's current low-carbon policies reveals both achievements and areas needing improvement. The government's commitment to peak carbon emissions by 2030 and achieve carbon neutrality by 2060 underscores the nation's strategic focus on low-carbon development. The establishment of a carbon emission trading market and the promotion of renewable energy industries, such as wind and solar power, demonstrate significant progress. However, challenges persist, including regional disparities, underdeveloped market mechanisms, and insufficient R&D capabilities within enterprises. To enhance policy effectiveness, it is crucial to refine policy details, improve operability, and foster greater market participation. Ensuring policy coordination across different governmental departments and localities will also be vital. Technological innovation remains a cornerstone of China's low-carbon economy. Advances in renewable energy technologies, energy efficiency, and carbon capture and storage (CCS) are critical to reducing emissions. China's leadership in photovoltaic technology and the rapid development of electric vehicles illustrate the potential of technological breakthroughs. Nevertheless, increasing R&D investment and strengthening independent intellectual property rights are essential to maintaining competitiveness. Encouraging public participation and raising awareness about low-carbon lifestyles can further support the adoption of these technologies. International cooperation offers significant opportunities for China's low-carbon transition. Participation in global climate agreements and collaborations enables China to gain technical support and share best practices. The integration of green finance mechanisms, such as green bonds and credits, provides essential funding channels for low-carbon projects, attracting private investment and driving economic transformation. However, the energy structure transition remains a formidable challenge. Despite progress in renewable energy, coal continues to dominate China's energy mix. Accelerating the shift towards cleaner energy sources is imperative for meeting long-term climate goals. Looking forward, China's low-carbon economic development will hinge on optimizing industrial structures, enhancing market mechanisms, and fostering innovation. Developing low-carbon industrial parks and circular economies can facilitate the green transformation of traditional industries. Expanding the carbon market to more sectors will incentivize emissions reductions across a broader spectrum of the economy. Increasing public awareness and acceptance of low-carbon lifestyles will provide a robust social foundation for sustainable development. In conclusion, China's journey towards a low-carbon economy is complex and requires sustained effort across multiple dimensions. Effective policies, technological advancements, and international cooperation are the pillars supporting this transition. By addressing current challenges and seizing emerging opportunities, China can lead the way in global low-carbon development, contributing significantly to mitigating climate change and achieving sustainable growth. The path forward demands continuous innovation, robust policy frameworks, and active engagement from all societal sectors to build a greener, more sustainable future.

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