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Analysis of the High-Quality Development Path of China's Green Economy under the Dual Carbon Target

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Abstract. Global climate change is intensifying. China has proposed the goals of peaking carbon emissions and achieving carbon neutrality, commonly known as "dual carbon", which provides a core strategic direction for the comprehensive green transformation of the economic and social system. This article will systematically review the scale layout, technological innovation, and consumption of China's green economy based on industry data, energy statistics, and policy documents from 2008 to 2025, and analyze the bottleneck that limits the country's high-quality development. This study adopts industrial economics and institutional analysis methods, combined with the characteristics of domestic industrial operation and international green trade rules, and finds that the imbalance of industrial structure, insufficient core green technology capabilities, single green financing channels, and inconsistent green standard systems jointly hinder the low-carbon transformation process. On this basis, this article proposes targeted paths from the aspects of industrial upgrading, factor guarantee, and institutional improvement, aiming to promote the coordinated development of green industries, technology, finance, and markets, accelerate the construction of a complete green economic system, and provide theoretical reference and practical decision-making basis for achieving the dual carbon strategy and enhancing China's competiveness in the global green supply chain.

Keywords: Dual carbon target, green economy, industrial low-carbon transformation, green technology, carbon market

1. Introduction

Over the last few years, there has been an increase in global extreme weather events like sea-level rise; high-temperature droughts; and extreme rainstorms. These extreme weather events have affected production and living systems worldwide. Because of this, global climate governance has become a common responsibility; and low carbon transformation and the development of a green economy are now dominating trends in how the global economy is evolving [1]. In order to take on the climate responsibilities of being a major global power, and to get out of the problem of a domestic economy built on the consumption of high levels of energy, China officially announced its "Dual Carbon Goals" – carbon peaking by 2030 and achieving carbon neutrality by 2060 [2, 3]. The achievement of these two objectives will lead to a comprehensive green transformation of both social and economic development and become one of the country's most critical long-term strategic

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objectives. As a result, the green economy will play a role in implementing the "Dual Carbon Goals" and building a new development pattern and is characterized by being low-carbon, closed-loop (circular), and sustainable; it will serve as a key vehicle for achieving both the "Dual Carbon Goals" and the construction of a new development pattern. Thus, a systematic assessment of China's green economy will provide theoretical significance and practical guidance for developing countries.

Many different articles have looked at either the Green Economy or the transitioning into a "Dual Carbon Economy," which is made up of two carbon structures: natural and man-made. Internationally, many scholars have studied carbon pricing mechanisms, the operation of the EU's carbon market, and policies to assist green industry in developed nations by focusing on designing market-based emission reduction instruments. For example, William Nordhaus created a climate-economy integrated model to illustrate how carbon taxes can limit output of carbon emissions, and Ghisellini et al. created a systematic literature review of the industrial models of circular economy in order to provide a theoretical framework for green transformation of the manufacturing process [4, 5].

There are three primary research directions on a domestic level: the first is to investigate green industrial development, where researchers are conducting analysis of data from Hochiki corporations that manufacture items such as photovoltaic cells (PV), which is used in the solar industry, and new energy vehicles (NEV), which are considered part of green industry development, to identify if China has a comparative advantage in the manufacturing of green technology, and that as the foundation of a full-chain competitive advantage (new energy) to compete globally. Second, is looking at green finance and carbon markets; researchers are investigating how to create a liquidity shortage in the national carbon market due to inconsistent standards for green projects, which is preventing the effective reduction of carbon dioxide emissions, and there is limited innovation in green credit and bonds and is not being adequately funded for long-term financing of green projects [6]. The third research direction looks into three significant restrictions to the dual carbon transition; the two main identified obstacles are the extremely high cost to convert traditional energy-intensive industries, technology-related bottleneck challenges with energy storage and carbon capture, utilization, and storage (CCUS), and regional imbalances as the three primary barriers to achieving a dual carbon transition at scale [7, 8].

Limited use has been made of combining studies on green industries, green finance, and low-carbon technologies into a singular dimension for systematic analysis. This impedes researchers from assessing the impact that international trade barriers have on the development and implementation of clean technologies and industries.; Second, empirical research related to this topic is limited. For example, the largest portion of data pulled from the most recent macroeconomic data available (2024 and 2025) does not adequately address new and emerging issues previously unaddressed (for example: international barriers or restrictions on green trade, geopolitical supply chain reconfiguration.) [9, 10]. This paper will help fill the previously mentioned gaps by utilizing industrial and institutional economic principles based on the most recently available official statistical data from the 3 aforementioned. The ultimate goal of this study is to identify bottlenecks along all three manufacturing value chains and industry, identify bottlenecks along each value chain (i.e., factors and institutions), develop various layered and actionable high-quality development pathways while considering both domestic (i.e., transition requirements) and international (i.e., competition for green supply chains) perspectives.

The paper is structured as follows: Section II contains a review of the accomplishments related to scale, innovation, and consumption; Section III provides an analysis of the challenges associated with transitioning from traditional to green economy (i.e., challenges facing industry), factors, and

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institutions; Section IV recommends potential ways to achieve these goals; and Section V considers future challenges associated with this trend.

2. Status and achievements of China's green economy

China has made large advances in terms of its green economy over the past 10 years due to both government initiatives such as its "Dual Carbon" strategy, as well as additional policy initiatives such as its "1 + N" policy system. As a result, people have seen the green industry scale up, the breakthrough of new green technologies, and a network of green consumers emerging.

China has developed a fully functioning and diverse industrial economy that produces Clean Renewable Energy (CRE) from renewable resources. This includes energy conservation technologies, the traditional manufacturing sector, as well as the newer circular manufacturing sector. As a result, the regionalized green development method in China reflects this development.

2.1. Development scale and industrial layout

In terms of overall scale, the green industry in China has experienced high growth. Over 6,000 national-level green factories were established by the end of 2025, covering steel, chemicals, manufacturing equipment, and new energy. The value of China's green and environmental protection industry is expected to be 11 trillion yuan by 2025, with the output of green factories making up nearly 20% of all domestic manufacturing's above designated size output.

The green transformation of the energy structure is visible in the increased installation of non-fossil energy power plants. As of 2025, the total installed power capacity in China was 3.89 billion kW, with 1.2 billion kW of PV power and 640 million kW of wind power. Non-fossil energy accounted for 60.9% of the total installed power capacity. Further, the consumption of coal has reduced significantly. The "New Three" industries of PV, lithium batteries, and NEVs have become the core of China's green exports. Between 2021 and 2025, the production of PV modules and lithium batteries increased by 3.7 and 6.4 times, respectively. NEVs have ranked as the best-selling vehicles globally for ten consecutive years. Chinese companies have expanded their production bases outside China to reduce the impact of the Western countries' green trade barriers.

The layout of the green industrial regions in China indicates "Eastern leadership and Central-Western characteristic breakthroughs." The Yangtze River Delta, Pearl River Delta, and Beijing-Tianjin-Hebei regions have green industrial chains of PV, energy storage, and NEVs, accounting for over 70% of the national green high-tech enterprises. The central provinces focus on the retrofitting of energy-intensive industries towards ultra-low emissions and the development of circular economy industrial parks. The western provinces use their natural resources of wind, solar, and hydropower to develop large-scale new energy bases. The "Desert-Gobi-Wilderness" wind-solar power bases are examples. Hydropower-rich provinces like Yunnan and Sichuan are focusing on the green hydrogen industry. Significant industrial clusters of green industries exist, with companies like LONGi, CATL, and BYD leading the billion-RMB industrial clusters in provinces like Shandong and Jiangsu.

2.2. Technological innovation and application

China has increased fiscal and corporate investment in green R&D, leading the world in green patent output. The patent numbers for energy conservation and new energy and storage technologies increased by more than 18% each year from 2020 until 2025 while various world records got established [8]. LONGi achieved silicon-perovskite tandem cell efficiency of more than 34.6%

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while CATL managed to increase energy density through their condensed battery technology. The two technologies of large-scale wind turbines and floating offshore wind systems now exist completely in local markets which bring down expenses while boosting their worldwide market position.

The main low-carbon technologies now function independently but scientists need to resolve missing elements in their most advanced research areas. The production of PV wafers and LFP batteries and onshore wind equipment has achieved more than 95% of local manufacturing. Scientists have made significant progress in developing new storage systems for energy and in creating green hydrogen proton exchange membranes and CCUS technology. CCUS high-end catalysts, electrolytic hydrogen production special membranes, and high-precision high-purity energy storage materials still rely on foreign imports, and some mid-range key materials have been replaced by domestic mass production [8].

The national laboratories together with innovation centers now operate an improved system which facilitates technology transfer. Many cutting-edge technologies continue to exist in laboratory settings because they lack enough testing facilities and financial support which results in prolonged development periods before they reach commercial markets. The steel industry has completed ultra-low emission retrofits at 590 million tons of crude steel capacity through its development of mature coal power flexibility and waste heat recovery systems.

2.3. Green consumption and market cultivation

As the idea of "Dual Carbon" becomes more popular, consumers are becoming more aware of the need for green consumption. Consumers are demanding products that offer low-carbon travel, are energy-saving, and are made with circular products. More than 25% of the transactions on e-commerce platforms relating to green products have grown annually for the past five years. More NEVs and distributed PV systems are being introduced into households, and the government is leading the way in purchasing these products for their fleets and buildings.

Various new scenarios are being created for green consumption, such as green supermarkets, low-carbon parks, and zero-carbon communities. Various models of the circular economy are being improved, such as second-hand recycling and appliance trade-ins.

The standards and certifications for green products have advanced, and thousands of them have been introduced at the national level. A four-tier system has also been introduced to certify the products, factories, parks, and supply chains. However, various challenges exist within the market. The products are often certified in various ways, which creates challenges for consumers. Many of the products also have high premiums, and there are limited incentives for consumers to purchase these products. A mechanism for encouraging all consumers to adopt green consumption is still being developed.

3. Challenges for green economy under "Dual Carbon" goals

3.1. Industrial transformation pressure

The first requirement for traditional heavy industries to survive requires them to obtain high funds because they need to switch their operations, but they face difficulties when they want to exit their current business activities. The industrial sector continues to depend on steel production and petrochemical operations and cement manufacturing because these industries operate with extensive aging facilities and their equipment has become outdated. Retrofitting needs substantial financial

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support which creates funding difficulties for small to medium businesses during their operational stages. Resource-dependent urban centers experience economic lock-in which creates threats for their financial stability when they start their economic shift. The process of removing outdated infrastructure takes longer in certain areas because these regions need to sustain their economic growth during the short term.

The core green technologies face two main problems which include supply chain obstacles and essential production facility limitations. The three essential materials which include storage electrolytes and high-end membranes and CCUS adsorbents depend on foreign suppliers who protect their products through patents which drive up prices. The system shows poor coordination between its upstream and downstream operations because wind and solar power plants operate at full capacity, but energy storage and peak-shaving facilities underperform which prevents new power systems from becoming operational. The supply chain shows poor SME support which makes businesses more susceptible to risks [8].

The third problem shows that organizations fail to create enough collaboration which results in similar development patterns across different geographic regions. Some central and western regions blindly layout low-end photovoltaic module and energy storage battery production lines, lacking market demand assessment, resulting in overcapacity of low-end products and a supply gap of high-end battery materials. The operational rates for PV modules and lithium batteries stand at 60% and 56% respectively. The Western resources and Eastern manufacturing systems operate independently which results in internal operational conflicts because they lack established mechanisms for regional supply chain interaction.

3.2. Multi-factor constraints

The financial system depends on solitary funding sources which produce extensive financial shortages between available resources and necessary capital amounts. CCUS carbon sequestration and large-scale wind and solar power base projects have high investment costs and long investment return cycles, making it difficult to match ordinary working capital loans. Therefore, special green credit tools are needed to provide long-term financial support. Green credit stands as the main source of funding because bond issuance and carbon pledges and insurance capacity remain restricted [6]. The process of acquiring affordable financing which lasts for extended periods proves difficult for small businesses and rural development initiatives. Financial institutions continue to exercise caution when lending to transition assets because they do not have enough developed climate risk evaluation systems.

The world faces an urgent shortage of composite green talent which stands as a major problem. The green economy needs workers who understand energy systems and material management and financial operations and global regulatory frameworks. The current university education system fails to meet industry requirements because foreign students from hydrogen and CCUS research fields receive their first educational experience abroad. The corporate sector faces major challenges because different regions throughout central and western parts of the country operate with distinct carbon management approaches.

The distribution of land and energy resources remains inadequate for current needs. Green industries need large land spaces for their operations yet urban planning systems fail to establish specific green industry development targets. The process of switching from energy "dual control" to carbon "dual control" remains unfinished because high-energy industries continue to limit the expansion of green projects. The power grid system which supports renewable energy integration requires development because current market-based allocation systems do not function properly.

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3.3. Imperfect institutions and market mechanisms

First, there are issues with the national carbon market. In the early days, the national carbon emission trading market only covered the power industry. Starting from 2025, high energy consuming industries such as steel, chemicals, and building materials will be included in the quota trading system in batches. The market is not liquid because there are few participants, and financial institutions are absent. Carbon accounting standards vary across different regions in China, and the quota allocation mechanism for the carbon market can be improved.

Second, green standards in China are fragmented. Different departments are responsible for green certifications, leading to varying standards across different regions of China. The green standards of third-party agencies are not up to the standards required, leading to greenwashing. Furthermore, China's green standards are not aligned with international standards like the EU's Carbon Border Adjustment Mechanism (CBAM), leading to additional costs for exporters to China [10].

Third, China lacks the right incentives and constraints to encourage green development. The carbon and environmental taxes are inadequate. Subsidies for green development are short term. The coverage of green procurement and carbon credit does not encourage companies and residents to reduce emissions voluntarily.

4. Recommended paths for high-quality development

To address these bottlenecks, this paper proposes a systematic path to balance short-term relief with long-term system building.

4.1. Strengthening industrial upgrading

The first step requires organizations to classify their existing low-carbon retrofit projects while they need to eliminate their outdated power generation facilities. The government should offer financial help through grants and affordable loan programs to assist businesses which use high levels of energy. Establish dynamic exit mechanisms and capacity-swap systems. Support resource-based cities with green industry transfers.

The Second step needs emerging green industries to expand their operations while they develop their own independent supply networks. The project requires financial support for developing perovskite cells and building long-term storage systems and green hydrogen production facilities and CCUS operations. The "Open Competition" process solves the problem of limited access to essential materials [8]. The organization should establish a cross-regional system which assigns research activities to Eastern regions and resource management to Western areas for preventing business expansion beyond necessary limits. The development of service industries needs to focus on carbon consulting and zero-carbon design services.

The third step requires organizations to establish worldwide environmentally friendly supply networks. Leading new energy enterprises can establish overseas localized production bases to hedge against green trade barriers, while also building a full product carbon footprint tracking system to meet EU import carbon verification requirements [10]. The country needs to establish its carbon footprint measurement system which should match international standards through CBAM integration. The development of digital carbon-tracking platforms needs to happen while businesses should use "grouping" strategies for their overseas expansion activities.

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4.2. Enhancing factor guarantee systems

The first step requires creating a financial system which supports multiple green finance initiatives. The financial sector needs to expand green credit availability while creating specialized loan programs which support storage operations and carbon capture and storage activities. The development process includes carbon bonds and REITs and pledge loans [6]. The government needs to create national green funds which will support initial experimental projects. The development of climate risk models requires better disclosure standards which must become mandatory.

The second step involves creating a talent system which operates at various levels. Universities need to create academic programs which combine hydrogen studies with storage and carbon management education. National laboratories together with top industry companies should establish postdoctoral research facilities. The central and western regions provide housing subsidies and personal income tax reductions for low-carbon technology talents, while simultaneously promoting local universities to offer targeted majors in new energy and carbon management, in order to supplement talent supply in the long run.

The third requirement needs market-based systems to allocate both land resources and energy resources. The government should create specific land allocation programs which support green projects while making the approval process more straightforward. The organization must finish its complete transition to carbon "dual control" for successful implementation. The western renewable energy resources need UHV grid construction to speed up their integration into the power system.

4.3. Improving long-term institutional mechanisms

The objectives of carbon pricing in China are to develop a national carbon market with a strong presence of steel and chemical companies; to allow financial institutions to participate in the allocation and pricing of emission quotas; to create uniform accounting standards; and to create a national big-data platform for carbon pricing and emissions measurement to prepare for futures and options trading to enhance liquidity.

Other objectives include the establishment of a unified set of green standards that are consistent with and integrated into international standards and are recognized in different sectors and regions; regulation of third-party verification companies to stop greenwashing; alignment of the China emissions pricing mechanism with the EU CBAM; and China's participation in establishing global standards for carbon pricing.

Lastly, objectives include improving the use of market-based incentives to optimize environmental and carbon taxes to increase emission costs; establishing a long-term provider of fiscal support for frontier technologies on a stable basis; increasing the use of green procurement and carbon credits for individuals; and using smart monitoring of carbon markets to create a system that rewards for carbon reduction while constraining high carbon activities.

5. Conclusion

Against the backdrop of global climate governance and China's "Dual Carbon" strategy, this paper looks at the green economy from both a global and a sectoral perspective using industrial economics data from 2008-2025, The major findings of this research include.

China's green economy has made substantial progress toward development in stages, most notably through the relative advantages that China has in the New Three, and its enormous renewable capacity. The transition to high quality development is being impeded by three

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bottlenecks: pressure for industrial transformation, constraints on resources and factors (financing, talent, land), and gaps in institutional capacity (e.g., in carbon markets and standards). Addressing these will require a three-dimensional synergy between industrial upgrading, ensuring adequate factors, and improving institutional capacity.

In summary, the global long-term low-carbon transformation is a major trend in overall development, but fluctuations in international energy prices and policy adjustments in various countries will temporarily slow down the pace of green transformation in each country. The changing nature of global trade under green trade barriers will alter the current global supply chains]. The green economy is critical to China's long term sustainable development and maintaining its position of global leadership in the international economy. Future trends include hydrogen being produced and utilized on a large scale; carbon markets will mature into functional mechanisms; alignment with global standards will deepen; and the adoption of green living principles on a global basis. Future studies should utilize micro-level data to quantify the effects of policy within each of the transition strategies and should continue to identify optimal transition strategies for meeting the 2030 and 2060 targets.

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