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Green Economy Development and Industrial Structure Upgrading in the Yangtze River Delta under China's "Dual Carbon" Goal

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Abstract. Currently, the Chinese government is striving to achieve the "dual carbon" goal, a new driving force for China's economy. With guiding policies being introduced under the "dual carbon" goal, China has witnessed rapid development in new energy vehicles, lithium batteries, and other industries. Meanwhile, the pursuit of the "dual carbon" goal is beneficial to China's industrial structure upgrading. Research on the Yangtze River Delta, a region with the most dynamic economic development and a stable industrial system, in terms of economic and industrial structure development against the backdrop of the "dual carbon" goal is of great significance. Based on previous studies selected from China National Knowledge Infrastructure concerning green economy development and industrial structure of cities in the Yangtze River Delta under the "dual carbon" goal, this study summarizes the current status of the green economy and industrial structure of this region, and discusses the impact pathways of how policies, market, technologies, industry, energy utilization and consumption influence the green economy development and industrial structure upgrading under the "dual carbon" goal. Furthermore, in light of the current advances in applications and research, it explores the future trend of the Yangtze River Delta development and proposes relevant policy recommendations from six aspects. Including the market, employment, technologies, energy utilization, energy-intensive industries, and emerging industries.

Keywords: "dual carbon" goal, the Yangtze River Delta, green economy, industrial structure upgrading

1. Introduction

At present, with climate change posing one of the toughest challenges humanity faces, the call for green development has resonated across the world. As China enjoys holistic and rapid development, the carbon emission surges in parallel with China being the largest carbon dioxide emitter. In 2023, China's carbon emissions increased by approximately 565 million tons, the largest rise worldwide. Therefore, it is both pressing and essential to implement policies of environmental governance, energy conservation, and emission reduction, thus realizing the goal of building a Green China. General Secretary suggested that China increase its Intended Nationally Determined Contributions (INDCs) during the General Debate of the 75th session of the United Nations General Assembly in September 2020. China will implement stronger policies and measures for the global low-carbon transition. To be specific, China will endeavor to reach the peak of carbon emission before 2030 and realize carbon neutrality before 2060. It is the first time that China proposed the "dual carbon" goal. According to Table 1, the carbon emissions of the three provinces (Jiangsu, Zhejiang, and Anhui Provinces) and one city (Shanghai Municipality) in the Yangtze River Delta region of China are experiencing a fluctuating upward trend [1]. To achieve the "dual carbon" goal, local governments in the Yangtze River Delta region have issued a series of documents for planning and implementation for effective and scientific energy conservation and emission reduction. Multiple fields of the Yangtze River Delta region under the "dual carbon" background have been discussed in previous studies. However, a comprehensive evaluation of the green economy and industrial structure of this region is relatively lacking. Currently, China is on track to peak carbon emissions. The earlier the goal is achieved, the lower the peak value will be, making it easier to achieve the "dual carbon" goal. Therefore, research focusing on the period of "peaking the carbon emissions" is of significance. Reviewing and analyzing current studies and literature, this research discusses the impact of the "dual carbon" goal on both the green economy development and industrial structure upgrading of the Yangtze River Delta region. Meanwhile, it focuses on the period of "peaking the carbon emissions", aiming to promote the theoretical research development concerning the economy and industrial structure of the Yangtze River Delta under the "dual carbon" goal.

Table 1. Carbon emissions of the three Province and one city from 2018 to 2021 [1]

	2018	2019	2020	2021
Zhejiang Province	401.66	419.15	454.55	526.01
Jiangsu Province	644.97	636.58	628.06	669.22
Anhui Province	392.43	398.96	397.17	415.06
Shanghai	151.47	159.50	154.63	161.29

2. Literature Review

Presently, studies related to the green economy and industrial structure upgrading of the Yangtze River Delta under the "dual carbon" goal mainly focus on two aspects.

One is the green economy development in the context of the "dual carbon" goal. In line with the "dual carbon" goal, green economy development can be promoted by policy implementation, technological innovation, as well as energy consumption and efficiency. Li and Zhang found that government intervention, technological innovation, and energy efficiency are the main driving factors of a low-carbon economy, and pointed out that the low-carbon economic levels of the eastern coastal region of China are differentiated at multiple levels with energy efficiency as the decisive factor of the low-carbon economy development [2]. Zhang found that the synergistic effect of green technological innovation and energy consumption structure optimization greatly advances the high-quality development of the circulation economy [3]. Chi et al. found that the new economic form, namely the "dual carbon" economy, enables cities in the Yangtze River Delta region to tap new sources of economic growth [4].

The other is the industrial structure upgrading in the context of the "dual carbon" goal. Qiao and Zhang argued that the industrial structure can be upgraded through two paths, including controlling the newly added capacity of traditional energy- and emissions-intensive industries and accelerating the development of emerging industries [5]. Chen et al. conducted a case study of Jiaxing and established a multi-objective optimization model of municipal-level industrial structure based on green total factor productivity (GTFP) to reduce carbon emissions and pollution and develop the economy [6].

By reviewing and summarizing previous studies, it is found that multiple influencing factors of the green economy and industrial structure upgrading of the Yangtze River Delta under the "dual carbon" goal have been identified. Studies are abundant regarding the impact mechanism of green economy development and industrial structure upgrading on carbon emissions. Nevertheless, studies that focus on analyzing the Yangtze River Delta region and summarizing both the impacts of green economy development and industrial structure upgrading are relatively scarce. Furthermore, although China is still in the midst of the "peaking the carbon emissions" period, studies are scarce that discuss the green economy development and industrial structure upgrading during the period of "peaking the carbon emissions". In light of the aforementioned unaddressed issues, this study summarizes the current literature, identifies research gaps, and proposes relevant suggestions.

3. Impact Pathways

3.1. Green Economy Development of the Yangtze River Delta Region

3.1.1. Policy

First and foremost, policies function as a guide, guiding the direction and specifying the objectives for the Yangtze River Delta region to realize green growth in the context of the "dual carbon" goal. For instance, according to the *Implementation Plan for Carbon Emission Peak of the Eco-green Integrated Development Demonstration Zone in the Yangtze River Delta*, local governments and relevant departments of Qingpu District in Shanghai, Wujiang District in Suzhou, Jiashan County in Jiaxing Municipality can develop green development, green fund, green credit, and other financial products and instruments. They are encouraged to leverage green finance to provide financing channels and investment opportunities. Financial support can be provided to enterprises for development, thus stimulating the green economy development of the three aforementioned regions. Meanwhile, policies under the "dual carbon" goal incorporate both environmental and economic factors into the performance assessment of governments at all levels, promoting local governments to effectively play their role in macroeconomic control, motivating all industries and sectors to reduce carbon emission, improving the green and low-carbon awareness in the production and consumption sectors, thus facilitating the green economy development.

3.1.2. Energy Utilization and Consumption

Regarding energy utilization, energy efficiency is improved by comprehensively utilizing energy recycling, the marginal costs of related industrial entities in the Yangtze River Delta region are reduced, weaken impacts of resources and the environment on the high-quality economic development are weakened, and the transition from extensive economic growth to high-quality

development is promoted under the "dual carbon" goal. Regarding energy consumption, the "dual carbon" goal guides and accelerates the Yangtze River Delta to develop energies for economic purposes and renewable energies tailored to local conditions, reduces the pressure of carbon emissions on the ecological environment and promotes the common development of ecological civilization construction and high-quality development of the economy.

3.1.3. Industrial Transformation

Regarding the industrial transformation, under the "dual carbon" goal, low-carbon sectors are developed to drive the transformation of industries in the Yangtze River Delta region. The feature of technology-innovation integration in the Yangtze River Delta region is utilized and the advantages of research institute clusters are leveraged, contributing to the development of intelligent and low-carbon enterprises. Following the emergence and development of these enterprises, employment has increased, the income and consumption of permanent residents in the Yangtze River Delta region is improved, and the economic reform of the region is promoted. For example, local governments in the region have implemented policies and strategies to increase investment in the new energy vehicle (NEV) industry in line with the "dual carbon" goal. Compared to traditional vehicles, NEVs are more environmentally friendly, energy-saving, and economical. With support and guidance from governments, NEV businesses are receiving support nationwide and enjoy bright prospects globally. Cities in the Yangtze River Delta region, such as Shanghai, Hefei, and Changzhou with relatively highly-developed NEV industry, are expected to see an increasing demand for a substantial amount of related professional staff for research, development, and manufacturing. Thus, the employment rate and income will be improved in the region, boosting consumption and green economy development.

3.2. Industrial Structure Development of the Yangtze River Delta

3.2.1. Policy

Regarding policies, they control the carbon emissions of enterprises in the Yangtze River Delta region as an external driving force under the "dual carbon" goal. New technological requirements of production are proposed for enterprises to reduce carbon emissions. To facilitate low-carbon development, industries have been transferring factors of production and upgrading their industrial structure. For instance, according to the *Implementation Plan for Carbon Emission Peak of the Eco-green Integrated Development Demonstration Zone in the Yangtze River Delta*, governments and relevant departments of Qingpu District in Shanghai, Wujiang District in Suzhou, Jiashan County in Jiaxing Municipality can encourage enterprises to establish a green manufacturing system featuring green products design, green low-carbon factory, green industrial park, and green supply chain. The industrial structure will be upgraded by accelerating the transition of traditional industries towards high-end, green, and intelligent development. This requires the research, development, and promotion of key, effective, and energy-efficient equipment and advanced technologies in the chemical fiber and textile sectors, as well as the advancement in energy conservation and emission reduction, informatization and industrialization integration, product restructuring, and technological innovation of traditional manufacturing industries.

3.2.2. Market

Under the "dual carbon" goal, the market affects the industrial structure from both the supply end and the demand end. On the supply end, the "dual carbon" goal guides enterprises in the Yangtze River Delta region to research, develop, manufacture, and sell NEVs, foods, and other low-carbon products. On the demand end, vigorously promoting the "dual carbon" goal will prompt consumers to purchase more low-carbon and energy-efficient products, which fosters the green upgrading of the demand structure, alters the consumption structure, promotes industrial innovation, drives the development of related industries, and guides the industrial structure upgrading [7].

3.2.3. Technologies

Regarding technologies, under the "dual carbon" goal, new requirements have been introduced for energy structure optimization, so as to achieve "carbon neutrality" in a shorter timeframe and better quality. At present, given the relatively high share of coal and other fossil fuels in the energy consumption structure of the Yangtze River Delta region, enterprises should realize low-carbon development by increasing the use of high-quality energy and clean energy. It requires enterprises to increase their investment in energy development and use as well as waste gas treatment technologies, facilitating them to take the lead in the energy technological reform. The promotion of advanced technologies will drive the transformation of some traditional enterprises, thereby guiding the industrial structure upgrading.

3.2.4. Energy-intensive Industries

The net inflow of energy-intensive industries produces negative impacts on local green economic efficiency [8]. According to the *Status of Energy Consumption Dual-control Target Completion for Various Regions in the First Half of 2021* published by the National Development and Reform Commission (NDRC) on August 21, 2021, Jiangsu received a level 1 warning for energy intensity while Zhejiang received a level 2 warning. As provinces with the largest carbon emissions among the three provinces and one city in the Yangtze River Delta region, Jiangsu and Zhejiang should implement necessary measures for energy-intensive industries to conserve energy and reduce emissions. Therefore, to reduce carbon emissions under the "dual carbon" goal, it is crucial to control the newly added capacity of energy-intensive industries and prompt the technological transformation of enterprises that want to remain competitive, thus facilitating the elimination of outdated capacities and contributing to the industrial structure upgrading.

3.2.5. Emerging Industries

Regarding emerging industries, the strengths of enterprise clusters in the Yangtze River Delta region are fully leveraged. To conserve energy, reduce emissions, and develop new industries under the "dual carbon" goal, it is encouraged to utilize the research and development advantages of the Yangtze River Delta region in new energy, artificial intelligence, and other fields. This approach will increase the share of emerging industries in the overall economy, further complete and optimize the industrial system, and drive the industrial structure upgrading.

4. Policy Suggestions

Policy suggestions are proposed in this section in terms of market, technology, employment, energy utilization, energy-intensive industries, and emerging industries based on the discussions of impact pathways.

4.1. Market

The government needs to improve the market supervision system and incorporate the evaluation policy of market economy indicators. An improved market supervision system will ensure a normative market, facilitating the local governments in the Yangtze River Delta region to promote and supervise the low-carbon economy development. Incorporating market economic indicators to assess policies will encourage local governments to effectively play their role in macroeconomic control. Meanwhile, fully utilizing the market mechanism will advance the development of the carbon emissions trading market of both the Yangtze River Delta and the three provinces and one city within the region. This will enable rational carbon emissions in industries and the achievement of the carbon reduction goal.

4.2. Technologies

The Yangtze River Delta region should increase investment in energy development and research and development. It is suggested to fully utilize the strengths of university clusters and research institute clusters in the Yangtze River Delta region, developing an industrial chain with research and development, manufacturing, and selling of low-carbon products, and leading the high-quality economic development of the Yangtze River Delta region. Simultaneously, regional and Sino-foreign exchanges and cooperation on technologies should be encouraged. Being one of the most open regions in China, the Yangtze River Delta region can promote regional technological development via exchanges and cooperation. For instance, in recent years, technological communications and cooperation between China and foreign countries on NEVs have soared. In general, European countries have a longer history of nuclear power development and possess more research experience. Currently, Europe is committed to the development of NEVs, particularly electric vehicles (EVs), demonstrating strong latecomer advantages. China and Europe can cooperate on the research and development of batteries and technology sharing of NEVs [9]. Cooperation with European countries will benefit domestic technological development as well. However, it is worth noting that China faces multiple challenges such as different manufacturing standards, environmental standards, and safety standards across different countries. To conduct better technological exchanges and cooperation worldwide, it is suggested to establish rules, standards, and technological systems that are in parallel with the international market.

4.3. Employment

It is suggested that the government introduce preferential policies to attract talents in the fields of energy and artificial intelligence. The emerging industries will create more job opportunities. Subsidies or preferential policies that favor the settling down, housing, and education of related talents should be implemented. The introduction and implementation of the aforementioned policies will attract the aforementioned talent to gather in the Yangtze River Delta region, prompting relevant

research. Policies for the employment and settlement of scientific talents introduced by the Lin-gang Special Area of China (Shanghai) Pilot Free Trade Zone can serve as a specific reference.

4.4. Energy Utilization

It is suggested that the Yangtze River Delta region accelerate the development and utilization of electric power and other clean energy to achieve coordinated and sustainable development of business environment and economy. Supply of natural gas, electrical energy, and other clean energies should be increased, and the energy structure of enterprises should be optimized, improving manufacturing efficiency as well as the environment [10]. At the same time, it is suggested to actively develop green power trading in the Yangtze River Delta region, providing support through tax policies and satisfying the clean energy demand of enterprises.

4.5. Energy-intensive Industries

It is suggested that the government should control the development of energy-intensive industries in the Yangtze River Delta through policy restrictions. Emission targets can be established to control the carbon emission of enterprises compulsorily during their manufacturing optimization process. Emitting times can also be restricted. A mandatory elimination mechanism can be introduced to phase out enterprises with heavy pollution and high emissions to control resource waste in relevant industries, thus achieving the goal of conserving energy and reducing emissions. Simultaneously, for energy-intensive enterprises that expect to transform towards green development, it is suggested to formulate relevant policies, provide fiscal subsidies or reduce taxes, thereby supporting the low-carbon development of these enterprises [11].

4.6. Emerging Industries

It is necessary to increase capital investment for new energy-related, intelligent manufacturing-related, and other emerging enterprises in the Yangtze River Delta region. It can be accomplished by cutting taxes and providing subsidies for scientific research and infrastructure construction of enterprises, hence encouraging the development of relevant industries. For instance, to develop new energy industries, new energy technology research and development centers can be established in the Yangtze River Delta region, fully utilizing its scientific research strengths. By providing related technological support to new energy industries, innovative cooperation of related enterprises will be enhanced.

5. Conclusion

Presently, the carbon emission of the Yangtze River Delta region of China is still on the rise. As soon as possible, steps should be taken to accomplish the objectives of reducing emissions and conserving energy. As a result, research and recommendations for the Yangtze River Delta's overall development under the "dual carbon" goal are rapidly expanding. Meanwhile, China is on track to "peak carbon emissions" before 2030. It requires joint efforts from all parties to better realize a carbon-neutral society. This study reviews related literature on the green economy development and industrial structure upgrading of China's Yangtze River Delta in the context of the "dual carbon" goal, discusses the impacts of the "dual carbon" goal on both the green economy development and industrial structure upgrading of the region, and clarifies the impact mechanism of the "dual carbon" goal on these two aspects. Furthermore, this study identifies the research gap and inadequacies of current studies and policies, and proposes relevant policy suggestions from six aspects including market, employment, technologies, energy utilization, energy-intensive industries, and emerging industries, aiming to provide guidance on the future theoretical research concerning the green economy development and industrial structure upgrading of the Yangtze River Delta under the "dual carbon" goal and promote high-quality, coordinated development of this region. Additionally, the influencing factors of this research topic are not comprehensively discussed. In the future, data on carbon emission of enterprises in different industries within the region will be included to further improve the study.

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