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The Study of Policy Coordination Mechanisms and Industry-Regional Emission Reduction Pathways in China's Carbon Peak Process

Genxuan Lu

Baylor University, Waco, TX 76798, USA
Genxuan_Lu1@gmail.com

Abstract:
China's proposed goal of achieving carbon peaking before 2030 incorporates carbon peaking and carbon neutrality into a major national strategy. To achieve this target, it is crucial to create an effective policy coordination mechanism and enhance the overall effectiveness of emission reduction efforts. Given its complexity, carbon peaking is not an isolated task but a systemic project that involves the comprehensive transformation of the economy and society. As such, this paper takes the construction of China's policy system in the carbon peaking process as its research topic, exploring the differentiated paths, implementation strategies, and collaborative governance mechanisms across regions and industries. Through a combination of literature review, policy text analysis, and case studies, the study draws on national and local policy documents, statistical data, and practical experience from representative regions. The results indicate that China's carbon peaking policy system is gradually evolving from a single-dimensional control approach to one of systematic coordination. However, challenges persist in areas such as regional coordination, industrial transformation, and policy alignment. This study argues that future efforts should further enhance the synergy framework, strengthen the local capabilities, and optimizing market mechanisms. These measures will improve overall energy efficiency and offer feasible pathways, along with theoretical support, to help China meet its carbon peaking goal on time.

Keywords: Carbon peaking, Policy synergy, Emission reduction path, Green transition, Climate governance

1. Introduction

Against the backdrop of accelerating global climate governance, China has become the world's largest carbon emitter. To tackle climate change, China has proposed strengthening its nationally determined contributions and implementing more robust policies and measures in response [1]. The achievement of carbon peaking is a pivotal goal in China's green economic transition and will also have substantial effects on global carbon reduction efforts. In line with China's commitment, this country aims to reach carbon peaking before 2030 and then promote high-quality development and ecological civilization construction. However, existing studies largely focus on emission reduction strategies within single sectors, such as energy structure optimization or industrial transformation, while exploration of cross-sectoral synergy mechanisms and integrated policy design remains relatively insufficient [2]. At the same time, given that the carbon peaking process spans multiple sectors, including energy, industry, transportation, and construction, the complexity of these systems presents challenges like coordination issues and technological bottlenecks during policy implementation [3]. Therefore, further research is required to identify key emission reduction pathways and design coordinated and efficient policy systems. This paper aims to analyze key issues within China's carbon peaking process from a systemic perspective, focusing on emission reduction potential and synergy mechanisms across different sectors. And this study combines policy text analysis with quantitative model evaluation methods to explore the feasibility of multi-sectoral coordinated emission reduction pathways, providing policy references for achieving the carbon peaking goal. By constructing an integrated analytical framework, this paper attempts to supplement current research gaps in cross-sectoral synergy and policy integration, offering reference value for global climate governance research.

2. Policy Framework and Theoretical Basis of Carbon Peaking

2.1 Target System and Basic Principles

The carbon peaking target system consists of three dimensions: total control, intensity reduction, and structural optimization, all of which are clearly outlined within the 1+N policy framework [1]. Among these, total control focuses on gradually lowering overall emission levels to ensure a cap on absolute peak emissions. Meanwhile, intensity reduction targets carbon emissions per unit of economic output, reflecting requirements for controlling emission intensity during economic growth. Besides, structural optimization emphasizes adjusting the economic, energy, and industrial structure to promote a shift from high-carbon-intensive models toward low-carbon-oriented ones. These three components form the core framework of the carbon peaking target system, each serving distinct roles in guiding direction, controlling the process, and driving structural adjustments.

Under this system, policy design must follow basic principles. Equity requires allocating emission reduction responsibilities reasonably based on the development stage and capabilities of different regions and industries to avoid overly concentrated burdens. Efficiency emphasizes reducing emission reduction costs through market mechanisms and institutional arrangements, improving the economic rationality of policy implementation [5]. Feasibility involves aligning targets with current economic conditions and technological capabilities, hence ensuring that policies are both ambitious and practical. Synergy, on the other hand, emphasizes coordinating carbon reduction efforts with pollution control, energy security, and industrial upgrading to avoid conflicts between policy objectives. Thus, the target system provides direction and core content for emission reduction, while the basic principles provide methods and constraints for policy implementation. The two support each other and jointly form the foundation of the carbon peaking policy framework.

2.2 Policy Tools and Implementation Paths

The tools for carbon peaking policy can be grouped into four categories: command-and-control, market mechanisms, technological innovation, and social participation [6]. Command-and-control measures directly constrain emission behaviors by setting dual-control indicators for energy consumption and establishing industry access standards. Market mechanisms, such as carbon emissions trading and green electricity trading, guide enterprises and society through price signals to adjust carbon emission behaviors. Technological innovation policies mainly include research and development funding and demonstration promotion to support the development and application of low-carbon technologies [7]. Social participation mechanisms promote the cultivation of low-carbon culture through information disclosure, public participation, and behavioral guidance. These policy tools must be adapted to align with the different stages of target implementation.

In the short term, policies focus on optimizing industrial structures and improving energy efficiency to boost feasibility and execution effectiveness. In the mid-term, the role of market mechanisms should be strengthened to promote renewable energy development and energy struc-

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ture optimization. Long-term goals rely on large-scale applications of breakthrough low-carbon technologies to achieve deep decarbonization and long-term carbon neutrality. Meanwhile, different policy tools create synergistic effects. For example, combining technological innovation with market mechanisms can accelerate the diffusion and cost reduction of low-carbon technologies, while social participation boosts transparency and public support for policy execution. Therefore, the carbon peaking policy system utilizes different combinations of tools across stages to achieve complementarity among emission reduction approaches and continuity of pathways, ensuring steady implementation of emission reduction outcomes.

3. Industry and Regional Carbon Emission Characteristics and Reduction Pathways

3.1 Current Carbon Emission Status and Decarbonization Pathways of Key Industries

In China's carbon emission structure, the power, steel, building materials, chemical, and transportation industries are the major sources of emissions, collectively contributing the majority of national carbon dioxide emissions. And these industries feature high energy consumption and large emission reduction potential, making them critical areas for promoting economic restructuring and green transformation. The decarbonization goals of these industries are aligned, but their priorities differ. The power sector, as the core of the energy system transition, focuses on accelerating the deployment of renewable energy such as wind and solar power. It also aims to control coal power capacity and improve grid flexibility and energy storage systems to support renewable energy integration.

The steel and building materials industries aim for green process transformation, promoting short-process production, hydrogen metallurgy, scrap steel recycling, and low-carbon cement production. At the same time, the chemical industry focuses on optimizing feedstocks, developing green hydrogen and bio-based materials, and boosting energy efficiency. The transportation sector prioritizes electrification, improving charging and hydrogen infrastructure, and developing multimodal transport systems. Overall, emission reduction pathways across industries share common goals, such as reducing carbon intensity through energy substitution and efficiency improvements. Nonetheless, the priorities differ. The power sector focuses on clean energy substitution, industry on technological innovation, the chemical sector on feedstock transformation, and transportation on electrification. Multi-industry coordinated progress will form the essential foundation for China's low-carbon transition.

3.2 Regional Carbon Emission Characteristics and Peak Timing Differences

At the regional level, China's carbon peaking exhibits a "early-mid-late" staggered timing pattern. Economically developed regions such as the Yangtze River Delta and Pearl River Delta, though high in total emissions, boast high energy efficiency and are well-positioned to reach peak emissions before 2025. These regions' development priorities are gradually shifting toward high-end manufacturing and modern services, while also imposing strict constraints on new high-energy-consuming projects. In contrast, central regions such as Henan and Anhui, which remain in the mid-industrialization stage, must balance economic growth with emission reduction, with peak emissions expected around 2028. Meanwhile, western energy bases like Inner Mongolia and Ningxia face greater reduction pressure and should focus on optimizing energy development methods and promoting circular economy initiatives, with peak emissions likely occurring by 2030. Lastly, the northeast's old industrial bases must achieve gradual emission reductions through technological transformation and industrial upgrading.

3.3 Optimization of Industry-Region Coupled Pathways

Industry-region coupling refers to the significant differences in emission reduction responsibilities, costs, and transition pathways caused by the uneven distribution of industries across regions during the emission reduction process, requiring a unified synergy mechanism between industrial restructuring and regional coordinated development to improve national emission reduction efficiency. To this end, emission reduction targets should be tailored to regional development stages, resource endowments, and industrial structures. Developed regions should therefore lead the transition, while cross-regional compensation mechanisms can provide financial and technological support to less-developed areas. In addition, promoting the low-carbon transformation of industrial clusters and building regional circular economy systems should be prioritized [8]. Moreover, the national unified carbon market should be improved to optimize the allocation of resources such as carbon quotas across regions, and cross-regional low-carbon technology cooperation platforms should be established to accelerate the diffusion and application of key technologies [9]. Through coordinated industry-region governance, China's green and low-carbon development strategy can be effectively implemented.

4. Policy Synergy and Future Pathways

4.1 Multi-Goal Conflicts and Implementation Barriers

Multiple coordination challenges exist in the carbon peaking process, involving economic, energy, regional development, policy system, and technological-social adaptation dimensions [10]. In terms of economic development and emission reduction, short-term reduction pressures, particularly in energy-rich regions, may hinder economic growth and disrupt employment structures and industrial layouts. Energy security and the low-carbon transition are often interdependent, requiring the maintenance of industrial and supply chain stability while facilitating the substitution of conventional energy sources with clean alternatives and advancing technological innovations. The integration of renewable energy and grid management systems still requires substantial enhancement. Additionally, regional disparities create equity concerns, as emission reduction capacities and development stages vary widely across different regions. Existing policy systems still face coordination and execution challenges, including insufficient interdepartmental alignment and policy fragmentation, which may reduce implementation efficiency. In terms of technology and social acceptance, the commercialization of key low-carbon technologies still requires significant breakthroughs, while public tolerance for changes in energy costs also plays a key role in determining the pace of emission reduction. These multidimensional obstacles require top-level design and institutional arrangements to ensure that carbon peaking can advance effectively while balancing economic development, energy security, regional equity, and technological feasibility.

4.2 Key Technological Progress and Institutional Evolution

The achievement of carbon peaking depends on the continuous advancement of key technologies, which serve as the material foundation for emission reduction [11]. In the zero-carbon power sector, the costs of photovoltaic and wind power continue to decline, with breakthroughs in energy storage improving renewable energy integration and regulation capacity. The hydrogen energy industry chain is gradually improving, with green hydrogen production costs expected to decrease greatly, enabling low-carbon substitution in industry and transportation. Technologies for carbon capture, utilization, and storage have moved into demonstration applications, while the development of biomass energy and new low-carbon materials continues, hence providing essential technological support for optimizing the energy structure and achieving substantial emission reductions. In addition, the growth of strategic emerging industries, like next-generation information technology, biotechnology, high-end equipment manufacturing, and new-energy vehicles, expands the potential for applying low-carbon technologies. Institutionally, the national carbon market's coverage is gradually expanding, with carbon pricing mechanisms improving to provide economic incentives for technology adoption. The development of green finance standards and transition finance frameworks facilitates the support of low-carbon projects and technology research and development. The improvement of multi-level governance systems and regional synergy mechanisms offers institutional guarantees for technology adoption and cross-regional cooperation. In this context, technological progress and institutional evolution are mutually reinforcing, with institutional incentives driving the diffusion of low-carbon technologies. As these technologies mature, they facilitate the continuous improvement of institutions and policies.

4.3 Targeted Strategy Design and Policy Improvement

To address key obstacles like market fragmentation, regional disparities, and transformation constraints in high-carbon industries, China must establish a low-carbon governance system integrating institutions and tools. In the market and financial sector, integration of carbon, electricity, and energy markets should be advanced; green finance standards should be improved; and financial instruments such as green credit and green bonds should be expanded to guide funding into low-carbon transformation. In technological and industrial policy, it is essential to accelerate the R&D and demonstration of key technologies, such as hydrogen energy, advanced energy storage, and Carbon Capture, Utilization, and Storage (CCUS). Besides, a just transition fund should be established to support affected industries and communities, thus ensuring a stable and equitable transition. In regional and international collaboration, cross-regional coordination mechanisms, mutual recognition of emission indicators, and industrial linkages can enhance overall emission reduction efficiency. These measures help address institutional weaknesses, improve policy execution, and accelerate the achievement of the "dual-carbon" goals.

5. Conclusion

This study analyzes the policy system, industry differences, and regional coordination requirements in China's carbon peaking process from a systemic perspective, pointing out that achieving the "dual-carbon" goals requires overcoming obstacles such as market fragmentation, technological

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bottlenecks, and regional development imbalances, and developing a comprehensive governance framework that coordinates industry, region, and institutional elements. The study concludes that resource allocation should be directed by a policy framework that balances total control with market-driven approaches, while technological innovation should serve as the key driver for the decarbonization of key industries And differentiated regional strategies should be implemented to enhance overall emission reduction efficiency, thereby strengthening policy execution and transition resilience. Although the research still has limitations in quantitative analysis and data depth, the integrated analysis framework proposed provides theoretical reference for improving the systematic nature and effectiveness of China's carbon peaking pathway. Future research should focus on assessing the cost-effectiveness of policies and the impact of cross-regional cooperation on China's low-carbon transition.

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