

Constraints and Implementation Pathways for the Transition from Energy Consumption Dual Control to Carbon Emissions Dual Control in Hebei Province

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Abstract: With the “Dual Carbon” objectives being vigorously advanced, the comprehensive transition from dual control of energy consumption to dual control of carbon emissions has become an inevitable trend in China’s green and low-carbon development. As a major traditional industrial province dominated by energy-intensive sectors such as steel and chemicals, Hebei faces a particularly urgent need for transformation and upgrading. Drawing on theories of sustainable development, the green economy and tiered environmental regulation, this paper systematically elucidates the theoretical rationale and practical feasibility of Hebei’s transition from energy consumption dual control to carbon emissions dual control. It analyses the constraints facing this transition from three dimensions—institutional, market and enterprise—including poor connection between old and new policies, the inadequacy of incentive mechanisms in the carbon market and green finance, and the prominent bottlenecks in low-carbon technologies and the pressure of transition costs faced by enterprises. On this basis, the paper proposes a “three-in-one” coordinated transition pathway comprising institutional provision, market incentives and corporate behavior. This research provides decision-making guidance for Hebei Province to refine its dual-control system for carbon emissions and to advance carbon peaking and carbon neutrality in a proactive yet prudent manner; it also offers valuable lessons for other heavy industrial provinces seeking to transition to dual-control of carbon emissions.

Keywords: Dual control of energy consumption; Dual control of carbon emissions; Constraints; Implementation pathways

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1. Introduction

In December 2021, the Central Economic Work Conference proposed for the first time that “conditions should be

created to transition as early as possible from ‘dual control’ of energy consumption to ‘dual control’ of carbon emission totals and intensity.” The Third Plenary Session of the 20th Central Committee of the Communist Party of China explicitly called for the establishment of a new mechanism for the comprehensive transition from dual control of energy consumption to dual control of carbon emissions. As a province with a strong traditional industrial base, Hebei’s industrial structure is dominated by energy-intensive sectors such as steel and chemicals, and its energy consumption has long been heavily reliant on coal; at the same time, it possesses enormous potential for renewable energy sources such as wind and solar power. Hebei’s transition to dual control of carbon emissions is not only a response to national strategic requirements but also a key pathway to curbing fossil fuel consumption, promoting the substitution of renewable energy, and resolving the tensions between the province’s economic development and ecological constraints. In 2024, the General Office of the Hebei Provincial People’s Government issued the “Implementation Plan for Accelerating the Establishment of a Dual-Control System for Carbon Emissions,” proposing specific measures such as actively participating in the development of carbon footprint calculation methodologies for key industries and promoting product carbon labeling and certification to strengthen product carbon footprint management. Furthermore, a pilot scheme for dual-control management of carbon emissions in the steel industry is to be launched this year. However, the specific constraints facing Hebei in its transition from dual control of energy consumption to dual control of carbon emissions, and the pathways through which these bottlenecks can be overcome to achieve the “dual carbon” strategic goals, are issues that require urgent and in-depth examination.

Existing research is largely based on the assumption of national homogeneity and lacks an in-depth analysis of the constraints on the transition from energy consumption dual control to carbon emissions dual control in heavy industrial provinces. This paper breaks away from traditional research perspectives by taking Hebei Province—a province dominated by heavy industry—as its subject. It analyses, from the institutional, market and enterprise perspectives, the factors constraining Hebei’s comprehensive transition from energy consumption dual control to carbon emissions dual control; explores the pathways for achieving this transition; and constructs a transition pathway based on the synergy of multiple stakeholders—namely “institutional provision– market incentives – enterprise behavior,” thereby providing new approaches to the transition from energy consumption dual control to carbon emission dual control in heavy industrial provinces. This deepens existing research into the pathways for such a transition and holds significant practical implications for Hebei’s proactive and steady advancement of the “Dual Carbon” strategy and the promotion of a comprehensive green transformation of its economy and society. It also provides practical guidance for other similar regions in China seeking to transition to carbon emission dual control.

2. Current state of domestic and international research

Existing research has indicated that, under the dual-control policy for energy consumption and the dual-control targets for energy consumption, energy-intensive enterprises tend to reduce investment in independent research and development whilst increasing efforts to introduce technology; the dual-control system promotes green innovation in heavily polluting industries by incentivizing environmental regulation, enforcement and government subsidies for environmental protection ^[1]. The dual-control policy for energy consumption can effectively reduce energy consumption levels and promote a rational industrial structure, but it may result in economic losses ^[2]. However, the dual-control policy on energy consumption may be

detrimental to regional GDP growth, exacerbate disparities in green total factor productivity between regions, and hinder coordinated regional development ^[3]. The transition from dual-control of energy consumption to dual-control of carbon emissions has become an inevitable choice for achieving the “dual carbon” targets and promoting sustainable economic growth. The dual-control policy on carbon emissions is superior to that on energy consumption and helps to minimize economic losses. Existing research has conducted preliminary explorations into how to transition from dual control of energy consumption to dual control of carbon emissions ^[4]. Studies indicate that the key to this transition lies in the rational determination of control indicators, the comprehensive improvement of foundational conditions, and the orderly and coordinated implementation of the policy scope.

Based on the current status of energy and carbon emissions, target setting, and action strategies, a general framework for the technical pathway of the dual-control transition in industrial parks has been proposed, and a mindset for the transition to dual control of carbon emissions should be established, grounded in government regulation and driven by corporate compliance and the carbon market ^[5-6].

It is evident that current research focuses on the limitations of energy consumption dual-control and, from a national perspective, has preliminarily explored the pathways and mechanisms for transitioning from energy consumption dual-control to carbon emissions dual-control. However, there are marked differences in energy consumption structures, industrial structures and carbon emissions across China’s various provinces; in-depth research is urgently needed on how specific regions should achieve this transition from energy consumption dual-control to carbon emissions dual-control. As a major traditional industrial province with a high concentration of heavy and chemical industries such as steel and building materials, this paper focuses on Hebei’s characteristics of heavy industry dominance and high carbon emissions. By investigating the constraints and pathways for Hebei’s comprehensive transition from energy consumption dual control to carbon emissions dual control, this study holds significant theoretical value and practical significance.

3. The theoretical logic behind Hebei’s transition from dual control of energy consumption to dual control of carbon emissions

Dual control of energy consumption targets both the total energy consumption of regions and market entities, as well as the energy intensity per unit of output. The scope of control covers all energy categories, including coal, oil and gas, and wind, solar and hydropower, with the core objective centered on the conservation and efficient utilization of energy resources across society. Dual control of carbon emissions centers on greenhouse gases generated by the combustion of fossil fuels and industrial production processes, using total carbon emissions and carbon emission intensity per unit of output as assessment indicators; it imposes no constraints on zero-carbon clean energy sources such as wind and solar power.

The theory of sustainable development calls for the coordinated pursuit of three long-term objectives: economic growth, resource conservation and climate protection. The traditional, blanket regulation of energy consumption tends to create a false dichotomy between economic development and emission reduction. In contrast, dual carbon control can resolve this contradiction through differentiated regulation, thereby achieving long-term balanced development. From the perspective of green economic theory, dual carbon control steers the allocation of production factors toward low-carbon industries and technologies. This catalyzes the emergence of novel green service sectors—such as carbon accounting, carbon trading, and carbon finance—thus cultivating new drivers of economic growth. Furthermore, the theory of hierarchical environmental regulation classifies these two policy instruments into distinct regulatory tiers. While dual

energy consumption control serves as a rigid, aggregate constraint, dual carbon control functions as a precise, incentive-based regulatory mechanism. The transition from energy consumption management to carbon emission control represents an optimization and upgrading of environmental governance tools, which enhances regulatory efficiency and reduces the economy-wide total decarbonization costs.

In terms of structural industrial conflicts, Hebei boasts an enormous scale of high-energy-consuming industries including steel and cement. Traditional energy consumption indicators impose stringent constraints on enterprises' low-carbon technological transformation and green electricity investment. Dual carbon control can distinguish between the use of high-carbon and zero-carbon energy, releasing policy space for the green transformation of industry. From the perspective of energy endowment, the northern part of Hebei Province has abundant reserves of wind and solar resources. The total energy consumption constraint is likely to restrict the large-scale construction of renewable energy power plants. The transformation to dual control of carbon emissions can remove the indicator shackles binding clean energy development of clean energy and accelerate the process of energy de-coal in the province. Starting from the requirements of high-quality development, dual carbon control has compelled enterprises to carry out low-carbon technology research and development, promote the green upgrading of the entire industrial chain, and help regions break away from the extensive and high-energy-consuming growth model, thereby building a modern low-carbon industrial system.

At the same time, Hebei Province possesses the technical, institutional, and economic feasibility to advance this transition in carbon management. From a technical perspective, domestic low-carbon processes such as CCUS, green hydrogen steelmaking and photovoltaic metallurgy are gradually being commercialized; the province's steel industry has already launched pilot schemes for carbon footprint accounting, and a mature technological framework provides the technical foundation for precise carbon control; From an institutional perspective, comprehensive top-level regulations on carbon markets, carbon accounting and carbon labelling have been introduced at the national level, whilst Hebei Province has simultaneously issued its provincial implementation plan for dual-control of carbon emissions; pilot schemes in the steel industry have accumulated practical experience in local institutional implementation; from an economic perspective, in the long term, the retrofitting of low-carbon equipment and the substitution with new energy sources can sustainably reduce enterprises' fossil fuel procurement costs, whilst carbon trading and carbon incentive mechanisms can generate stable emission-reduction revenues for entities responsible for emissions control; the long-term benefits of this transition are sufficient to offset the initial investment in retrofitting, thereby establishing a sustainable economic rationale.

4. Constraints on Hebei Province's transition from energy consumption dual control to carbon emissions dual control

The practical obstacles faced by Hebei Province in its transition from energy consumption dual control to carbon emissions dual control provide a basis for designing pathways and formulating policy recommendations. Based on preliminary research, the main factors constraining Hebei's transition to carbon emissions dual control are as follows. Firstly, challenges regarding policy coordination and implementation. The transition from energy consumption dual control to carbon emissions dual control involves restructuring the coordinated management system for core indicators, such as total energy consumption, total carbon emissions and emission intensity, as well as refining supporting regulations, systems and standards; this requires resolving the disconnect between old and new policies. As a province with high levels of energy

consumption and carbon emissions, Hebei must also balance the transition of its traditional energy structure with the development of new energy sources during this transition. Secondly, market incentive mechanisms are inadequate. Key emitting sectors in Hebei, such as steel and cement, have not yet been fully integrated into the national carbon market, and the carbon pricing mechanism provides insufficient incentives for enterprises to reduce emissions; support from green finance is weak, with low coverage of specialized loans for enterprises' low-carbon technology R&D and equipment upgrades, leaving enterprises facing a shortage of funds for the transition; the development of market-based services for energy conservation and carbon reduction is lagging, and the regulatory mechanisms for the carbon market are not yet fully established. Third, enterprises face bottlenecks in low-carbon technology and pressure from transition costs. The level of independent R&D into key technologies such as carbon capture and storage is low, whilst the costs of commercial application are high; weak collaboration mechanisms between industry, academia and research institutions have led to delays in technology transfer; the transition requires significant upfront investment, and under a short-term profit-driven mindset, enterprises tend to adopt a reactive approach to emissions reduction, lacking the strategic awareness to proactively plan for a low-carbon transition. Furthermore, factors such as the carbon emissions statistics and accounting system, the development of urban green infrastructure, and enterprises' carbon management capabilities all influence the progress of Hebei's transition from dual control of energy consumption to dual control of carbon emissions.

5. Pathways for the transition from energy consumption dual control to carbon emissions dual control in Hebei Province

As a province with a strong traditional industrial base, Hebei's transition from dual control of energy consumption to dual control of carbon emissions must take into account its specific characteristics, namely the high proportion of heavy industry, an energy mix heavily reliant on coal, and high carbon emission intensity. A transition pathway for dual control of carbon emissions, involving collaboration among diverse stakeholders, should be established across three dimensions: institutional provision, market incentives, and corporate behavior.

At the institutional level, the first step is to refine the regulatory and standards framework. The dual control of carbon emissions requires a framework of emission reduction mechanisms to ensure the sustainability of the transition. Government departments should establish substantive and procedural emission reduction systems to drive the transformation of the energy mix; set clear limits on carbon emission intensity and total emission control targets for each sector; and standardize corporate reporting requirements for carbon-related information. Furthermore, a robust system for calculating product-level carbon emissions in key industries should be established to guide enterprises in conducting such calculations and implementing a product carbon emission registration and management system. Secondly, regulatory and assessment mechanisms should be innovated. Big data and blockchain technologies should be utilized to monitor and issue early warnings regarding the carbon emissions data of key enterprises in real time; the weighting of carbon emission dual-control targets in the performance assessments of county and municipal governments across Hebei should be increased; and a framework combining economic performance evaluation with the assessment of carbon emission dual-control targets should be established. Thirdly, deepen exchanges and cooperation on carbon emission dual-control measures within the Beijing–Tianjin–Hebei region; carry out collaborative innovation in carbon capture and storage (CCS) technologies; promote the joint development

of carbon credit standards, information sharing and mutual recognition of projects; and establish a unified carbon credit system for the Beijing – Tianjin–Hebei region.

At the level of market incentives: firstly, deepen participation in the carbon market by encouraging emission-controlled enterprises to actively participate in the national carbon emissions trading market and explore mechanisms for the paid allocation of allowances; secondly, innovate green financial products and services, with financial institutions required to expand the development of carbon reduction products, increase lending and financial product innovation in areas such as energy conservation and emission reduction for key emitting enterprises, promote the securitization of carbon emission reduction credits, and enhance the incentive and guiding role of monetary policy tools; Thirdly, climate finance should be developed; through the capital markets, more funds should be channeled towards carbon reduction, and a low-carbon transition fund should be established to prioritize support for emerging sectors such as hydrogen energy and energy storage.

At the corporate level, the core lies in the transformation of emission reduction awareness and the improvement of emission reduction capabilities. First, shift from passive emission reduction to proactive carbon reduction, incorporate low-carbon goals into the enterprise's development strategy, and link them with departmental performance and executive remuneration to stimulate the internal motivation for carbon reduction and establish a long-term decision-making mechanism for emission reduction. Second, enhance the innovation and application of low-carbon technologies, collaborate with research institutions and universities to develop key low-carbon technologies, reduce carbon emissions through technological iteration, and quickly transform laboratory technologies into commercial applications to lower the cost of transformation. Optimize production processes, upgrade energy-saving equipment, strengthen the quality management of carbon emission data, and establish a full life cycle carbon footprint accounting system. Third, drive the upstream and downstream to reduce carbon emissions in a coordinated manner, incorporate carbon emission intensity into the supplier access and assessment indicators, require upstream enterprises to disclose carbon footprint data, and promote the low-carbon upgrade of the supply chain. Promote low-carbon products to downstream enterprises and expand the market for low-carbon products through the linkage of supply and demand. Fourth, improve the internal carbon management mechanism, establish a dedicated carbon management department, build an intelligent carbon emission management platform, cultivate a low-carbon corporate culture and talent reserve, and effectively enhance the level of carbon asset management.

6. Conclusion

Taking Hebei Province as the subject of this study, this paper systematically examines the theoretical logic, constraining factors and implementation pathways for the transition from dual control of energy consumption to dual control of carbon emissions. The research finds that, as a province dominated by heavy industry, Hebei's advancement of the transition to dual control of carbon emissions possesses both intrinsic necessity and practical feasibility; however, it still faces constraints such as poor institutional coordination, insufficient market incentives, and technological bottlenecks within enterprises. Overcoming these challenges requires concerted efforts in institutional provision, market incentives, and corporate behavior: improving regulations, standards and regulatory mechanisms, and deepening coordination within the Beijing–Tianjin–Hebei region; promoting the participation of key industries in the carbon market and innovating green financial instruments; and enterprises should embed low-carbon targets into strategic decision-making, whilst strengthening

technological innovation and supply chain collaboration to reduce carbon emissions. The conclusions of this study can provide practical guidance for Hebei in improving its dual-control system for carbon emissions; in the future, the effectiveness of the implementation of the transition pathways could be empirically tested using provincial panel or enterprise microdata.

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Disclosure statement

The authors declare no conflict of interest.

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