

The Theory and Practical Pathways of New-Quality Productivity Empowering Green and Low-Carbon Economic Development

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Abstract

As global climate and resource-environment constraints intensify, the green economic transition under China's "dual-carbon" strategy has become urgent. The traditional development model faces bottlenecks such as an over-reliance on heavy industries and insufficient green technologies. New-Quality Productivity, driven by technological innovation and characterized by intelligentization, digitalization, and ecologicalization, is inherently green productivity and highly aligned with green, low-carbon development. Drawing on the Marxist theory of natural productive forces and the cycle of material metabolism, this paper analyzes the internal logic through which New-Quality Productivity enables green and low-carbon development via four mechanisms: technology-driven innovation, factor structure reshaping, industrial system restructuring, and institutional-market synergy. In response to practical bottlenecks-including insufficient coverage of new infrastructure, shallow technology-industry integration, lagging institutional and standard systems, and poor multi-stakeholder coordination-this paper proposes practical pathways from four dimensions: strengthening new infrastructure, deepening technology-industry integration, innovating institutional and standard systems, and building a multi-stakeholder collaborative ecosystem. The aim is to provide theoretical and practical references for New-Quality Productivity to drive a green, low-carbon, and high-quality economic development.

Keywords

New-quality Productivity; Green and Low-carbon Development; Dual Carbon Goals; Technological Innovation.

1. Introduction

The intensification of global climate change and increasing resource and environmental constraints have rendered the traditional extensive growth model-characterized by high energy consumption and high emissions-unsustainable. China has explicitly set the strategic goals of achieving a carbon peak by 2030 and carbon neutrality by 2060, making a comprehensive green transformation of the economy and society a core task for high-quality development[1]. However, in reality, prominent contradictions persist, including an over-reliance on heavy industries, an energy structure dependent on fossil fuels, insufficient capacity for green technological innovation, and uneven capabilities for green transformation between urban and rural areas and across regions. Meanwhile, the ongoing new round of technological revolution and industrial transformation is advancing rapidly, with digital technologies such as artificial intelligence, the Internet of Things, big data, and blockchain being deeply integrated. The deep convergence of green and smart technologies has given rise to an advanced form of productivity characterized by innovation as the primary driving force and a substantial increase in total factor productivity-namely, New-Quality Productivity[2].

The assertion that "New-Quality Productivity is itself green productivity" profoundly reveals the inherent unity between New-Quality Productivity and green, low-carbon development. New-Quality Productivity not only emphasizes revolutionary technological breakthroughs and innovative factor allocation but also intrinsically requires deep green transformation of industries and ecological sustainability[3]. Therefore, systematically exploring the theoretical logic, internal mechanisms, and practical pathways through which New-Quality Productivity enables green and low-carbon development-and addressing the practical question of "through which mechanisms New-Quality Productivity drives the green and low-carbon transition"-bears significant theoretical value and policy implications[4].

On the basis of reviewing the conceptual characteristics of New-Quality Productivity and the theoretical logic of green development, this paper focuses on analyzing the internal mechanisms through which it enables green and low-carbon development. Taking into account the current practical bottlenecks in infrastructure, technological integration, institutional supply, and multi-stakeholder coordination, this paper proposes systematic practical pathways, aiming to provide theoretical references and practical guidance for various regions and sectors in advancing green and low-carbon development.

2. Theoretical Foundations of New-Quality Productivity and Green, Low-Carbon Economic Development

2.1. Conceptual Characteristics of New-Quality Productivity: The Organic Unity of Intelligentization, Digitalization, and Ecologicalization

New-Quality Productivity represents an advanced form of productivity driven by technological innovation, marked by a substantial increase in total factor productivity, and integrating the features of intelligentization, digitalization, and ecologicalization. Its conceptual characteristics are primarily manifested in three aspects[5] [6].

First, intelligentization. Intelligentization refers to the extensive application of technologies such as artificial intelligence, the Internet of Things, and automation in production processes. Through intelligent sensing, data analysis, and autonomous decision-making, production systems can achieve dynamic optimization and precise control, significantly improving resource utilization efficiency and reducing energy consumption and emissions per unit of output. The essence of intelligentization is the autonomous and lean nature of production processes, which transforms the traditional model of relying on manual experience and fixed procedures.

Second, digitalization. Digitalization uses technologies such as big data, blockchain, and cloud computing as carriers to facilitate the full-process digitization of production and management activities. Data becomes a new factor of production, and resource allocation shifts from experience-based judgment to data-driven decision-making. Digitalization not only improves the efficiency of information transmission and processing but also reduces trial-and-error costs and physical resource waste through virtual simulation and digital twins. Digitalization endows production systems with the attributes of measurability, traceability, and optimizability.

Third, ecologicalization. Ecologicalization embodies the inherent green attributes of New-Quality Productivity. It requires that production processes pursue not only economic efficiency but also environmental protection and resource recycling. Green technologies, cleaner production, and circular economy principles are embedded throughout the development of productivity. By reducing carbon emissions and pollutant discharge and increasing resource recycling rates, New-Quality Productivity achieves synergy between economic growth and ecological protection.

Intelligentization, digitalization, and ecologicalization are not separate but mutually reinforcing and organically unified. Digitalization provides the data foundation for intelligentization; intelligentization supplies the technological means for ecologicalization; and ecologicalization sets the value orientation for digitalization and intelligentization. Together, they constitute the core conceptual characteristics of New-Quality Productivity.

2.2. Core Logic of Green and Low-Carbon Development: Synergistic Transformation of Energy Structure, Resource Efficiency, and Industrial Systems

The essence of green and low-carbon development is a shift from the traditional development model reliant on fossil fuels and high resource consumption to a new model characterized by clean energy, efficient utilization, and low-carbon emissions. Its core logic encompasses three interrelated dimensions[7].

First, energy structure adjustment. The transformation of the energy structure is fundamental to green and low-carbon development. Globally, fossil fuels are the primary source of greenhouse gas emissions. Achieving carbon neutrality requires a shift from a predominantly coal-, oil-, and gas-based energy mix toward one dominated by renewable sources such as wind, solar, and geothermal energy. The large-scale application of renewable energy faces challenges of intermittency and instability, making the development of energy storage technologies and smart grids a critical support[8].

Second, resource efficiency enhancement. Inefficient resource extraction and utilization under the traditional economic model lead to resource depletion and environmental pollution. Enhancing resource efficiency means obtaining the same or greater output with less resource input. Technological innovation, particularly the dissemination of cleaner production and circular economy technologies, can reduce raw material consumption, lower waste generation, and increase resource recycling rates. Improved resource efficiency directly reduces the carbon intensity of production and consumption processes[9].

Third, industrial structure optimization. The green transformation of high-carbon industries (e.g., steel, cement, chemicals) and the cultivation of emerging industries such as new energy and energy conservation and environmental protection constitute the dual drivers of industrial structure optimization. Industrial structure optimization not only reduces the economy's dependence on high-carbon sectors but also drives the transition from quantitative expansion to qualitative improvement in economic growth. The energy structure, resource efficiency, and industrial structure interact with and reinforce one another, jointly forming the basic logical framework of the green and low-carbon transition.

2.3. Theoretical Convergence between New-Quality Productivity and Green Development: An Interpretation Based on Marx's Conception of Natural Productive Forces and the Metabolism Cycle

Marxist theory of productive forces provides a profound theoretical foundation for understanding the inherent convergence between New-Quality Productivity and green development[10]. InCapital, Marx introduces the concept of "natural productive forces," pointing out that nature itself is the fundamental condition for material production. Both labor and nature constitute the sources of wealth. Furthermore, Marx proposes the theory of "metabolism" (Stoffwechsel), emphasizing that human production activities represent a material exchange process between humanity and nature, which must maintain a cyclical balance; otherwise, ecological crises will ensue.

Marx reveals the fundamental contradiction between the unlimited expansion of production under capital logic and the finite carrying capacity of nature. Under the capitalist mode of production, nature is alienated into a plunderable resource, leading to a "metabolic rift." To

repair this rift, a new form of productivity is required—one in which production processes respect natural laws and achieve resource recycling.

New-Quality Productivity represents the contemporary embodiment of this new form of productivity. It inherits Marx's ideas on natural productive forces by embedding the ecological dimension into the objective function of productivity development. New-Quality Productivity emphasizes that technological progress should serve resource conservation and environmental friendliness, rather than merely pursuing output growth. By precisely controlling material and energy flows through digital and intelligent means, production activities align with the recycling laws of natural ecosystems. Therefore, New-Quality Productivity and green development share a logical isomorphism: the former is the means and form, while the latter is the goal and outcome. This theoretical convergence provides a solid scholarly foundation for subsequent mechanism analysis and pathway design.

3. Mechanisms of New-Quality Productivity Enabling Green and Low-Carbon Development

3.1. Technology-Driven Innovation Mechanism: From Green Technology Breakthroughs to the Formation of a Low-Carbon Industrial System

Technological innovation serves as the initial driving force through which New-Quality Productivity enables green and low-carbon development[11]. Unlike traditional technological innovation, the innovation driven by New-Quality Productivity is characterized by a distinct green orientation and systemic integration. At the micro level, breakthroughs in clean energy technologies, energy-saving technologies, carbon capture, utilization and storage (CCUS), and high-efficiency energy storage technologies have continuously reduced the application costs of green technologies and enhanced their economic feasibility. At the meso level, the deep integration of digital and green technologies has given rise to systematic solutions such as smart grids, intelligent energy management systems, and carbon asset management platforms, enabling individual technologies to move from laboratories to large-scale application[12].

Technological innovation drives the formation of a low-carbon industrial system through two pathways. The first is the substitution pathway: the continued decline in the cost of renewable energy generation allows it to gradually replace fossil fuels in the electricity mix; the substitution of new energy vehicles for internal combustion engine vehicles reduces carbon emissions in the transportation sector. The second is the optimization pathway: digital technologies such as industrial internet and artificial intelligence optimize production processes, reducing energy consumption and emissions per unit of output. Together, these technological breakthroughs and systemic integrations drive the low-carbon industry from dispersed points of activity toward a systemic development, forming a green technology matrix covering energy, manufacturing, transportation, construction, and other sectors.

3.2. Factor Structure Reshaping Mechanism: Coordinated Allocation of Data, Human Capital, and Green Resources

New-Quality Productivity enhances green total factor productivity by introducing new factors of production and reshaping the way factors are allocated. Data, as a new factor of production, is characterized by non-depletability, replicability, and diminishing marginal cost. In the production process, data factors are embedded in energy management, material distribution, process control, and other links, making resource consumption and carbon emissions measurable, traceable, and optimizable. Data-driven decision-making reduces information asymmetry and improves factor allocation efficiency.

The upgrading of human capital structure represents another key dimension of factor reshaping. The green and low-carbon transition requires workers to acquire digital skills, green

skills, and interdisciplinary technical capabilities. Skill training oriented toward new energy, intelligent equipment, carbon management, and related fields improves the match between the labor force and green jobs, generating a human capital dividend.

Green resources—such as forest carbon sinks, biomass energy, and ecological services—are transformed from public goods into tradable factors of production. Through rights confirmation, accounting, and market-based transactions, the ecological value of green resources becomes explicit, providing incentives for ecological protection and restoration. The coordinated allocation of the three types of factors—data, human capital, and green resources—breaks the linear constraints of traditional factor combinations and enables a transition toward a low-carbon, high-efficiency factor input structure[13][14].

3.3. Industrial System Restructuring Mechanism: Green Upgrading of Traditional Industries and Ecologicalization of Emerging Industries

New-Quality Productivity drives a profound restructuring of the industrial system from a linear, consumption-based model to a circular, low-carbon one. This restructuring encompasses two parallel directions.

On the one hand, traditional high-energy-consuming and high-emission industries achieve green upgrading through technological transformation. Sectors such as steel, cement, and chemicals adopt industrial internet and artificial intelligence to optimize combustion and reaction processes, reducing energy consumption and emissions. At the same time, cleaner production, end-of-pipe treatment, and recycling technologies are integrated into production processes to minimize the generation of pollutants and waste[15].

On the other hand, strategic emerging industries are accelerating their development and exhibiting ecological characteristics. Industries such as new energy, energy conservation and environmental protection, new energy vehicles, and green building materials have achieved economies of scale, and their production processes themselves have a low carbon footprint. Moreover, there is a notable trend of industrial integration: cross-sector combinations such as agriculture with photovoltaics, fisheries with wind power, and mining with ecological restoration form "production + ecology" synergistic models, improving the composite utilization efficiency of natural resources such as land and water bodies. The restructuring of the industrial system gradually frees the economic structure from path dependence on high-carbon industries and shifts it toward a new trajectory of green, low-carbon, and high-value-added development.

3.4. Institutional and Market Synergy Mechanism: The Interactive Effects of Carbon Pricing, Green Finance, and Benefit Distribution

Technological and industrial transformations require institutional environments and market mechanisms to provide incentives and constraints. Carbon pricing mechanisms (carbon taxes and carbon trading markets) transmit explicit carbon cost signals to microeconomic agents, prompting firms to incorporate emission reduction into their operational decisions. Through allowance allocation and trading, carbon trading markets optimize the allocation of carbon emission rights among different entities while providing revenue streams for emission reduction projects.

The green finance system channels social capital into low-carbon technology R&D and green project construction through products such as green credit, green bonds, green funds, and carbon emission reduction support instruments. The leveraging effect of financial instruments can mitigate challenges faced by green investment, including long payback periods and high uncertainty.

The synergy between institutions and markets is also reflected in the improvement of benefit distribution mechanisms. Through channels such as carbon trading revenues, green electricity

premiums, and ecological compensation, the dividends of emission reduction are reasonably distributed among technology providers, emission reducers, and ecological protectors, enhancing the endogenous motivation of various actors to participate in the green transition. Carbon pricing, green finance, and benefit distribution form a closed loop, collectively constituting the institutional guarantee for New-Quality Productivity to enable green development.

4. Practical Pathways for Leveraging New-Quality Productivity to Advance Green and Low-Carbon Development

4.1. Strengthening New Infrastructure: Bridging the "Last Mile" of Data, Computing Power, and Energy Networks

New infrastructure constitutes the material and technological foundation for the operation of New-Quality Productivity. It mainly includes fifth-generation mobile communication networks (5G), the Internet of Things (IoT), industrial internet, big data centers, intelligent computing centers, smart grids, and charging facilities for new energy vehicles. In the context of green and low-carbon transition, the function of new infrastructure is not limited to information transmission and processing; it also serves as a key carrier for the coordinated regulation of energy flows, data flows, and carbon flows. At present, in some regions-especially rural areas and small- and medium-sized industrial parks-the coverage of new infrastructure is insufficient and its application is shallow, with obvious last-mile connectivity challenges. To address this, new infrastructure should be strengthened in the following ways[16].

First, extend 5G and IoT connectivity to the frontlines of production. Deploy sensing devices at end nodes such as farmland, forest farms, mines, workshops, and livestock farms to enable real-time collection and transmission of key data on energy consumption, emissions, and environmental conditions. By employing low-power wide-area IoT technologies, reduce the costs of data collection and transmission, ensure full-area coverage, and achieve high-frequency data updates.

Second, deploy edge computing nodes and industry-specific data middle platforms. For scenarios requiring millisecond-level responses, deploy edge servers to process data locally, thereby reducing latency and bandwidth pressure. Establish county-level or industry-level data middle platforms that unify data interfaces, cleaning rules, and security standards, breaking down data silos between different vendors and systems, and providing a high-quality data foundation for subsequent analysis and decision-making.

Third, build a "source-grid-load-storage" coordinated intelligent energy network. In development zones, rural communities, and other areas, construct new energy microgrids that integrate distributed photovoltaics, small-scale wind power, energy storage devices, and controllable loads, enabling participation in power demand response through intelligent controllers. Smart grid technologies facilitate the efficient utilization of renewable energy, reduce curtailment of wind and solar power, and improve the overall efficiency of the energy system.

Fourth, innovate investment, financing, and operation models for new infrastructure. Given the high investment and long payback periods associated with new infrastructure in rural and remote areas, adopt a cost-sharing mechanism combining government subsidies, corporate investment, and user fees. Explore the assetization of credible carbon emission reduction data to enable participation in carbon trading or the design of green financial products, thereby creating a revenue loop. Meanwhile, ensure long-term availability of facilities through local operation and maintenance teams or government-purchased services.

4.2. Deepening Technology–Industry Integration: Creating a Full-Chain "Smart Production–Precision Management–Digital Marketing–Green and Low-Carbon" Ecosystem

Technology empowerment must be guided by real industrial needs to avoid indiscriminate technology stacking and disconnect from reality. A systematic design of integrated scenarios along the entire industrial chain-encompassing smart production, precision management, digital marketing, and green and low-carbon practices-should be pursued.

In the smart production stage, develop technology solutions tailored to different industries, i.e., agriculture-appropriate and manufacturing-appropriate solutions. For manufacturing, promote digital twin systems to optimize production parameters; for agriculture, develop low-cost, easy-to-operate small intelligent equipment. Core technologies include automated navigation operations, variable input application, and energy consumption optimization[17].

In the precision management stage, establish a full-process carbon footprint management platform. Track carbon emissions throughout the entire lifecycle-from raw material procurement, manufacturing, and logistics to product use and recycling-to identify high-carbon links and propose optimization plans. Through energy management systems and material balance systems, enterprises can achieve refined management, reducing energy consumption and emission intensity per unit of output.

In the digital marketing stage, leverage blockchain traceability and digital labelling technologies to make product carbon footprints and environmental certification information queryable and verifiable. Establish a green product labelling and certification system to guide consumers toward low-carbon products, thereby creating market-based green preferences. Platform enterprises can set up dedicated green product sections, using price signals to incentivize producers to continuously reduce carbon emissions.

In the green and low-carbon closed-loop stage, promote coordinated emission reduction between the production and consumption sides. Encourage product recycling and remanufacturing to extend material lifecycles. In agriculture, promote circular models such as crop–livestock integration and the resourceful utilization of crop residues. Through full-chain information integration, achieve systematic optimization from source reduction to end-of-pipe treatment[18].

The creation of full-chain scenarios should take counties or industrial parks as basic units, select representative industrial chains for pilot digital and green transformation of the entire chain, and after summarizing replicable technology solutions and business models, gradually scale up the rollout[19].

4.3. Innovating Institutional and Standard Systems: Accelerating the Implementation of Data Rights Confirmation, Green Certification, and Carbon Trading Rules

Institutional supply constitutes the soft infrastructure for green and low-carbon transition. At present, institutional gaps remain in areas such as the ownership of agricultural data, the coverage of carbon trading, and the mutual recognition of green product certifications, which constrain the effective functioning of market mechanisms[20].

First, establish a system for the rights confirmation, circulation, and benefit distribution of ecological and agricultural data. In pilot areas of the national Digital Village initiative, explore the "three rights separation" model for data resources-i.e., separating the rights of holding, rights of data processing and usage, and rights of product operation-and clarify the rights boundaries and benefit-sharing rules among different actors (governments, enterprises, farmers) in the process of data collection and application. Establish data trading platforms to facilitate the orderly circulation of data as a factor of production.

Second, accelerate the expansion and harmonization of green certification and carbon trading rules. Expand the coverage of the national carbon market to gradually include high-emission industries such as steel, cement, and chemicals. Develop national standards for product carbon footprint accounting, and establish a unified carbon footprint database and accounting software. Promote mutual regional recognition of green product certifications to reduce redundant testing and certification costs and improve market efficiency.

Third, establish market access facilitation channels for green technologies and green products. Grant priority in government procurement, project bidding, and credit approval to certified low-carbon technologies, energy-saving equipment, and green products. Simplify the approval process for green labels by combining corporate self-declarations with ex-post supervision, thereby shortening product time-to-market.

Fourth, improve ecological compensation and carbon sink trading mechanisms. Expand the coverage of methodologies for forestry carbon sinks, ocean carbon sinks, and agricultural carbon sinks, and establish regional carbon sink trading markets. Allow small-scale farmers to participate in carbon sink trading through cooperatives or brokers, lowering the transaction threshold. Gradually include wetland, grassland, and cultivated land soil carbon sinks as tradable products, broadening the channels for realizing the value of ecological goods.

4.4. Building a Multi-Stakeholder Collaborative Ecosystem: Government Guidance, Market Leadership, Social Participation, and Benefits for Farmers

Enabling the green and low-carbon transition through New-Quality Productivity involves a complex, multi-actor, multi-level system. It is necessary to build an ecosystem in which governments, enterprises, research institutions, social organizations, and the public collaborate[21].

At the government level, play a role in strategic guidance and policy provision. Formulate a roadmap for the green and low-carbon transition, defining phased goals and priority tasks. Establish special funds for the green and low-carbon transition, providing fiscal subsidies or low-interest loans to enterprises that adopt advanced green technologies. Use mechanisms such as open competition for research proposals (often referred to as "revealing the list and claiming the command") and tournament-based funding ("horse racing" mechanism) to organize collaborative research on key generic technologies, thereby reducing enterprises' R&D risks.

At the enterprise level, emphasize the role of market actors in technology adoption and innovation. Encourage leading enterprises in industrial chains to incorporate green performance into their supplier evaluation systems, driving coordinated emission reduction across upstream and downstream partners. Small and medium-sized enterprises can rely on industrial internet platforms to access green diagnostic services, quickly identifying entry points for carbon reduction. Enterprises in new energy, energy conservation, environmental protection, and related fields should increase R&D investment to drive technological iteration and cost reduction[22].

At the research institution level, strengthen in-depth industry–university–research collaboration. Encourage universities and research institutes to establish joint laboratories with enterprises, conducting targeted R&D focused on the green technology needs of regionally distinctive industries. Establish a green technology pilot-scale and maturation fund to help laboratory outcomes overcome the barriers to transitioning from R&D to application.

At the farmer and community level, ensure the inclusiveness of the green transition. Through organizational models such as "leading enterprises + cooperatives + farmers" and "digital platforms + small-holder farmers," integrate dispersed small-holders into the green industrial chain. For farmers in ecological protection areas, implement policies combining ecological

resettlement, skills training, and green job placement, enabling them to become beneficiaries of ecological protection rather than passive bearers of its costs.

At the social oversight level, leverage the role of environmental NGOs, industry associations, and media. Encourage third-party institutions to conduct corporate environmental performance ratings and disclose relevant information, guiding the green preferences of investors and consumers. Through the promotion of positive examples and the exposure of negative cases, foster a public opinion environment conducive to the green transition.

The ultimate goal of multi-stakeholder collaboration is to form a green and low-carbon community characterized by clear responsibilities, incentive compatibility, and resource sharing, ensuring that New-Quality Productivity is truly implemented and continuously delivers emission reduction benefits.

5. Conclusion

As an advanced form of productive forces centered on technological innovation and integrating intelligentization, digitalization, and ecologicalization, New-Quality Productivity is profoundly reshaping the underlying logic and practical pathways of green and low-carbon development. This paper has conducted a systematic analysis from theoretical foundations, internal mechanisms, to practical pathways, and draws the following main conclusions.

First, New-Quality Productivity and green and low-carbon development exhibit a high degree of theoretical convergence. Inheriting and developing the Marxist conception of natural productive forces and the cycle of material metabolism, New-Quality Productivity embeds the ecological dimension into the objective function of productive forces development, thereby providing theoretical support for the green transition.

Second, New-Quality Productivity enables green development through four major mechanisms: technology-driven innovation, factor structure reshaping, industrial system restructuring, and institutional-market synergy. These four mechanisms are mutually reinforcing and progressively interlinked, forming a complete chain of effects. Technological innovation provides the possibility, factor reallocation optimizes deployment, industrial restructuring unleashes potential, and institutional mechanisms ensure sustainability.

Third, the current green and low-carbon transition still faces practical obstacles, including insufficient last-mile coverage of new infrastructure, shallow depth of technology-industry integration, lagging institutional and standard systems, and poor multi-stakeholder coordination. To address these issues, systematic efforts are needed along four dimensions: strengthening new infrastructure, creating full-chain integrated scenarios, innovating institutional standards, and building a collaborative ecosystem.

Looking ahead, as the goals of carbon peak and carbon neutrality are further advanced and digital technologies continue to evolve, New-Quality Productivity will drive green and low-carbon development on a larger scale and at a deeper level. This is a systemic transformation involving production methods, lifestyles, and even value systems. Governments should maintain strategic resolve and improve policy systems that balance incentives and constraints. Enterprises should proactively embrace green technology innovation and carbon management, turning emission reduction into a core competitive advantage. Research institutions should strengthen R&D on cutting-edge generic technologies and lower the barriers to application. The public should enhance their awareness of green consumption, using market demand to drive supply upgrades. Only through the concerted efforts of the whole society can the powerful momentum of New-Quality Productivity be effectively transformed into the tangible driving force for green and low-carbon development, forging a high-quality development path that prioritizes ecological soundness, greenness, and low-carbonness, thereby making due contributions to the modernization of harmonious coexistence between humanity and nature.

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