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The Generative Logic and Governance Pathways of China's New-Type Energy System from the Perspective of Chinese Modernization

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Abstract: Since the 20th National Congress of the CPC, China has entered a new stage of accelerating the planning and construction of a new-type energy system. This system represents the strategic direction of future-oriented national energy transformation and embodies the intrinsic requirements, institutional arrangements, and strategic visions of Chinese modernization. The new-type energy system not only reflects China's major progress in energy transition but also reshapes the nation's energy governance paradigm. This paper analyzes the Chinese modernization and the new-type energy system, reviews China's recent progress, and proposes governance pathways to better align the system with the comprehensive advancement of Chinese modernization.

1. Introduction

Energy has long been recognized as a critical pillar for national development and security. Over the years, China has experienced profound changes in its energy systems, driven by growing demand, technological advancements, and environmental concerns. As the world faces climate change and geopolitical shifts, energy systems worldwide are undergoing transformation. China's energy system is no exception, as it faces challenges linked to fossil fuel dependency, rising energy needs, and the global push for sustainable energy solutions. Since the 18th National Congress, China's energy development has been characterized by an accelerating transition towards clean, diversified, and low-carbon energy. Central to this transition is the "Four Revolutions, One Cooperation" energy strategy proposed by nation, which emphasizes innovation, energy efficiency, green development, and international cooperation[1]. The 20th National Congress marked a new chapter in this transformation with the introduction of the new-type energy system, aligning energy policy with the broader goals of Chinese modernization[2].

2. Relationship Between the New-Type Energy System and Chinese Modernization

Understanding the intricate relationship between China's new-type energy system and its modernization trajectory requires examining both the historical evolution of this connection and the

conceptual foundations that underpin it. The following analysis proceeds in two stages: first, tracing how energy-modernization linkages have transformed across different developmental phases in China's reform era, revealing a progressive deepening from instrumental necessity to strategic integration; second, clarifying the distinctive characteristics of the new-type energy system that differentiate it from conventional energy infrastructure and align it with the specific requirements of Chinese modernization. This dual examination establishes the analytical foundation for understanding why energy system transformation has become not merely a technical adjustment, but a constitutive element of China's modernization pathway.

2.1. Energy Transition Amid

China’s energy journey is intricately tied to its modernization efforts. Following its establishment in 1949, the country relied heavily on coal and other fossil fuels, which played a central role in driving industrialization. However, as China grew into a global economic powerhouse, the limitations of this energy model became apparent, including environmental degradation and an overreliance on imported energy. Since the 21st century, China has pursued an aggressive energy transition, investing in renewable resources such as wind, solar, and nuclear energy.

This shift is embodied in the Renewable Energy Law and is further reinforced by governmental policies aimed at reducing carbon emissions and increasing energy self- sufficiency. Under the framework of the “Four Revolutions, One Cooperation” strategy, China is reshaping its energy system in a way that supports both environmental goals and long-term economic development[1]. The transformation towards a new-type energy system is thus not just an energy policy change but also a necessary component of Chinese modernization.

2.2. Emergence of the New-Type Energy System

The concept of the new-type energy system emerged in response to China’s evolving energy needs and the global demand for clean, sustainable energy. Unlike the traditional energy models based primarily on fossil fuels, the new-type energy system focuses on diversification, the integration of renewable energy sources, and the optimization of energy efficiency. This system is a direct extension of the modern energy system but with deeper emphasis on clean, low-carbon, and sustainable practices. Key aspects of the new-type energy system include: Energy structure: A shift from fossil fuels to renewable energy sources such as wind, solar, nuclear, and hydropower. System form: A more integrated and flexible energy grid capable of accommodating diverse energy sources. Industrial systems: Expansion of green technologies, energy-efficient industries, and clean energy infrastructures. Supply chains: Enhanced resilience and stability in energy supply networks to cope with global uncertainties. Governance systems: Modernized policies and governance frameworks that support a cleaner and more efficient energy future[3].

2.3. Deep Linkages with Chinese Modernization

The new-type energy system aligns with and supports the broader goals of Chinese modernization, particularly in the context of achieving national security, sustainable development, and ecological balance. As China transitions to a more modern and diversified energy structure, it simultaneously enhances its global energy leadership. Through this transformation, China aims to achieve energy security, environmental sustainability, and a dominant position in the international energy market. Thus, the new- type energy system is both a crucial enabler of and a response to Chinese modernization goals, aligning energy policy with the nation’s long-term development strategy.

3. Energy Transition and the Logic of Chinese Modernization

Having established the evolving relationship between energy systems and China's modernization in Section 2, this section advances a theoretical framework that explicates the underlying logic governing this relationship. The new-type energy system does not simply support Chinese modernization as an external resource base; rather, it embodies the distinctive developmental logic of Chinese modernization through five interconnected dimensions. These dimensions—dual functionality, structural constraints, governance instrumentality, long-term orientation, and institutional foundations—collectively constitute a coherent analytical framework that explains both why energy transition assumes centrality in China's modernization strategy and how this transition is shaped by China's unique developmental context. Each dimension reveals a specific aspect of the mutual constitution between energy transformation and modernization, demonstrating that China's approach to energy governance is fundamentally informed by, and reflective of, its broader modernization philosophy. The subsequent analysis elaborates these five dimensions sequentially, while emphasizing their systemic interrelationships.

3.1. Dual Functions of the New-Type Energy System in Chinese Modernization

Within the framework of Chinese modernization, the new-type energy system performs a dual and mutually reinforcing role that is both material and normative.

At the material level, it constitutes a foundational infrastructure for sustaining economic growth, enabling industrial upgrading, and supporting continuous improvements in living standards. Reliable and affordable energy supply remains indispensable for manufacturing, urbanization, digitalization, and the expansion of public services, all of which are central components of Chinese modernization trajectory. At the normative level, the new-type energy system embodies China’s evolving development philosophy, which emphasizes ecological civilization, social equity, and long-term national security. Energy transition is therefore not treated merely as a response to climate change or environmental pressure, but as an integral element of a broader transformation in development values. This duality distinguishes China’s approach from policy frameworks that conceptualize decarbonization primarily as a sector-specific or technocratic adjustment. In the Chinese context, energy transition is inseparable from questions of development quality, intergenerational justice, and the legitimacy of the modernization project itself.

3.2. Structural Constraints and Developmental Priorities in Energy Transition

The scale and structural characteristics of Chinese modernization process impose distinctive constraints on energy system transformation. A large population base, persistent regional disparities, and high energy demand intensity create a complex policy environment in which emissions reduction must be balanced against economic stability and social inclusion. Unlike economies that have already completed industrialization, China must pursue decarbonization while still undergoing structural upgrading and urban expansion.

As emphasized in the discourse of Chinese modernization, energy systems are required to support high-quality development while maintaining social stability and energy security[2]. This necessitates an integrated policy orientation in which reliability, affordability, and inclusiveness are treated as co-equal objectives alongside sustainability. Rather than sequencing energy security first and decarbonization later, Chinese modernization logic seeks to embed low-carbon transformation within a stable and resilient energy supply framework. Energy transition thus becomes a process of structural coordination rather than a linear substitution of energy sources.

3.3. The New-Type Energy System as a Governance and Development Instrument

Within this context, the new-type energy system functions not only as a technological configuration but also as a governance instrument that aligns energy transition with broader development goals. The expansion of renewable energy is closely linked to the cultivation of new productive forces, including advanced manufacturing, digital technologies, and strategic emerging industries. Energy transition policies are therefore deeply intertwined with industrial policy, innovation strategy, and supply chain restructuring.

Large-scale investments in renewable generation, power grids, and energy storage contribute simultaneously to carbon mitigation and to the strengthening of domestic technological capabilities. By embedding energy transition within national development planning, the state leverages energy infrastructure as a mechanism for coordinating environmental objectives with economic competitiveness and technological autonomy[4]. In this sense, the new-type energy system serves as an institutional platform through which ecological goals and development imperatives are jointly advanced rather than traded off against each other.

3.4. Long-Term Orientation and the Co-Evolution of Energy Transition and State Capacity

The logic of Chinese modernization situates energy transition within a long-term temporal horizon that prioritizes strategic capacity building over short-term cost minimization. The construction of a new-type energy system emphasizes gradual accumulation of technological capabilities, institutional learning, and governance experience. Energy infrastructure development proceeds alongside the refinement of regulatory frameworks, market mechanisms, and coordination capacities across different levels of government.

This long-term orientation reflects a developmental logic in which energy transition and state capacity evolve simultaneously. Rather than viewing energy transition as an external constraint on growth, Chinese modernization frames it as an enabling condition for sustained development under changing global and ecological conditions. Consequently, the new-type energy system is not only an outcome of Chinese modernization but also a key driver of its continued advancement, reinforcing a development pathway characterized by strategic planning, institutional coherence, and adaptive governance.

4. Progress and Effects of China’s New-Type Energy System Construction

The theoretical framework established in Section 3 provides an analytical lens for examining China's concrete achievements in energy system transformation. The following assessment demonstrates how recent progress embodies the dual functionality logic (Section 3.1) by simultaneously advancing energy transition and socioeconomic development goals; responds to structural constraints (Section 3.2) through differentiated regional strategies and technological innovations; operationalizes the governance instrument approach (Section 3.3) by leveraging energy system reforms to achieve broader policy objectives; and reflects the long-term orientation (Section 3.4) through systematic capacity building. Moreover, these advancements are underpinned by the institutional foundations (Section 3.5) that enable coordinated action across multiple scales and sectors. This empirical examination thus serves not merely as a descriptive account, but as evidence of how theoretical principles translate into measurable outcomes. Since the 20th National Congress, the nation has made significant strides in constructing a new-type energy system. These developments not only reflect advancements in China’s energy structure but also signal a major transformation in the way the country generates, consumes, and governs energy. Several key areas of progress include the diversification of energy sources, the integration of new technologies, and the strengthening of

energy security mechanisms.

4.1. Major Progress in Energy Structure

China has made substantial headway in shifting its energy structure toward cleaner, more sustainable sources. The nation has set ambitious targets for renewable energy production, focusing on solar, wind, hydro, and nuclear power. According to the International Energy Agency (2025), China's non-fossil fuel energy capacity now accounts for more than 50% of its total installed power capacity, marking a significant milestone in the country's energy transition.

The renewable energy sector in China has seen remarkable growth in recent years. Wind and solar power are leading the way, with the country's solar power generation capacity ranking as the largest globally. The rapid expansion of wind and solar energy has been driven by both technological innovation and government policy. For example, the Chinese government has implemented policies that encourage the development of large- scale renewable energy projects and promote the use of green technology[4]. In addition to solar and wind power, hydropower has long been a significant contributor to China's renewable energy mix. However, as the country continues to optimize its energy structure, the focus is increasingly shifting towards cleaner and more efficient energy systems. The development of offshore wind power and the enhancement of solar technologies are seen as key drivers in this shift towards a more diversified energy mix[5].

Nuclear energy plays a critical role in China's energy transition, especially as the country seeks to reduce its carbon footprint while ensuring a stable energy supply. China's nuclear power capacity has expanded rapidly in recent years, with the nation now holding the largest operational and under-construction nuclear fleet in the world. The development of fourth-generation nuclear technology, such as the Hua long One reactor, is also a key aspect of China's energy strategy, enhancing safety and efficiency while reducing waste[6].

4.2. Advancements in Energy System Integration

China's new-type energy system is not only characterized by the expansion of renewable energy but also by the development of integrated energy systems that can accommodate diverse power sources. The focus has been on improving the infrastructure that supports this system, particularly through the development of smart grids, energy storage solutions, and efficient energy management technologies.

One of the most important developments in China's energy system is the integration of smart grid technology, which helps manage the complex interactions between renewable energy sources and the electrical grid. Smart grids enable better forecasting, monitoring, and control of energy flows, thus enhancing grid stability and efficiency. As renewable energy sources like wind and solar are intermittent, smart grids are essential for balancing supply and demand, minimizing energy loss, and facilitating the integration of decentralized energy sources into the national grid. Energy storage systems, particularly battery storage, have also been a key area of development. These systems allow excess energy generated during peak renewable periods to be stored and used when demand is high, further improving grid reliability. In 2024, China became a global leader in the deployment of new-type energy storage technologies, including lithium-ion and sodium-ion batteries, which are crucial for supporting a large-scale transition to renewable energy sources[5]. The expansion of energy storage capacity in China is expected to continue as the country aims to significantly increase its renewable energy generation capacity by 2030.

In addition to renewable power generation and energy storage, China is also focusing on the development of green hydrogen as a key component of its new-type energy system. Hydrogen, when produced using renewable energy sources, can be a crucial energy carrier, offering a solution for hard-

to-decarbonize sectors such as heavy industry and transportation. China has already made substantial investments in hydrogen infrastructure and research, with multiple pilot projects underway across the country[4]. This emphasis on green hydrogen complements China's broader goals for energy diversification and helps to ensure that its energy system is both flexible and resilient in the face of external shocks, such as geopolitical disruptions or climate-related events.

4.3. Strengthening Energy Security and Resilient Supply Chains

Energy security remains a top priority for China, and the development of the new-type energy system is closely tied to efforts to ensure a reliable and stable energy supply. China is actively addressing its dependence on imported fossil fuels, particularly oil and natural gas, by increasing domestic energy production, diversifying energy sources, and improving energy efficiency.

China is focusing on increasing its domestic energy production, particularly in areas such as natural gas, coal, and renewables. By enhancing domestic supply and reducing reliance on imports, China aims to improve energy security and resilience. Recent efforts include the development of shale gas resources in China's western regions, alongside the enhancement of its coal-bed methane production. The government has also increased efforts to modernize its domestic oil refineries and gas infrastructure, allowing the country to become less vulnerable to global market fluctuations[3].

To reduce its reliance on fossil fuel imports, China is also diversifying its energy supply through international partnerships and investments. The country is increasingly active in securing energy resources from regions like Central Asia, Africa, and South America. The Belt and Road Initiative (BRI) has played a significant role in facilitating these energy investments, particularly in renewable energy infrastructure projects. Through these efforts, China aims to enhance its energy security while contributing to global energy stability[7].

Additionally, China's leadership in renewable energy technology and infrastructure is reinforcing its position as a global energy powerhouse. The rapid growth of China's green energy industry has positioned the country as a key player in the global energy transition, helping to shape international standards and best practices in energy development.

4.4. Theory and Practice of Institutional Foundations

China is also focusing on strengthening its governance frameworks to support the development of a new-type energy system. The country is modernizing its energy regulations, promoting sustainability, and supporting technological innovations. The introduction of the Energy Law in 2024 marked a significant step in the modernization of China's energy governance. The law provides a legal framework for the transition to renewable energy, encouraging investment in clean energy technologies while ensuring that the country's energy system remains secure and stable. In addition, the carbon market reforms and green certificates system have introduced market-based mechanisms to promote sustainability and reduce emissions. These reforms provide the necessary institutional support for the ongoing energy transition and the realization of China's carbon neutrality goals by 2060[7].

Furthermore, the Chinese government is integrating climate change policy into its broader development agenda. The establishment of the national carbon market has been a critical development in this regard, helping to guide investments toward low-carbon technologies and ensuring that carbon emissions are effectively priced in the energy market. The country's climate-related policies are continuously evolving to ensure that the energy system remains aligned with both domestic and global environmental objectives.

While technological innovation constitutes a visible driver of energy transition, growing international scholarship suggests that the effectiveness and stability of a new-type energy system are

fundamentally conditioned by its institutional foundations rather than by technology alone. In contrast to linear transitions centered on fuel substitution, the construction of a renewable-dominated energy system entails deep structural reconfiguration across regulatory frameworks, ownership arrangements, and coordination mechanisms. Institutional coherence therefore emerges as a decisive factor shaping the scalability, resilience, and long-term performance of the energy system.

The new-type energy system operates across multiple governance layers, including strategic planning, market regulation, infrastructure ownership, and operational coordination. Fragmentation across these layers may generate misaligned incentives, regulatory arbitrage, and coordination failures, particularly under conditions of rapid expansion of variable renewable energy.

Existing comparative studies indicate that liberalized energy markets often struggle to deliver system-level coordination when renewable deployment outpaces grid adaptation and storage capacity [7]. By contrast, an integrated institutional framework enables long-term investment planning, reduces transaction costs, and internalizes systemic risks that cannot be efficiently addressed through market mechanisms alone. China’s institutional configuration illustrates a governance model in which strategic coordination plays a central role in energy transition. Long-term national planning provides directional certainty for infrastructure investment, while public ownership of key network assets—particularly transmission and distribution grids—facilitates system-wide optimization rather than fragmented profit maximization.

This arrangement allows renewable energy expansion to be aligned with grid reinforcement, energy storage deployment, and inter-regional balancing, thereby mitigating instability risks associated with high renewable penetration[3]. The introduction of the Energy Law further consolidates the institutional foundation of the new-type energy system. By codifying principles such as security-first orientation, coordinated planning, and system resilience, the law marks a shift from sector-specific regulation toward a more integrated legal architecture.

This legal consolidation enhances policy credibility and reduces uncertainty for market actors while preserving the state’s capacity to intervene when systemic risks arise. Consequently, institutional design functions not merely as a regulatory constraint but as a productive force shaping the structural outcomes of China’s energy transition.

5. Governance Pathways for Enabling Chinese Modernization through the New-Type Energy System

Building upon the governance instrument attributes discussed in Section 3.3—wherein the new-type energy system serves as both a developmental objective and a policy tool—this section proposes four integrated pathways for operationalizing energy governance within China's modernization framework. These pathways translate the theoretical logic articulated in Section 3 into actionable governance strategies, addressing the dual imperatives of energy transition and socioeconomic development.

5.1. Constructing a New Cognitive Framework for the Energy System

To ensure the success of the new-type energy system, China must construct a new understanding of energy systems that aligns with the characteristics of renewable resources, such as abundance, decentralization, and technological complexity. This requires fostering widespread recognition and support for the energy transition, as well as providing education and training to develop the necessary technical and policy expertise[7].

5.2. Cultivating New-Quality Energy Productive Forces

A critical aspect of building a new-type energy system is fostering innovation in energy technologies. By investing in research and development, strengthening intellectual property protection, and improving the legal environment for energy innovation, China can enhance its technological leadership in the global energy market. The development of advanced nuclear technologies, energy storage solutions, and renewable energy efficiency will provide new sources of growth for the nation's energy sector[8].

5.3. Coordinated Promotion of Planning, Construction, and Governance

Effective governance of the new-type energy system requires coordinated efforts across various dimensions. China must ensure that energy planning is integrated at the national and local levels, avoiding overlapping or conflicting policies. The construction of key infrastructure, such as smart grids, charging stations, and energy storage systems, must be supported by a robust regulatory framework that encourages innovation and collaboration across sectors.

5.4. Proactively Shaping Global Energy Governance

China's leadership in global energy governance is crucial for the success of the new-type energy system. By engaging in international collaborations, setting technical standards, and contributing to global policy discussions, China can influence the direction of global energy transitions. This will not only benefit China's energy system but also promote sustainable development worldwide[9].

China plays an increasingly constructive role in reshaping global energy governance through multiple channels. In international standard-setting, China has actively participated in the International Electrotechnical Commission (IEC) and International Organization for Standardization (ISO) to promote technical standards for renewable energy equipment and smart grid technologies, contributing Chinese solutions to global energy infrastructure development. Through the Belt and Road Initiative (BRI), China has established extensive energy cooperation frameworks with partner countries, including joint development of renewable energy projects, cross-border power grid connectivity, and capacity building programs that transfer China's energy transition experience to developing nations. This South-South cooperation model offers an alternative pathway for countries facing similar developmental constraints. In global climate negotiations, China has consistently advocated for the principle of common but differentiated responsibilities, while demonstrating leadership through concrete commitments such as achieving carbon peak before 2030 and carbon neutrality before 2060. By integrating its domestic energy governance innovations with international cooperation mechanisms, China seeks to promote a more equitable and sustainable global energy order that balances developmental needs with climate imperatives.

6. Discussion

The preceding analysis has established the multifaceted relationship between China's new-type energy system and its modernization trajectory. The following discussion synthesizes four core theoretical contributions implicit in the foregoing sections, which collectively redefine our understanding of energy governance in the context of large-scale developmental transformation.

Through positioning China's New-Type Energy System within global energy transition debates, this analysis advances international discussions on decarbonization by challenging narrowly market-centric interpretations. It thereby enriches the academic discourse by integrating policy-driven and multi-stakeholder perspectives. Existing literature on global energy transitions has predominantly

emphasized technological substitution, cost reduction, and market liberalization as primary drivers of transformation[9]. While these dimensions remain important, the Chinese case demonstrates that high-renewable energy transitions are fundamentally institutional and governance-intensive processes that cannot be adequately explained through technology or markets alone.

First, this study advances the conceptualization of energy security under conditions of high renewable penetration. Much of the international literature continues to associate energy security with diversification of supply sources, geopolitical risk management, or fuel import dependence. However, China's experience illustrates a shift toward a system-oriented understanding of security, in which grid stability, coordination capacity, and resilience against non-traditional risks become central. This finding aligns with emerging work on energy systems as complex socio-technical configurations, while extending it by highlighting the role of state-led coordination in managing systemic volatility. In this sense, energy security is redefined not as the absence of external dependence, but as the capacity to govern complexity over long time horizons.

Second, the institutional foundations of the new-type energy system underscore the limits of governance fragmentation in energy transitions. Comparative studies have shown that liberalized energy markets often struggle to deliver system-level coordination, particularly when renewable energy deployment accelerates faster than grid adaptation. China's integrated institutional framework—combining strategic planning, public ownership of critical infrastructure, and selective market mechanisms—offers an alternative governance pathway. Rather than replacing markets, this model embeds them within a broader institutional architecture oriented toward system stability and long-term investment credibility. This challenges prevailing assumptions that market liberalization is a necessary precondition for successful decarbonization.

Third, by situating energy transition within the broader logic of Chinese modernization, this study contributes to debates on development pathways in the Global South. International scholarship frequently treats energy transition as a sectoral policy domain, disconnected from questions of industrial upgrading, social stability, and state capacity. The Chinese case suggests that energy systems can function as strategic instruments of modernization, simultaneously supporting economic restructuring, technological upgrading, and ecological objectives. This integrated approach highlights the importance of contextualizing energy transitions within national development trajectories rather than applying uniform policy prescriptions.

Finally, the findings have broader implications for global energy governance. As climate change intensifies and geopolitical uncertainties persist, the resilience of national energy systems will become an increasingly salient concern. The Chinese experience indicates that successful energy transitions require governance capacity capable of coordinating infrastructure investment, managing systemic risk, and aligning short-term efficiency with long-term security. While institutional arrangements are not universally transferable, the underlying principle—that energy transition is as much a governance challenge as a technological one—holds relevance across diverse national contexts.

7. Conclusion

The construction of a new-type energy system is a pivotal step in China's transition towards a cleaner, more sustainable energy future. This transformation is essential for achieving the broader goals of Chinese modernization, particularly in the areas of national security, environmental sustainability, and economic growth. By continuing to innovate and expand its energy infrastructure, China will strengthen its position as a global leader in energy transition and contribute to the global effort to combat climate change.

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