

Perspective

Energy Policy and Energy Management in China: Governance Logic and Future Pathways of Structural Transformation

Haixin Huang¹, Haowei Qie², Runyi Du³ and Feng Liu^{2,3,*} 

¹ School of Economics and Management, Northwest University, Xi'an 710127, China; 202310015@stumail.nwu.edu.cn

² School of Mechanical Engineering, Hebei University of Science and Technology, Shijiazhuang 050018, China; 2025107146@stu.hebust.edu.cn

³ International Research Center for Renewable Energy, State Key Laboratory of Multiphase Flow in Power Engineering, Xi'an Jiaotong University, Xi'an 710049, China; runyi@stu.xjtu.edu.cn

* Correspondence: fengliu@hebust.edu.cn

Abstract

China's energy policy and management are transitioning from scale expansion to systemic restructuring. During the 14th Five-Year Plan period (2021–2025), renewables accounted for approximately 60% of installed capacity, and the Energy Law took effect. Entering the 15th Five-Year Plan period (2026–2030), binding targets require non-fossil energy to reach 25% of primary consumption and 50% of electricity generation. Meanwhile, the management system is shifting from dual control over energy consumption to dual control over carbon emissions. This paper examines China's energy governance transition across three dimensions: policy evolution, management challenges, and institutional restructuring. In terms of policy, the 14th Five-Year Plan saw accelerated green transition, while the 15th centers on carbon peaking, shifting from scale to structure-orientation, and from policy-driven to rule-of-law-based governance. In terms of management, four challenges emerge, including tensions among security, low-carbon, and economic objectives, bottlenecks in new energy integration, social costs of transitioning traditional energy roles, and governance hurdles in digital transformation, revealing structural barriers to policy implementation. In terms of institutional restructuring, rule of law, marketization, and systematization are advancing in parallel, shaping the institutional framework for governance modernization. Looking ahead, computing-energy coupling, zero-carbon industrial park experiments, and international governance dimensions are emerging as frontier issues. This paper argues that China's energy transition is not merely technological or industrial, but a fundamental shift in governance logic. The modernization of governance capacity, rather than unidimensional gains in installed capacity or technical metrics, determines the transition's success. The deep shift from scale expansion to systemic restructuring, and from administrative dominance to institutional governance, will shape the future of China's energy development.

Keywords: energy policy; energy management; energy governance; carbon peaking and carbon neutrality goals; new energy system

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1. Introduction

Energy is a fundamental driving force of economic and social development, and its production, distribution, and consumption are deeply embedded in national development strategies, ecological and environmental quality, and daily life [1]. Global climate

governance is accelerating, the geopolitical landscape is shifting profoundly, and a new technological and industrial revolution is rising. Against this backdrop, energy issues have long transcended the narrow domain of technical supply. They have increasingly become a composite governance challenge integrating economic efficiency, national security, ecological constraints, and social equity [2,3]. How energy policies are formulated and how energy management is implemented directly bear on the fundamental transformation of development models, the reconfiguration of regional interests, and the practical assumption of intergenerational responsibilities [4,5].

China is at a critical historical juncture in its energy transition. During the 14th Five-Year Plan period (2021–2025), observed outcomes include: the share of renewable energy installed capacity in total national installed capacity rose from approximately 40% to about 60%, the share of non-fossil energy in primary energy consumption reached 21.7%, and the energy self-sufficiency rate remained above 84%. The construction of a national unified electricity market was accelerated, and the Energy Law of the People's Republic of China was officially promulgated and implemented, establishing the basic framework for energy governance at the legal level [6,7]. Entering 2026, with the full launch of the 15th Five-Year Plan, a series of major policies, including the 15th Five-Year Plan for Building a New Energy System and the 15th Five-Year Plan Action Plan for Carbon Peaking, have been issued. These policies explicitly set binding targets for 2030: a 25% share of non-fossil energy in primary energy consumption, a 50% share in electricity generation, and wind and solar power installed capacity exceeding 50% [8,9]. New energy is accelerating its transition from a supplementary power source to a main power source in the electricity system, and the energy management system is undergoing a profound shift from dual control over energy consumption to dual control over carbon emissions. It can be said that China's energy policy and energy management are at a historic threshold of transition from scale expansion to systemic restructuring. The intensive introduction of policies and the accelerated reshaping of institutions provide rich empirical material and urgent practical demand for academic scrutiny.

Existing research has accumulated a considerable body of literature on China's energy policy transition, renewable energy development, electricity market reform, and carbon emissions trading [10–12]. However, most studies focus on a specific policy instrument or technological pathway. They rarely place policy evolution, management systems, and institutional change within a unified governance analytical framework for systematic examination. They pay more attention to the technical feasibility and economic optimality of energy transition [13,14], while lacking sufficient academic synthesis and forward-looking assessment of the inherent tensions among policy objectives, structural obstacles to institutional implementation, and the political-economic logic behind multiple value prioritizations. It is precisely at this intersection of academic space and practical reality that this paper attempts to systematically examine the transition logic of China's energy governance from three dimensions: policy evolution, management challenges, and institutional restructuring. The paper first reviews the stage-specific characteristics and paradigm shift trajectory of energy policy from the 14th to the 15th Five-Year Plan period, then analyzes the practical tensions and adjustment pathways among the triple objectives of security, low-carbon development, and economic efficiency in management practice, and finally explores the institutional implications and future directions of the transition from dual control over energy consumption to dual control over carbon emissions. It aims to provide an analytical framework that combines policy sensitivity and academic insight for understanding the internal logic of China's energy transition.

From a theoretical perspective, this paper contributes to the growing literature on

energy governance and sustainability transitions in three ways. First, it proposes “governance logic transformation” as an analytical concept that is distinct from, yet complementary to, existing frameworks such as socio-technical transitions, energy governance regimes, and policy paradigms [15–19]. Second, it identifies three interrelated transformation trajectories, from scale expansion to systemic restructuring, from politically driven regulation to rule-based governance, and from energy consumption control to carbon emission control. These analytical categories are constructed by the authors through inductive analysis of policy documents and governance practices, rather than as official policy terminology. Third, it explicates the causal mechanisms through which governance structures, institutional arrangements, and policy instruments interact to shape the direction and pace of China’s energy transition. These contributions speak not only to China’s own transition but also to broader international debates on energy governance. Several aspects of China’s experience have wider theoretical implications: the concept of governance logic transformation as a third-order change; the causal chain linking policy objectives, implementation barriers, and institutional responses; and the hybrid governance model that combines rule of law, marketization, and systematization. At the same time, other aspects are closely tied to China’s specific institutional and economic context, such as the central role of five-year planning, the dual control system, and the state’s capacity to coordinate large-scale infrastructure and industrial policies. Clarifying this distinction helps international readers assess which lessons are transferable and which are context-dependent.

2. Analytical Framework and Methodology

2.1. Theoretical Foundation: Governance Logic Transformation

The concept of “governance logic transformation” is central to this paper. We define governance logic as the underlying rationale, value orientation, and institutional principles that guide how energy policy objectives are formulated, how governance mechanisms are designed, and how policy instruments are selected and implemented. Governance logic transformation thus refers to a fundamental shift in these underlying rationales and principles, rather than merely a change in policy content or governance tools.

This concept draws on and extends existing theory. From socio-technical transition theory [15,16], we adopt the insight that transitions involve co-evolutionary changes across technology, policy, markets, and user practices. From energy governance theory [17,18], we take the emphasis on institutional arrangements, actor constellations, and multi-level coordination. From policy paradigm theory [19], we incorporate the notion that policy change occurs at different orders, with third-order change involving a shift in the overarching goals and problem definitions themselves.

Building on these foundations, we argue that China’s energy governance is undergoing a third-order change—a transformation not merely in policy settings or instruments, but in the underlying logic that defines what energy governance is for and how it should operate. This transformation is characterized by three analytical trajectories: (1) from scale expansion to systemic restructuring, (2) from politically driven regulation to rule-based governance, and (3) from energy consumption control to carbon emission control. These trajectories are not derived from official policy documents but are analytical categories constructed by the authors through inductive analysis of policy texts, statistical data, and governance practices. They serve as conceptual tools for explaining why and how China’s energy governance is transforming.

The mechanisms linking governance structures, institutional arrangements, and policy instruments can be summarized as follows. Governance structures refer to how

authority, responsibility, and coordination mechanisms are distributed among state, market, and societal actors. They shape the range of feasible institutional arrangements. Institutional arrangements—the formal rules, norms, and organizational forms that govern energy production, distribution, and consumption—determine which policy instruments are available and effective. Conversely, changes in policy instruments can reinforce or undermine institutional arrangements, and institutional learning can gradually reshape governance structures [20]. In China's case, the shift from dual control over energy consumption to dual control over carbon emissions exemplifies how a change in the assessment logic (a governance structure element) cascades into new institutional arrangements (carbon assessment systems, carbon markets) and new policy instruments (carbon emission trading, green certificates), while also being reinforced by these very instruments.

2.2. Analytical Dimensions and Source Selection

The three analytical dimensions employed in this paper, including policy evolution, management challenges, and institutional restructuring, are constructed by the authors to capture the causal chain of “policy objectives—implementation barriers—institutional responses.” Policy evolution traces the shift in energy policy from the 14th to the 15th Five-Year Plan period. Management challenges identify the structural tensions and implementation obstacles that emerge when policy targets confront governance reality. Institutional restructuring examines how governance systems adapt through rule of law, marketization, and systematization. These dimensions are analytical categories, not official policy terminology.

The analysis timeframe spans from 2021 to 2030, covering the full cycle of the 14th Five-Year Plan (2021–2025) and the opening period of the 15th Five-Year Plan (2026–2030). This timeframe is selected because it captures the critical transition from accelerated renewable energy deployment to carbon peaking, and from dual control over energy consumption to dual control over carbon emissions.

Sources of policy documents and data include: (1) official policy documents issued by the National People's Congress, the State Council, the National Development and Reform Commission, the National Energy Administration, and other relevant ministries; (2) statistical data from the National Bureau of Statistics, the National Energy Administration, and the China Electricity Council; (3) official press conferences and reports; and (4) peer-reviewed academic literature retrieved from Web of Science, Scopus, and CNKI. Policy documents were selected based on the following criteria: national-level issuance, direct relevance to energy policy or energy management, and binding or guiding force for energy governance.

The analysis employs text analysis, policy interpretation, comparative analysis, and inductive reasoning to identify patterns and causal relationships in China's energy governance transformation [21,22]. By explicitly stating the analytical framework and methodological choices, this paper aims to enhance the transparency, coherence, and reproducibility of the analysis. These three analytical dimensions are not independent but are linked through a clear causal chain. Policy evolution defines the objectives and paradigm shifts of China's energy governance. Management challenges identify the structural tensions and implementation barriers that emerge when these objectives confront governance reality. Institutional restructuring examines how governance systems respond to these challenges through rule of law, marketization, and systematization. Together, they explain the transition from capacity expansion-oriented management to structural transformation-oriented governance.

3. Policy Evolution: From Scale Expansion to Systemic Restructuring

The evolution of energy policy is both an institutional reflection of the energy industry's development trajectory and a concentrated expression of national strategic intent in the energy sector [4,23,24]. Looking back at the 14th Five-Year Plan period (2021–2025), China's energy policy took green and low-carbon transition as its main line, promoting leapfrog development of renewable energy while maintaining energy supply security [25–28]. Entering the opening year of the 15th Five-Year Plan period (2026–2030), policy objectives have shifted from scale orientation to structure orientation. The introduction of a series of binding targets marks a profound transition from “encouragement and guidance” to “rigid constraints” [21,22,29,30]. A systematic review of this policy evolution helps to grasp the internal logic and development direction of China's energy governance.

3.1. The 14th Five-Year Plan Period: Accelerated Green Transition

The 14th Five-Year Plan period was the fastest five years of China's green and low-carbon energy transition. In terms of overall achievements, China built the world's largest and fastest-growing renewable energy system during this period. According to observed statistics, by the end of 2025, total installed renewable energy capacity reached 2.337 billion kilowatts, accounting for approximately 60% of the national total power installed capacity, up from around 40% at the beginning of the 14th Five-Year Plan period (Figure 1) [31,32]. Renewable energy generation reached 3.99 trillion kilowatt-hours, accounting for 38.5% of total electricity consumption [25]. In 2025, China added 452 million kW of renewable energy installed capacity, accounting for 83% of the national total new power capacity. Wind power added 120 million kW (up 51% year-on-year), and solar power added 318 million kW (up 14% year-on-year). Renewable energy generation covered the entire national electricity consumption increment: 519.3 billion kWh of new renewable generation versus 516.1 billion kWh of total electricity consumption growth [32]. Cumulative grid-connected installed capacity of wind and solar power reached 1.84 billion kilowatts, historically surpassing thermal power installed capacity [8]. As shown in Figure 2, annual new installations of wind and solar power successively exceeded the 100 million, 200 million, and 300 million kilowatt thresholds, achieving stepwise leaps [33]. Meanwhile, the energy self-sufficiency rate increased from around 80% to over 84%, and China's energy volume ranked first in the world [33]. New-type energy storage installed capacity exceeded 100 million kilowatts, accounting for more than 40% of the global total, ranking first worldwide [34]. More specifically, the share of coal in total energy consumption declined from 56.7% in 2020 to 51.4% in 2025, a drop of 5.3 percentage points, while the share of primary electricity and other energy sources rose from 16.0% to 21.7%, an increase of 5.7 percentage points [35]. Non-fossil energy consumption historically surpassed oil to become China's second-largest energy consumption category, forming a new pattern of “four pillars” comprising coal, oil, gas, and non-fossil energy. These data indicate that during the 14th Five-Year Plan period, China not only achieved quantitative expansion in installed capacity but also completed an important shift in its energy structure from coal-dominated to diversified and clean.

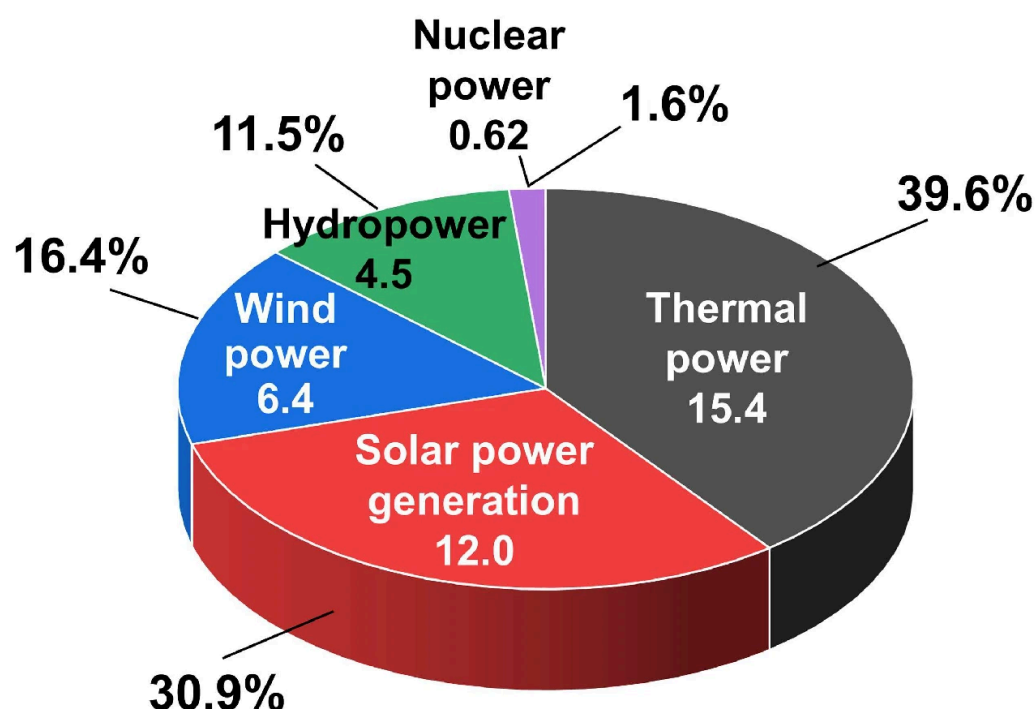


Figure 1. China's power installed capacity structure in 2025 (by source), unit: 100 million kW. Data source: National Energy Administration, 2025 national power statistics [32]. Notes: ① Data as of the end of 2025; ② Of the 1.54 billion kW of thermal power installed capacity, coal power accounts for approximately 1.26 billion kW, with its share dropping to 32.4%; ③ Wind and solar power combined total 1.84 billion kW, accounting for 47.3%, historically surpassing thermal power; ④ Total installed renewable energy capacity (including hydropower, wind, solar, biomass, etc.) reaches 2.34 billion kW, approximately 60% of the national total.

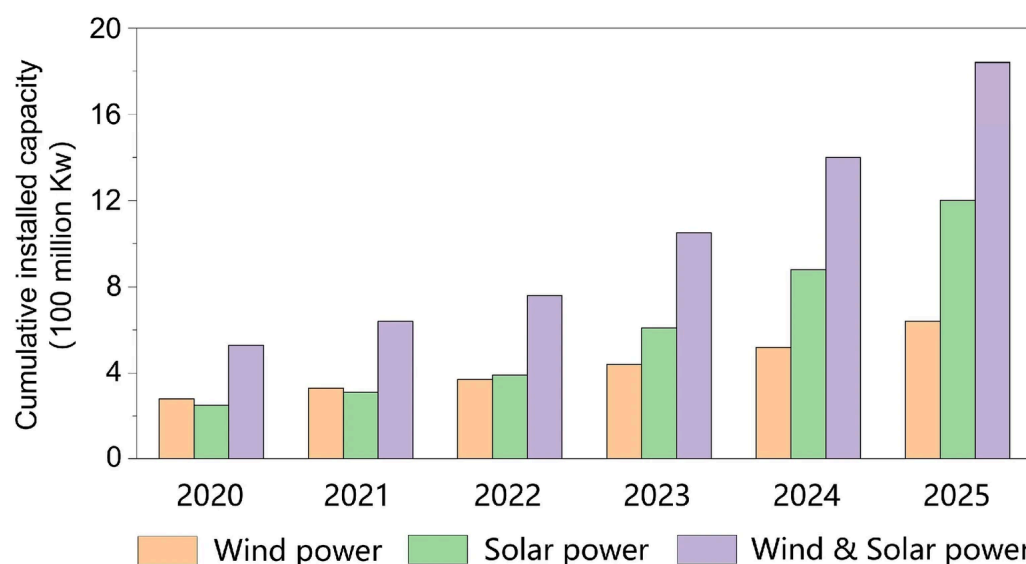


Figure 2. Cumulative installed capacity growth trend of wind and solar power in China (2020–2025). Data source: National Energy Administration, annual renewable energy grid-connected operation reports [33]. Notes: ① 2020 data based on the National Energy Administration's 2021 press conference disclosure (by the end of 2020, total installed renewable energy capacity was 930 million kW, accounting for 42.4% of total installed capacity); ② 2021–2024 data compiled from annual statistics of the National Energy Administration; ③ 2025 data based on the National Energy Administration's 2025 national power statistics; ④ During the 14th Five-Year Plan period, com-

bined new wind and solar installations reached approximately 1.31 billion kW, 3.4 times that at the end of the 13th Five-Year Plan period; ⑤ In the past four years, annual new wind and solar installations successively exceeded 100 million, 200 million, 300 million, and 400 million kW.

Institutional breakthroughs at the policy level also deserve attention. During the 14th Five-Year Plan period, the construction of a national unified electricity market system was accelerated. The average annual growth rate of market-based trading electricity reached 16.0%, and in 2025, annual market-based trading electricity increased by 109.7% compared with the end of the 13th Five-Year Plan period. The proportion of market-based trading electricity in total electricity consumption exceeded 60% for four consecutive years [11,36]. The electricity market covered intra-provincial and inter-provincial transactions spatially, annual, monthly, intraday, and real-time transactions temporally, and energy trading as well as ancillary services such as peak regulation, frequency regulation, and reserve [37,38]. In 2025, the national unified electricity market system was initially established [39]. The allocation of electricity resources thus underwent a fundamental change, with the market replacing planning as the basic mechanism for electricity resource allocation [40,41].

More profound changes occurred at the legal level. On 8 November 2024, the 12th Session of the Standing Committee of the 14th National People's Congress voted to pass the Energy Law of the People's Republic of China, which came into effect on 1 January 2025. The law consists of nine chapters and eighty articles, covering general provisions, energy planning, energy development and utilization, energy market system, energy reserves and emergency response, energy science and technology innovation, supervision and management, legal liability, and supplementary provisions. In the past, single laws such as the Electric Power Law, Coal Law, and Renewable Energy Law focused on a specific energy sector, and the energy legal relations they adjusted had certain limitations. The Energy Law, however, regulates key common legal relations across the entire energy industry chain, including upstream, midstream, and downstream, as well as production, supply, storage, and sales. According to the relevant responsible person of the Legislative Affairs Commission of the Standing Committee of the National People's Congress, enacting the Energy Law is a legal achievement of deeply practicing the "Four Revolutions, One Cooperation" energy security new strategy, an external declaration of the Chinese government's medium- and long-term energy strategy and policies, and an important milestone in improving the energy legal system [6]. The promulgation and implementation of the Energy Law marks a key step in China's energy governance transition from policy-driven to law-driven.

As the concluding year of the 14th Five-Year Plan, 2025 saw the National Energy Administration issue the Guiding Opinions on Energy Work in 2025, which set clear annual targets: national total power installed capacity reaching over 3.6 billion kW, with new energy power installed capacity increasing by more than 200 million kW [42]. The share of non-fossil energy power installed capacity was to increase to around 60%, and the share of non-fossil energy in total energy consumption to around 20%. The Guiding Opinions also proposed the initial establishment of a national unified electricity market system. The setting and achievement of these targets both summarized the energy work of the 14th Five-Year Plan period and laid the foundation for the continued development of the 15th Five-Year Plan period.

3.2. The 15th Five-Year Plan Period: The Critical Period for Carbon Peaking

2026 is the opening year of the 15th Five-Year Plan period and the first year of China's comprehensive shift from dual control over energy consumption to dual control over carbon emissions. A series of major policies were intensively issued during this pe-

riod, outlining a clear roadmap for energy development over the next five years.

Systematic layout of top-level design. In March 2026, the Outline of the 15th Five-Year Plan was officially released, making “actively and prudently promoting and achieving carbon peaking” an independent chapter and clarifying the overall requirements and key tasks for carbon peaking during the 15th Five-Year Plan period [43,44]. In June, the National Development and Reform Commission and the National Energy Administration jointly issued the 15th Five-Year Plan for Building a New Energy System [9]. The plan positions the 15th Five-Year Plan period as a superposition of five critical phases: a period of overlapping and evolving security risks, a period of intensified low-carbon transition, a period of accelerated energy innovation breakthroughs, a period of deep institutional reform, and a period of adjustment and reshaping of international co-operation. It proposes to initially build a clean, low-carbon, safe, and efficient new energy system by 2030 [7].

Operationalization of binding targets. The “dual carbon” goals have been transformed from abstract strategic slogans into a set of measurable and assessable binding indicators (as shown in Table 1). The 15th Five-Year Plan for Building a New Energy System explicitly proposes policy targets for 2030: the share of non-fossil energy in primary energy consumption reaches 25%, the share of non-fossil energy in electricity generation reaches 50%, and the installed capacity share of wind and solar power exceeds 50% [7]. National comprehensive energy production capacity reaches 5.8 billion tons of standard coal, and national total power installed capacity reaches 5.4 billion kW (a net increase of 1.51 billion kW compared with 3.89 billion kW in 2025). The reduction in carbon dioxide emissions per unit of electricity generation exceeds 10% [44]. Vertically, China’s non-fossil energy consumption share reached 21.7% in 2025 and needs to rise to 25% by 2030, meaning it must increase by 3.3 percentage points over the next five years. Horizontally, wind and solar installed capacity exceeding 50% and non-fossil energy generation accounting for 50%. These two “50%” targets mark that new energy will historically leap from a supplementary power source to a main power source in the electricity system. This is a milestone node in the fundamental transformation of the energy structure.

Table 1. Comparison of observed outcomes (2025) and policy targets (2030) for core energy development indicators.

Indicator	End of 14th Five-Year Plan (2025)	15th Five-Year Plan Target (2030)	Direction of Change
Share of non-fossil energy in primary consumption	21.7%	25%	↑
Share of non-fossil energy in electricity generation	/	50%	New binding indicator
Installed capacity share of wind and solar power	~46%	>50%	↑
National total power installed capacity	3.89 billion kW	5.4 billion kW	↑
Comprehensive energy production capacity	/	5.8 billion tons standard coal	New total volume target

Indicator	End of 14th Five-Year Plan (2025)	15th Five-Year Plan Target (2030)	Direction of Change
Reduction in CO ₂ emissions per unit of electricity generation	/	>10%	New binding indicator
Energy management system	Dual control over energy consumption	Dual control over carbon emissions	Institutional transition

Notes: ① “/” indicates that the indicator was not publicly disclosed as an independent statistical or assessment indicator at the end of the 14th Five-Year Plan period; ② Column “End of 14th Five-Year Plan (2025)” reports observed outcomes based on National Energy Administration’s 2025 annual statistics and information disclosed at the State Council Information Office press conference on the achievements of high-quality energy development during the 14th Five-Year Plan; ③ Column “15th Five-Year Plan Target (2030)” reports policy targets set in the 15th Five-Year Plan for Building a New Energy System and the 15th Five-Year Plan Action Plan for Carbon Peaking; ④ Dual control over energy consumption refers to dual control over total energy consumption and intensity; dual control over carbon emissions refers to dual control over total carbon emissions and intensity; ⑤ “↑” indicates that the indicator increased.

Dual logic of substitution and expansion. In July 2026, the State Council issued the 15th Five-Year Plan Action Plan for Carbon Peaking [43,45]. As China’s last five-year action plan for achieving the goal of carbon peaking before 2030, the plan clearly states that the 15th Five-Year Plan period is a critical period for achieving carbon peaking. As observed in 2025, China’s carbon intensity—CO₂ emissions per unit of GDP—declined by 5.0% year-on-year, and by approximately 12% cumulatively during 2020–2025 [46]. The plan proposes overall targets: by 2030, carbon dioxide emissions per unit of GDP will decrease by 17% compared with 2025, and the share of non-fossil energy consumption will reach 25%. Substituting stock and expanding incremental volume is a main line running through the plan. On the one hand, it expands clean energy increments by vigorously developing non-fossil energy. On the other hand, it orderly reduces fossil energy stock by deeply promoting clean substitution of coal consumption. In terms of accelerating energy structure adjustment and optimization, the plan identifies four key tasks: vigorously promoting non-fossil energy development; accelerating the improvement of new energy consumption capacity in the power system; deeply promoting clean substitution of coal consumption; and continuously optimizing the oil and gas consumption structure. The plan also deploys two major projects: inter-provincial power mutual assistance and clean substitution of coal consumption. The former focuses on opening up new energy transmission channels and resolving the structural contradiction of reverse distribution between energy production areas and electricity load centers; the latter, with electrification and clean transformation as the starting point, promotes coal’s transition from a main energy source to a supporting, regulating, and backup energy source.

Special deployment for renewable energy. Almost simultaneously, the National Development and Reform Commission and the National Energy Administration jointly issued the 15th Five-Year Plan for Renewable Energy Development [7]. The plan proposes that during the 15th Five-Year Plan period, renewable energy will enter a new development stage of “expanding volume and improving quality, and reliable substitution.” “Expanding volume and improving quality” means comprehensively considering energy security supply and green low-carbon transition needs, maintaining reasonable development scale and pace, continuously increasing the share of renewable energy supply, and continuously improving the comprehensive efficiency of renewable energy development, transmission, and utilization. “Reliable substitution” means adhering to the principle of establishing the new before abolishing the old, and promoting renewable energy to “stand up” and “be reliable” faster, gradually achieving safe and reliable substi-

tution of traditional energy. The plan sets main targets in four aspects: total volume target—by 2030, total renewable energy consumption reaches approximately 1.8 billion tons of standard coal; power generation target—total installed renewable energy power capacity reaches approximately 3.5 billion kW, annual generation reaches approximately 6 trillion kWh, and total installed wind and solar power capacity reaches over 2.8 billion kW, with installed capacity share exceeding 50% [31]; non-electric utilization target—total non-electric utilization of renewable energy increases by 1.5 times compared with 2025; reliable substitution target—national average confidence output of wind and solar power reaches 8%, and during the 15th Five-Year Plan period, new reliable peak power generation capacity of renewable energy exceeds 300 million kW [7]. The plan deploys seven key tasks, covering expanding renewable energy power supply, enhancing reliable substitution capacity, promoting breakthroughs in non-electric utilization, improving consumption levels, consolidating technological and industrial advantages, improving policy systems and long-term mechanisms, and deepening international cooperation. In terms of spatial layout, the plan establishes five major growth sectors: the “Three North” wind and solar bases, the southwest hydro-wind-solar integrated bases, coastal nuclear power bases, offshore wind power bases, and distributed new energy. The plan also clearly promotes that 70% of the energy consumption increment in the eastern region during the 15th Five-Year Plan period will be guaranteed by local production. This means that the eastern coastal region will no longer be a mere energy recipient but will form considerable local supply capacity in offshore wind power, distributed photovoltaics, nuclear power, and other fields.

Spatial restructuring of the energy map. The superimposed effects of the above policies are fundamentally reshaping China’s energy map. The historic leap of new energy from an important increment to a dominant position is by no means simple capacity expansion but a deep restructuring of the functional architecture of the entire energy system. Based on policy targets, during the 15th Five-Year Plan period, non-fossil energy installed capacity is targeted to exceed 3.5 billion kW, an increase of nearly 50% compared with the end of the 14th Five-Year Plan period [9]. Such a massive installed capacity scale gives new energy the quantitative foundation to assume main responsibility. And a 50% share of non-fossil energy in electricity generation means that new energy must not only be installed but also become a solid supply force in power system operation [47]. At the same time, the coordinated layout of energy development and energy-using industries is being advanced, promoting the integrated development of electricity with advanced manufacturing, computing power, hydrogen energy, and other industries. New economic circulation relationships are forming between energy-resource-rich regions and key energy-using regions.

3.3. Theoretical Observations on Policy Paradigm Shift

A review of policy evolution from the 14th to the 15th Five-Year Plan period clearly reveals three paradigm shifts. First, the shift in assessment logic from dual control over energy consumption to dual control over carbon emissions. 2026, as the opening year of the 15th Five-Year Plan, is also the first year of China’s comprehensive shift from dual control over energy consumption to dual control over carbon emissions. The Third Plenary Session of the 20th Central Committee of the Communist Party of China explicitly proposed establishing a new mechanism for the comprehensive transition from dual control over energy consumption to dual control over carbon emissions. This shift is by no means merely a change in assessment indicators but a reconstruction of development logic. The previous dual control over energy consumption mainly focused on the total amount and intensity of energy consumption without distinguishing the “quality” of en-

ergy, that is, renewable energy consumption was also counted in total energy consumption, objectively constraining the development of clean energy to some extent [48]. Dual control over carbon emissions shifts the focus of control from “how much energy is used” to “how much carbon is emitted,” directly aligning with carbon reduction targets [44]. It encourages renewable energy development (since green electricity consumption is no longer restricted by energy consumption limits) while precisely controlling fossil energy, guiding the energy structure toward deep low-carbon and clean transition. The dual control over carbon emissions system includes multi-level control mechanisms such as local carbon assessment, industry carbon control, enterprise carbon management, project carbon evaluation, and product carbon footprint [49]. As one commentary pointed out, shifting from dual control over energy consumption to dual control over carbon emissions, previously focusing mainly on the amount of energy consumed without distinguishing its quality, now directly converting to how much carbon dioxide is emitted, reflects a profound change in governance logic.

Second, the shift in governance approach from policy-driven to rule-of-law-based. The promulgation and implementation of the Energy Law is a milestone in China’s energy rule-of-law construction. Before this, energy governance mainly relied on various policy documents, guiding opinions, and planning texts, lacking a basic and overarching law to regulate key common legal relations across the entire energy industry chain, including upstream, midstream, and downstream, as well as production, supply, storage, and sales [9]. The introduction of the Energy Law means that energy governance is moving from campaign-style promotion and document-based management to institutionalized, normalized, and rule-of-law-based governance [6]. Of course, there is still a considerable distance from “having laws to abide by” to “administering according to law.” The revision of the Electric Power Law and the Renewable Energy Law is underway, and a large number of supporting institutional constructions still require time. But the determination of the direction of rule of law itself is a profound shift in policy paradigm.

Third, the shift in strategic thinking from scale expansion to systemic restructuring. The core task during the 14th Five-Year Plan period was to “expand the increment”, expanding renewable energy installed capacity and increasing the share of non-fossil energy consumption. The task during the 15th Five-Year Plan period is more complex: not only to continue expanding volume but also to improve quality; not only to increase increment but also to substitute, that is, replacing fossil energy with clean energy; not only to consider supply-side expansion but also to coordinate consumption, storage, power grids, and other system links [7]. The focus of policy is shifting from single-dimensional scale targets to system optimization under multi-objective constraints. The 15th Five-Year Plan for Building a New Energy System proposes adhering to three principles: integrated integration (promoting multi-energy complementary integration among different types of renewable energy and between renewable energy and other energy sources), multi-dimensional coordination (strengthening target coordination, power source coordination, grid-source coordination, and factor coordination), and efficient and orderly (placing efficiency and benefits in a more important position) [9]. The proposal of these principles itself indicates that policymakers have realized that energy transition is not a simple replacement but a holistic transformation requiring systemic thinking.

In summary, the evolution of China’s energy policy from the 14th to the 15th Five-Year Plan period clearly presents an institutional change trajectory from scale expansion to systemic restructuring, from policy guidance to rule-of-law guarantee, and from energy consumption control to carbon emission control. From the authors’ analytical perspective, this trajectory not only reflects the development laws of the energy industry itself but also mirrors the deep evolution of national governance concepts in the energy

field, from pursuing “quantitative growth” to pursuing “qualitative improvement,” from “single-point breakthroughs” to “systemic integration,” and from “administrative promotion” to “institutional governance.” This trajectory sets the stage for the management challenges analyzed in Section 4 and the institutional responses examined in Section 5. Understanding this evolutionary logic is a prerequisite for grasping the practical challenges and future direction of China’s energy management.

4. Management Challenges: Synergy Among Security, Low-Carbon, and Economic Objectives

Building on the policy evolution analyzed above, this section examines the management challenges that arise when these policy objectives are translated into governance practice. These challenges constitute the intermediate link between policy goals and institutional responses, revealing why and how the transition from capacity expansion to structural transformation generates tensions and implementation barriers. A central theme running through these challenges is the inherent tension among three objectives: maintaining energy supply security, supporting economic growth, and achieving low-carbon transition. These objectives are not always mutually reinforcing. Energy security concerns may justify continued reliance on fossil fuels, which conflicts with decarbonization goals; rapid renewable energy expansion may strain grid stability and increase system costs, affecting economic efficiency; and aggressive carbon reduction may impose short-term economic burdens on coal-dependent regions and industries. Governance mechanisms must therefore manage these trade-offs rather than assume that all objectives can be maximized simultaneously.

Policy target setting is one matter; policy implementation is another. In the evolution of China’s energy policy from the 14th to the 15th Five-Year Plan period, the objectives have become clear: a 25% share of non-fossil energy in primary energy consumption, a 50% share in electricity generation, and wind and solar installed capacity exceeding 50%. However, from policy texts to governance reality, multiple structural challenges persist. The complexity of energy management lies precisely in the fact that security, low-carbon development, and economic efficiency are not naturally compatible; profound tensions exist among them. During the 15th Five-Year Plan period, as China’s energy development enters a critical stage characterized by the superposition of five phases, overlapping and evolving security risks, intensified low-carbon transition, accelerated energy innovation breakthroughs, deep institutional reform, and adjustment and reshaping of international cooperation. These tensions are further amplified in practice. This chapter examines the prominent challenges facing China’s energy management from four dimensions: the non-negotiable nature of energy security, systemic bottlenecks in renewable energy integration, social costs of the role transition of traditional energy, and the governance dilemmas of digital and intelligent transformation in energy management.

4.1. Energy Security: An Uncompromising Bottom Line

Energy security has always been the primary consideration in China’s energy policy. During the 15th Five-Year Plan period, the urgency of this bottom-line thinking has only increased. The 15th Five-Year Plan for Building a New Energy System lists building a strong and resilient energy security guarantee system as one of its six key tasks, highlighting the extreme importance of energy security in 15th Five-Year Plan development [9]. The global energy and climate landscape is undergoing profound adjustment: escalating geopolitical conflicts threaten the global energy supply system. After the escalation of the Middle East conflict in 2026, transportation volume through the Strait of

Hormuz, a critical global energy chokepoint, declined sharply for a time [50]. This waterway normally carries about one-quarter of global seaborne oil trade and handles substantial LNG shipments. More than 30 countries or regions worldwide have proposed local content requirements and exclusionary restrictive measures for new energy equipment [51]. The trend toward bloc-based and regionalized energy trade has accelerated markedly, and competition over energy control, trade route dominance, and market pricing has intensified. These dramatic changes in the external environment have elevated energy security from a routine issue to a strategic bottom line.

Structural constraints imposed by resource endowments constitute an inherent dilemma for energy security. China's resource endowment, that is, rich in coal, poor in oil, and deficient in gas, determines a high dependence on international markets for oil and gas supply (Table 2). In 2025, China's crude oil imports reached approximately 578 million tons, and natural gas import dependence was about 40% [52]. The vulnerability of oil, gas, and nuclear fuel supply chains means that China's energy security is, to a considerable extent, subject to geopolitical fluctuations and the smooth functioning of key maritime chokepoints. As some analyses have pointed out, relying solely on domestic resources is insufficient to fully withstand external shocks; deepening international energy cooperation is an intrinsic requirement for addressing security challenges [53].

Table 2. China's oil and gas import dependence and key chokepoint risks (2025).

Energy Type	Import Dependence (%)	Key Chokepoint Risk (%)	Risk Description
Crude oil	72.7%	22%	Imports through the Strait of Hormuz account for 22% of national consumption
Natural gas	40%	6.6%	LNG imports through the Strait of Hormuz account for 6.6% of national consumption
Uranium	80%	/	Over 80% of uranium demand for nuclear power units relies on imports

Notes: ① Crude oil import dependence of 72.7% and natural gas import dependence of 40% are 2025 data; ② Strait of Hormuz data are based on remarks by Zhang Yuqing, former deputy director of the National Energy Administration, at the China Energy Week Forum in May 2026; ③ "Key chokepoint risk" refers to the proportion of imports through the Strait of Hormuz in total domestic consumption, reflecting the impact of a single chokepoint disruption on energy supply.

The hidden costs of the "security premium" are emerging. The tilt of the strategic balance toward security is not without cost. On the one hand, international oil and gas price volatility and rising transportation costs directly push up import costs. On the other hand, maintaining fossil energy production capacity reserves, building strategic petroleum reserves, and diversifying import routes to safeguard energy security all require sustained investment. More importantly, the tension between security considerations and low-carbon objectives is becoming increasingly prominent [54]. Before new energy can form reliable substitution capacity, the backup role of fossil energy means that rigid carbon emission constraints cannot be achieved overnight [55]. How to find a dynamic balance between security backup and low-carbon transition is the primary strate-

gic challenge facing China's energy management. This tension also has an economic dimension. Maintaining fossil fuel backup capacity and strategic reserves imposes additional costs on the energy system, which may be passed on to consumers or require fiscal subsidies. At the same time, over-reliance on imported oil and gas exposes the economy to price volatility and supply disruptions, while under-investment in domestic renewable energy could slow the growth of green industries. Thus, energy security is not merely a physical supply issue but also an economic and fiscal one. Governance mechanisms must weigh the costs of security premiums against the benefits of reduced import dependence and long-term economic resilience.

4.2. Renewable Energy Integration: Systemic Bottlenecks Amid Rapid Growth

If energy security is a challenge brought by external shocks, renewable energy integration is a problem arising from internal structural factors. The growth rate of China's renewable energy installed capacity is unmatched globally [56–58]. By the end of September 2025, the cumulative installed capacity of wind and solar power reached 1.71 billion kW, accounting for 46% of national total power installed capacity [26,30,59]. However, the rapid expansion of installed capacity is exposing deep-seated structural contradictions.

Integration pressure is intensifying across the board. In the first three quarters of 2025, national utilization rates for wind and solar power were 94.0% and 94.7%, respectively, and integration pressure further emerged against the backdrop of rapid renewable energy growth [60,61]. Utilization rates in some resource-rich regions were below the national average [62]. The scope of wind and solar curtailment has expanded from the traditional "Three North" region to central and eastern regions, and the monthly distribution of curtailment has become broader, with the proportion of curtailment during non-heating periods continuing to rise [58]. This means that renewable energy integration is no longer a local problem in resource-rich northwest regions but is evolving into a nationwide systemic issue.

The root of the integration dilemma lies in the structural mismatch of "generating, transmitting, and consuming." First is the spatial mismatch between power sources and load centers. The "Three North" and western regions, rich in renewable energy resources, are far from eastern electricity load centers, and the construction speed of inter-provincial and inter-regional transmission corridors cannot match the explosive growth of renewable energy installed capacity [56,61]. Second is temporal mismatch. The randomness, volatility, and intermittency of renewable energy output make it difficult to match the timing of electricity load [63]. As wind and solar installed capacity continues to grow and exceeds the system's peak electricity load, the net load characteristics of the power system are undergoing fundamental changes, and the "scissors gap" between source growth and load growth will further increase regulation demand. Third is institutional mismatch. The construction of regulation capacity lacks coordinated optimization, existing regulation resources are not fully utilized, and price mechanisms and market mechanisms remain imperfect [62,64].

Distorted market signals further amplify integration difficulties. During periods of high renewable energy output, negative electricity prices have appeared in some spot markets, reflecting short-term supply-demand imbalances and insufficient system flexibility [64]. Renewable energy faces prominent issues such as increased revenue uncertainty and weak bargaining power. When price mechanisms cannot effectively guide resource allocation, the paradox of "building more, losing more" may inhibit the sustainable development of the renewable energy industry. To address these challenges, the National Development and Reform Commission and the National Energy

Administration issued the Implementation Plan for the Special Action on Optimizing Power System Regulation Capacity (2025–2027) in early 2025, proposing to support the reasonable integration and utilization of more than 200 million kW of new renewable energy annually through optimized regulation capacity construction, with a national renewable energy utilization rate of no less than 90% [63]. Achieving this target depends on the coordinated advancement of systemic projects such as coal power flexibility retrofitting, pumped-storage hydropower, new-type energy storage, and grid intelligence. However, these measures require substantial investment, and their costs must ultimately be recovered through electricity prices or government support. If integration costs are too high, they may undermine the economic competitiveness of renewable energy and slow the pace of substitution. Conversely, if integration is neglected, curtailment will waste clean energy resources and reduce the return on renewable investment, weakening the economic sustainability of the transition. Therefore, resolving integration bottlenecks is not only a technical and institutional task but also an economic one: governance must design cost-sharing mechanisms that balance the interests of power generators, grid operators, consumers, and taxpayers.

4.3. Role Transition of Traditional Energy and Social Costs

Energy transition is not only an addition, increasing clean energy installed capacity, but also subtraction and substitution: reducing the share of fossil energy and replacing the role of traditional energy. The difficulty of subtraction is often far greater than that of addition.

The role of coal power is undergoing a fundamental transformation. Coal power, which has been the absolute mainstay of electricity supply for decades, faces a historic repositioning from a basic guaranteed power source to a supporting and regulating power source [43]. In its reply to a suggestion from the National People's Congress, the National Energy Administration explicitly pointed out that against the backdrop of large-scale and rapid development of new energy, thermal power is facing a major challenge of transitioning from a traditional main power source to a dual role as both a basic guaranteed and system-regulating power source [21]. This shift means that coal power generation will gradually peak and enter a plateau, with its function changing from “generating more and supplying more” to “flexible regulation”. Reducing output or even shutting down when renewable energy output is high, and rapidly supplementing supply when renewable energy output is insufficient.

Behind this role transition lie enormous asset stranding risks and employment reallocation pressures. China's existing coal power fleet is massive [65]. A sharp contradiction exists between the remaining service life of large numbers of coal power assets and the carbon peaking time window. Early retirement means the sinking of huge assets, while continued operation means exceeding carbon emission targets [21]. The profit model of coal power enterprises is also being impacted during the transition: from “generating electricity equals profit” in the past to relying on capacity electricity prices and ancillary services markets for revenue [66]. Although China has established a coal power capacity electricity price mechanism, corporate financial pressure during the transition, fluctuations in local fiscal revenue, and adjustments to the economic structure of coal-producing regions are all practical difficulties that energy management cannot avoid.

The social justice dimension of a just transition also cannot be ignored. The costs of energy transition are not evenly distributed. Coal resource-rich regions such as Shanxi, Shaanxi, Inner Mongolia, and Xinjiang will bear greater employment losses and fiscal shocks, and workers in the coal power industry face challenges of skill resetting and reemployment [67]. The benefits of renewable energy development flow more to manu-

facturing-developed regions and coastal provinces [68]. How to embed compensation mechanisms in policy design and how to achieve equitable regional transition through transfer payments and industrial support are value questions that energy management must address when moving from technical optimization to social governance. As one commentary noted, coal power will experience a development path of capacity increase with volume control, plateau, and gradual decline, and the pace and intensity of this process are essentially a matter of political-economic trade-offs [69]. This observation highlights a broader governance challenge: the transition away from traditional energy dependence cannot be achieved through technical or regulatory measures alone. It requires coordinated policies that address regional economic restructuring, worker retraining, fiscal transfers, and social protection. Without such complementary measures, the economic and social costs of the transition may generate resistance, slow implementation, and undermine public support for decarbonization. In this sense, a just transition is not merely a normative aspiration but a functional prerequisite for the durability of China's energy governance transformation.

4.4. Digital and Intelligent Transformation of Energy Management

The rapidly increasing complexity of the energy system is forcing a transformation of energy management from traditional experience-driven approaches to data- and intelligence-driven approaches [70,71]. However, this transformation itself also constitutes a new governance challenge.

The energy system has become a typical data-intensive complex giant system. Hundreds of millions of power generation devices, transmission lines, and electricity consumption terminals generate massive amounts of data every day. In theory, these data can support precise forecasting, intelligent dispatch, and lean management, but reality is far from ideal. The energy sector has long faced a triple technical bottleneck of data silos, fragmented computing power, and algorithmic black boxes [70]. Data standards and interfaces are inconsistent among different energy subsystems (coal, oil, gas, electricity, heat). Data from different links within the same system (generation, transmission, distribution, consumption) are also often fragmented. Energy enterprises generally face problems such as multiple organizational levels, difficult data value extraction, data quality levels needing improvement, and unintelligent data tools [72].

The policy framework for “AI + energy” has been established, but implementation still faces multiple obstacles. In September 2025, the National Development and Reform Commission and the National Energy Administration jointly issued the Implementation Opinions on Promoting the High-Quality Development of “AI + Energy,” explicitly requiring the promotion of common key technology research in data, computing power, and algorithms applicable to the energy sector [71]. However, AI applications in the energy sector still face deep challenges such as data quality and security issues, insufficient model transparency and interpretability, insufficient coordination between technology and institutions, and lagging ethics and policies [73]. The digital transformation of the energy industry also faces legal difficulties such as insufficient feasibility of application scenario implementation, bottlenecks in key technology research and integration, and data rights, privacy protection, and security governance.

The deep dilemma of digital and intelligent transformation lies in the fact that technical tools themselves cannot automatically solve governance problems. Who sets data collection standards? How are data ownership, usage rights, and benefit rights defined? Should the decision logic of AI algorithms be disclosed and subject to oversight? When algorithmic recommendations conflict with traditional dispatch experience, which should prevail? These questions have gone beyond the technical domain and point to the

institutional framework and power structure of data governance. In this sense, the digital and intelligent transformation of energy management is not only a technological upgrade but also a governance reform. It requires establishing, above the technical system, matching data governance rules, algorithmic ethical norms, and organizational change pathways.

In summary, at the opening of the 15th Five-Year Plan period, China's energy management is facing a quadruple stress test: security bottom line, integration bottlenecks, transition pains, and digital-intelligent challenges. Security anxiety pushes up the demand for fossil energy supply guarantees, thereby compressing the space for low-carbon transition; integration difficulties inhibit the investment returns of renewable energy, thereby affecting the pace of substitution; and the pains of coal power transition in turn exacerbate the dilemma of insufficient system regulation capacity. The tensions among the three objectives are interwoven in practice into a complex governance network. How to find a dynamic balance point within this network is the key to moving energy management from target setting to effective governance, and it is also the core question that the next chapter on institutional restructuring seeks to address.

5. Institutional Restructuring: Three Pathways to Governance Modernization

The realization of policy objectives depends on effective institutional support. The previous two sections examined “what policies say” and “where management is difficult”. This section turns to how institutions respond. Specifically, it analyzes three institutional pathways—rule of law, marketization, and systematization—that collectively address the security, integration, transition, and digitalization challenges, and that together constitute the institutional foundation for shifting from capacity expansion-oriented management to structural transformation-oriented governance. On the basis of identifying the trajectory of policy evolution and the practical challenges of management, it explores the direction of institutional restructuring for modernizing China's energy governance. From current reform practice, institutional restructuring is mainly advancing along three pathways: the rule of law provides a stable regulatory framework for energy governance, marketization injects efficient operating mechanisms into energy allocation, and systematization builds a coordinated development pattern for energy transition. These three pathways support and embed within one another, jointly shaping the institutional foundation of China's energy governance.

5.1. Rule of Law in Energy Governance

The rule of law is the cornerstone of modern governance. The official implementation of the Energy Law of the People's Republic of China on 1 January 2025 marks a key step in China's energy governance from policy-driven to rule-of-law-based [6]. However, having laws to abide by is only the starting point. Administering according to law and governing according to law are the real tests of rule-of-law-based governance. As 2026 is the opening year of the 15th Five-Year Plan, energy rule-of-law construction is moving from legislative breakthroughs to institutional deepening (Table 3).

Table 3. Major energy policy documents in the opening year of the 15th Five-Year Plan.

Release Date	Policy Document	Issuing Authority	Key Points
March 2026	Outline of the 15th Five-Year Plan	National People's Congress	Lists “actively and prudently promoting and achieving carbon peaking” as an

Release Date	Policy Document	Issuing Authority	Key Points
			independent chapter, clarifying overall requirements for carbon peaking during the 15th Five-Year Plan
June 2026	15th Five-Year Plan for Building a New Energy System	National Development and Reform Commission, National Energy Administration	Proposes a six-system architecture; sets binding targets including a 25% share of non-fossil energy in primary consumption and a 50% share in electricity generation
July 2026	15th Five-Year Plan Action Plan for Carbon Peaking	State Council	Sets a 17% reduction in CO ₂ emissions per unit of GDP compared with 2025; deploys dual main lines of “substituting” existing stock and “expanding” incremental volume
July 2026	15th Five-Year Plan for Renewable Energy Development	National Development and Reform Commission, National Energy Administration	Proposes a new development stage of “expanding volume and improving quality, and reliable substitution”; sets a reliable substitution target for renewable energy for the first time
June 2026	Implementation Measures for the Minimum Renewable Energy Consumption Proportion Target and the Renewable Energy Electricity Consumption Responsibility Weight System	National Development and Reform Commission, Ministry of Industry and Information Technology, Ministry of Housing and Urban-Rural Development, Ministry of Transport	Builds a double-layer rigid constraint framework; upgrades green certificates from “voluntary trading certificates” to “mandatory compliance certificates”
February 2026	Implementation Opinions on Improving the National Unified	General Office of the State Council	Clarifies that by 2030, market-based trading electricity will account for about

Release Date	Policy Document	Issuing Authority	Key Points
	Electricity Market System		70% of total electricity consumption; proposes a “four-all” development path
February 2026	Annual Deployment of the Legal Construction Leading Group Meeting	National Energy Administration	Clarifies “accelerating the introduction of supporting regulations and policies for the Energy Law, and actively advancing the revision of important laws such as the Electric Power Law and the Renewable Energy Law”

Intensive introduction of supporting regulations for the Energy Law. In February 2026, the National Energy Administration convened the annual Legal Construction Leading Group meeting, explicitly proposing to “accelerate the introduction of supporting regulations and policies for the Energy Law, actively advance the revision of important laws such as the Electric Power Law and the Renewable Energy Law, and promote good laws and good governance in the energy industry” [6]. The pace of supporting legislation is accelerating. On 22 June 2026, the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Housing and Urban-Rural Development, and the Ministry of Transport jointly issued Order No. 42, the Implementation Measures for the Minimum Renewable Energy Consumption Proportion Target and the Renewable Energy Electricity Consumption Responsibility Weight System, effective 1 August 2026 [74]. These measures are specific institutional arrangements for implementing the statutory requirements of the Energy Law regarding the minimum renewable energy consumption proportion target and the Renewable Energy Law regarding the renewable energy electricity consumption guarantee mechanism. The measures establish a double-layer rigid constraint framework comprising the minimum renewable energy consumption proportion target and the renewable energy electricity consumption responsibility weight. The former is divided into two categories: minimum electricity consumption proportion target and minimum non-electric consumption proportion target, incorporating non-electric consumption into the national mandatory assessment system for the first time. The latter establishes a dual responsibility system of provincial administrative region consumption responsibility weights plus market entity consumption responsibilities. The promulgation of Order No. 42 marks a comprehensive upgrade of green electricity consumption from industry advocacy to annual rigid assessment, and the renewable energy green power certificate from a voluntary trading certificate to a mandatory compliance certificate. This is an upgrade of institutional milestone significance, meaning that renewable energy consumption no longer relies on local self-discipline and corporate voluntariness but has a clear legal basis and an operable assessment mechanism.

Revision of the Electric Power Law and the Renewable Energy Law. Advancing in parallel with the supporting regulations for the Energy Law is the revision of single laws such as the Electric Power Law and the Renewable Energy Law. In March 2025, the National Energy Administration clearly stated in its Report on the Construction of a Rule-of-Law Government in 2025: “Cooperate with the Environment and Resources Protection Committee of the National People’s Congress to accelerate the revision of the Renewable Energy Law” and “accelerate the revision of the Electric Power Law and the Regulations on Emergency Disposal and Investigation of Electric Power Safety Accidents, and promote the accelerated reshaping of the legal system adapted to the new-type power system” [6]. The Electric Power Law has been in effect for nearly thirty years since 1996. Although it has been amended several times, its institutional framework based on planning and regulation can hardly meet the needs of building a new-type power system. The emergence of new business forms such as large-scale grid connection of new energy, distributed generation, energy storage, and virtual power plants has created entirely new regulatory demands for the electric power legal system. The Renewable Energy Law faces pressure to transform from a law encouraging development to a law regulating development. As renewable energy moves from supplementary to dominant, the focus of legal adjustment also needs to shift from incentivizing installed capacity to guaranteeing consumption, regulating operation, and promoting integration. The revision of these two laws will fundamentally reshape the institutional architecture of China’s energy legal system.

Systematic improvement of energy regulatory capacity. The rule of law means not only legislation but also law enforcement and regulation. In 2026, the National Energy Administration deployed comprehensive regulation in the electric power field in Hebei, Jilin, Fujian, Hunan, Guangdong, Xinjiang, and other regions. The Northwest Energy Regulatory Bureau deployed regulation on prominent issues in electricity market order, focusing on fair competition and standardized operation of the electricity market [36]. The National Energy Administration held a joint meeting on power dispatch, trading, and market order among grid and power plant operators, emphasizing adherence to goal orientation and problem orientation, continuously deepening the construction of the national unified electricity market, and strengthening energy security supply regulation [11]. Regulatory methods are also transitioning from traditional post-event inspections to process regulation, digital regulation, and penetrating regulation. In February 2026, the Implementation Opinions on Improving the National Unified Electricity Market System issued by the General Office of the State Council explicitly proposed the stage goal of “basically forming a fair and unified market regulatory system” [38]. From legislation to law enforcement to regulation, the rule of law in energy governance is forming a relatively complete institutional closed loop.

Of course, the rule-of-law process is far from complete. The formulation of supporting regulations for the Energy Law is still underway. The revision of the Electric Power Law and the Renewable Energy Law still requires time [6]. Legal systems in emerging fields such as energy data security and full-chain safety access for hydrogen energy remain to be established [74]. As stated at the 2026 annual Legal Construction Leading Group meeting, “promote the rule of law in all aspects of the energy industry”, the establishment of this goal itself reflects a clear understanding of the long-term and systematic nature of the rule of law.

5.2. Marketization of Energy Allocation

If the rule of law addresses who governs and on what basis, marketization addresses how to allocate and where efficiency lies. The core proposition of China’s energy

marketization reform is to let the market play a decisive role in resource allocation while ensuring energy security [11,41]. Let price signals guide investment decisions, let competition mechanisms force efficiency improvements, and let trading rules guarantee fair participation [2,10,64].

From existence to excellence: the national unified electricity market. In February 2026, the General Office of the State Council issued the Implementation Opinions on Improving the National Unified Electricity Market System, clarifying the overall direction and pathway for building the national unified electricity market system during the 15th Five-Year Plan period [36]. The document proposes two stage goals: by 2030, basically complete the national unified electricity market system, with all types of power sources and electricity users except guaranteed users directly participating in the electricity market, and market-based trading electricity accounting for about 70% of total electricity consumption (Figure 3) [37]. By 2035, fully complete the system, with the multidimensional value of electricity resources, including energy, regulation, environment, and capacity, fully reflected by the market [75]. The document constructs a “four-all” development path: full market scope, full trading varieties, full subject participation, and full-process governance.

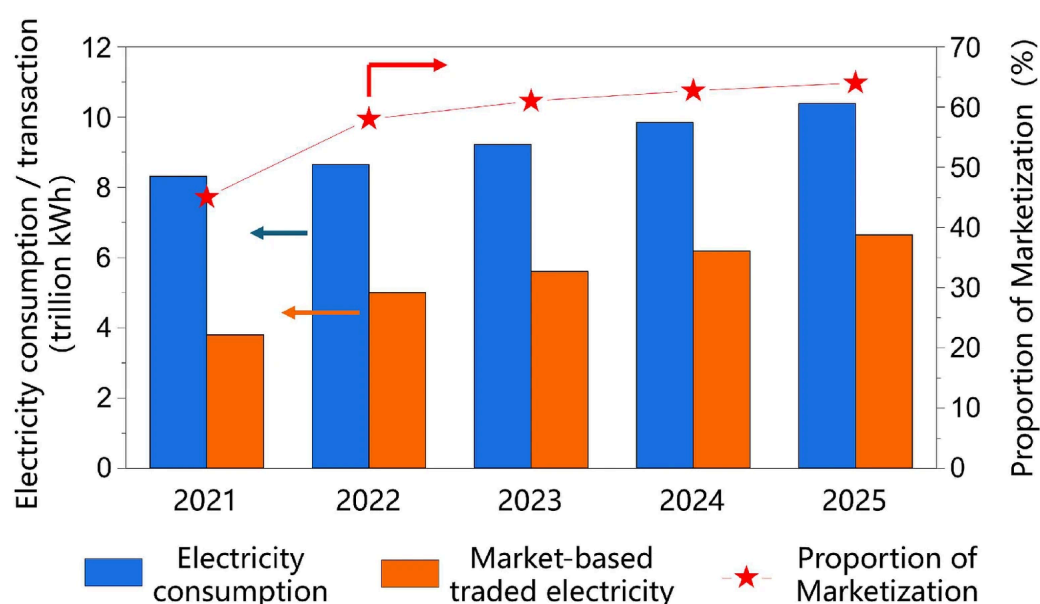


Figure 3. Trend of national market-based electricity trading volume and its share (2021–2025). Data sources: China Electricity Council, annual China Electricity Market Development Report; National Energy Administration press conference in January 2026; National Energy Administration and National Bureau of Statistics annual statistical bulletins.

At the opening of the 15th Five-Year Plan, the construction of the national unified electricity market has achieved a leap from nonexistence to existence. The next step is to achieve an upgrade from existence to excellence. By the end of 2025, the number of registered market entities nationwide exceeded 1 million, and annual market-based trading electricity reached about 6.6 trillion kWh, up 7.4% year-on-year, accounting for 64.0% of total electricity consumption [29]. Inter-provincial trading electricity reached 1.6677 trillion kWh, up 10.0% year-on-year, of which market-based inter-provincial trading accounted for 1.292 trillion kWh, up 10.7%. Inter-provincial renewable energy trading reached 317.7 billion kWh, up 41.1% year-on-year. Green electricity trading reached 328.5 billion kWh, up 38.3% year-on-year [76]. The inter-provincial spot market and seven provincial spot markets were officially operating, and 18 provincial spot markets

were conducting continuous settlement trial operations [75]. The cross-operating-region normalized trading mechanism was officially opened in 2025, achieving interconnection of medium- and long-term, spot, and green electricity trading between the State Grid and China Southern Power Grid. In July 2026, the first market-based transaction of transmission rights nationwide was completed, marking the first market-based allocation of transmission rights between the State Grid and China Southern Power Grid [36]. However, the challenges from existence to excellence are equally formidable. The synergistic benefits of the inter-provincial market have not been fully released, the degree of overall optimization in resource allocation needs improvement, and the efficient coordination of market structure and market varieties still requires strengthening [11]. In practice, this coordination involves not only energy trading but also ancillary services, capacity adequacy, and flexibility products. By 2025, ancillary services markets had been established in all provincial power systems, covering peak regulation, frequency regulation, reserve, and ramping products. A capacity compensation mechanism for coal power was introduced to ensure adequate backup capacity while renewable energy expands. These market instruments are designed to price the diverse values of electricity—energy, regulation, capacity, and flexibility—and to provide investment signals for storage, demand response, and flexible generation. The tension between “unification” and “regional coordination,” and the boundary between the government’s “visible hand” and the market’s “invisible hand,” remain issues that market-oriented reform must continue to explore [41].

Coordination and connection of multiple market instruments. The electricity market does not exist in isolation. Multiple market-based instruments, including carbon markets, green certificate markets, and green electricity markets, coexist, and how to achieve institutional connection and policy coordination is another challenge facing market-oriented reform. In January 2024, the national carbon emissions trading market officially launched voluntary greenhouse gas emission reduction trading [44]. By the end of 2025, the national carbon market had cumulatively traded 865 million tons of carbon allowances with a total turnover of 57.663 billion yuan. In 2025 alone, annual allowance trading volume reached 235 million tons, up 24.36% year-on-year, with annual turnover of 14.63 billion yuan. The year-end closing price reached 74.63 yuan per ton, up 55% from the opening price on the first day of market launch. The number of covered emission entities increased by 61.16% to 3378, including 2087 power sector entities and 232 steel and 232 cement entities [77]. The green certificate system has been upgraded from a voluntary trading certificate to a mandatory compliance certificate [78]. Enterprises in key energy-using industries can complete the minimum renewable energy consumption proportion target through green certificate and green electricity trading and other means. The institutional connection among the carbon market, electricity market, green electricity, and green certificates directly affects whether price signals can be effectively transmitted, whether environmental value can be reasonably priced, and whether market efficiency can be fully released. In practice, this connection is being operationalized through several concrete measures. The national carbon market expanded from the power sector to include steel, cement, and aluminum smelting sectors in 2025, covering approximately 60% of national carbon emissions. The green certificate system was upgraded to a mandatory compliance instrument, requiring key energy-using enterprises to fulfill renewable energy consumption obligations through green certificate or green electricity purchases. Carbon emission data verification and reporting were strengthened, and penalties for data falsification were increased. These measures show how market-based instruments are embedded in regulatory enforcement rather than operating as voluntary schemes. Some researchers have pointed out that previously the focus was

mainly on the quantity of energy consumed without distinguishing its quality. Now it is directly converted to how much carbon dioxide is emitted. Behind this is a profound change in governance logic [75]. This change also needs to be reflected in the design of market-based instruments.

Restoring the commodity attributes of energy. The core of market-oriented reform is to let the price mechanism truly play a decisive role in energy resource allocation [10]. For a long time, energy prices have been subject to considerable administrative control, and the cross-subsidy and cost-plus mechanisms of electricity prices have distorted price signals to some extent. The 2026 Implementation Opinions explicitly propose the goal of “basically perfecting the market-based electricity price mechanism”. This means that electricity prices must reflect not only generation costs but also transmission and distribution costs, environmental costs, and regulation costs. They must reflect not only short-term supply and demand but also guide long-term investment. However, restoring the commodity attributes of energy is not simply about liberalizing prices. As a basic public product, energy’s price formation mechanism needs to find a balance between efficiency and equity, and between market and guarantee [11]. In practice, China’s electricity pricing reform has followed a gradual approach. Time-of-use pricing has been widely implemented for industrial and commercial users to reflect supply-demand variations. A capacity electricity price mechanism for coal power was established in 2024 to compensate for fixed costs and ensure availability. Cross-subsidies between industrial and residential users are being gradually reduced. In spot market pilots, prices are allowed to fluctuate within specified limits to reflect scarcity and surplus, while safeguards remain for residential and agricultural users. These pricing reforms are not simply about “letting go” but about designing a price system that balances efficiency, security, and equity. This is the most subtle and critical institutional design issue in market-oriented reform.

Interaction between government regulation and market incentives. The marketization of energy allocation does not imply a retreat of government. Instead, it requires a re-definition of the government’s role—from direct allocation to rule-making, regulation, and the provision of public goods. Effective energy governance under market conditions depends on a complementary relationship between government regulation and market incentives.

Government regulation provides the institutional infrastructure for markets to function. This includes: (1) market rules and trading standards that ensure fair competition and non-discrimination; (2) supervision of market power to prevent manipulation and abuse; (3) data reporting and verification systems to ensure the integrity of carbon and green certificate markets; (4) emergency response and strategic reserve mechanisms to safeguard security; and (5) social protection for vulnerable consumers. In 2026, the National Energy Administration deployed comprehensive regulation in multiple provinces and strengthened oversight of electricity market order, reflecting a shift from ex-post inspection to process and digital regulation.

Market incentives, in turn, guide investment and operational decisions. Prices in electricity, carbon, and green certificate markets signal scarcity, environmental value, and flexibility needs. These signals influence decisions by generators, grid operators, storage providers, and consumers. For example, negative prices during renewable energy surplus periods encourage storage charging and flexible demand; carbon prices encourage fuel switching and efficiency improvements; green certificate prices reward renewable generation. When these incentives are well-designed, they can align private decisions with public objectives.

The interaction between regulation and incentives is not always harmonious. Excessive regulation may suppress market signals; insufficient regulation may lead to

market failure or social inequity. China's approach is to iterate: pilot markets, evaluate outcomes, adjust rules, and expand successful practices. The “four-all” development path for the national unified electricity market—full market scope, full trading varieties, full subject participation, and full-process governance—reflects this iterative logic. It combines market expansion with regulatory capacity building, and it treats governance reform as a continuous process rather than a one-time design.

These institutional changes are reflected in actual governance practices: carbon market expansion and data verification, green certificate enforcement, capacity compensation, spot market price limits, and regulatory oversight of market order. They demonstrate that China's energy governance is not simply shifting from administrative to market mechanisms, but rather constructing a hybrid system in which rules, markets, and regulation are mutually embedded. This hybridity is a defining feature of China's path toward rule-based and institutional governance.

5.3. Systematization of Energy Transition

If the rule of law provides rules and marketization injects efficiency, systematization addresses how to coordinate and integrate. Energy transition is never a linear advancement of a single link, but a systemic restructuring among all links of generation, grid, load, and storage; among coal, oil, gas, electricity, and heat; and among central and local levels [1]. The 15th Five-Year Plan for Building a New Energy System has carried out a systematic restructuring in its architecture, with significantly higher requirements for quality, efficiency, and systemic coordination [9]. The Outline of the 15th Five-Year Plan proposes deepening the implementation of the new energy security strategy, accelerating the construction of a clean, low-carbon, safe, and efficient new energy system, and building an energy powerhouse [7]. Systematization is precisely the core methodology for building a new energy system.

The collaborative logic of integrating generation, grid, load, and storage. In the construction of the new-type power system, the integrated and collaborative development of generation, grid, load, and storage is the key direction [79,80]. The 15th Five-Year Plan period is a critical period for China's new-type power system construction to shift from quantitative change to qualitative change. The deep integration of the four major areas, including generation, grid, load, and storage, has become the core lever for promoting energy transition, ensuring energy security, and achieving the “dual carbon” goals [25,34]. This integration is not a simple superposition of links. It requires that multi-energy complementarity on the generation side, interconnection on the grid side, flexible response on the load side, and regulatory support on the storage side form an organic whole. The 15th Five-Year Plan for Renewable Energy Development explicitly proposes to “adhere to a systematic perspective, coordinate new construction and existing retrofitting, promote multi-source complementary development, strengthen coordinated operation of sources and storage, guide bidirectional matching of sources and loads, and enhance the reliable substitution capacity of renewable energy power” [24,30]. The plan sets a reliable substitution target for renewable energy for the first time, proposing specific indicators such as the average confidence output of wind and solar power generation and new reliable peak power generation capacity [7,23]. The systematic perspective is being transformed from a conceptual advocacy into a quantifiable and assessable institutional arrangement.

The industrial integration trend of “new energy+”. Systematization of energy means not only coordination within the energy system but also deep integration of energy with energy-using industries. Integrated and collaborative development of new energy has become a major trend, and the new energy industry has entered a new stage of systemic

coordination. The 15th Five-Year Plan for Renewable Energy Development proposes guiding the coordinated planning and layout of new data centers and renewable energy power generation, classifying and tapping the spatiotemporal regulation potential of computing load, innovating methods such as green electricity direct connection and integrated generation-grid-load-storage, and steadily increasing the green electricity consumption level of digital infrastructure [7]. The plan also proposes promoting the construction of self-use new energy bases in the “Three North” region, coordinating the layout of green hydrogen, ammonia, and methanol production bases, and accelerating the construction of storage and transportation systems, so that new energy in resource-rich areas can be output in multiple forms such as green computing power, green fuels, green raw materials, and green materials [71]. The coordination of energy development and industrial layout is reshaping the geographical pattern of regional economies. Energy resource-rich areas are no longer merely the starting point for power transmission but are expected to become new highlands for green industry agglomeration.

Interaction between top-level design and local practice. Systematization also means effective connection between central top-level design and differentiated local practice. The Measures for Comprehensive Evaluation and Assessment of Carbon Peaking and Carbon Neutrality explicitly consider factors such as the main functional positioning, industrial and energy structure, and natural resource endowments of different types of regions, balancing rigid constraints and flexible regulation, and reflecting differentiated requirements [44,47]. In the design of assessment indicators, the Measures set 5 control indicators, including total carbon emissions, carbon emission intensity reduction, total coal consumption, total oil consumption, and share of non-fossil energy consumption, as well as 9 supporting indicators [37,39]. This double-layer structure of control indicators plus supporting indicators not only ensures the rigid constraints of national goals but also leaves flexible space for local adaptation. At the same time, micro-governance units such as zero-carbon parks, zero-carbon factories, and village and town micro-energy networks are becoming frontier positions for policy experimentation [74,81]. The success or failure experiences of these “small planning, small balance” units will provide valuable practical references for the choice of macro pathways for China’s energy transition.

Methodological shift from single-point breakthroughs to systemic integration. Looking across the three pathways of institutional restructuring, the significance of systematization is particularly profound. If policy thinking during the 14th Five-Year Plan period was more about single-point breakthroughs, concentrating efforts on expanding new energy installed capacity, then policy thinking during the 15th Five-Year Plan period is shifting toward systemic integration. While continuing to expand scale, it pays more attention to matching and coordination among links and to balance and overall planning among objectives. Compared with the 14th Five-Year Plan for a Modern Energy System, the 15th Five-Year Plan for Building a New Energy System has significantly higher requirements for quality, efficiency, and systemic coordination. The deeper meaning of this shift is that energy governance has moved from the simple logic of “doing addition” to the complex stage of “doing optimization.” How to achieve system optimum under multiple constraints is becoming the core test of modernizing energy governance capacity.

The three pathways of rule of law, marketization, and systematization do not operate independently. The rule of law provides regulatory guarantees and supervisory basis for marketization, while marketization injects efficiency orientation and competitive vitality into the rule of law. Systematization requires both the institutional framework of the rule of law for overall coordination and the price signals of marketization to guide resource allocation. These three pathways are mutually embedded and supportive,

jointly constituting the institutional framework for modernizing China's energy governance. Running through them is a main line: the deep transformation from administrative dominance to institutional governance. Let rules rather than commands, let the market rather than plans, and let systems rather than fragments become the basic logic of energy governance. The degree of completion of this transformation will, to a large extent, determine the effectiveness and quality of China's energy transition. From the perspective of coordinating security, economic development, and low-carbon objectives, systematization plays a particularly important role. It does so by integrating policy objectives across sectors and levels, aligning investment decisions with long-term transition goals, and creating feedback mechanisms that allow for adjustment when trade-offs become too severe. For example, the reliable substitution target for renewable energy—combining confidence output, peak capacity, and non-electric utilization—represents an attempt to balance security (reliable supply), economic efficiency (cost-effective use of resources), and decarbonization (scaling up clean energy). Similarly, the carbon peaking evaluation system with control and supporting indicators reflects an effort to combine rigid national targets with local flexibility, thereby accommodating regional economic differences while maintaining progress toward carbon reduction. These institutional designs illustrate how governance mechanisms can manage, rather than ignore, the inherent tensions among multiple objectives.

6. Future Outlook: Toward the Governance Frontier of a New Energy System

Policy evolution has outlined the trajectory of institutional change, management challenges have revealed the practical constraints of transition, and institutional restructuring has indicated the direction of reform. Building on this integrated analysis, looking ahead to 2030 and beyond, what frontier issues will China's energy governance face? These frontier issues are not merely technological trends; they entail profound governance transformations. This section therefore examines not only what technologies and business models are emerging, but also what institutional arrangements, regulatory frameworks, and coordination mechanisms are required to support them. The 15th Five-Year Plan explicitly proposes to initially build a clean, low-carbon, safe, and efficient new energy system by 2030 [9]. This positioning implies that energy policy and energy management are undergoing a fundamental paradigm shift from sectoral governance to systemic governance. Based on a review of the policy implications of the new energy system, this chapter selects three frontier issues for forward-looking discussion: computing-energy coupling governance, zero-carbon industrial park policy experimentation, and the international dimension of energy governance.

6.1. Policy Implications and Governance Logic of the New Energy System

The new energy system is not a simple policy slogan but a governance framework with clear institutional implications. The 15th Five-Year Plan for Building a New Energy System establishes a complete policy architecture centered on six major systems: an advanced and adaptable new energy infrastructure system, a strong and resilient energy security guarantee system, a green and low-carbon energy consumption system, a self-reliant energy science and technology innovation system, a coordinated and efficient modern energy governance system, and a multi-dimensional energy international cooperation system [1,9]. Compared with the 14th Five-Year Plan for a Modern Energy System, the 15th Five-Year Plan has carried out a systematic restructuring of its architecture, expanding the number of indicators from 7 to 12 and significantly raising requirements for quality, efficiency, and systemic coordination.

From the perspective of governance logic, this systemic architecture conveys several important signals. First, energy governance is moving from sectoral management to systemic governance. The 14th Five-Year Plan energy planning was more of a sectoral development arrangement: setting installed capacity targets, deploying key projects, and advancing technological breakthroughs [9]. The 15th Five-Year Plan explicitly lists a coordinated and efficient modern energy governance system as one of the six major systems. This means that energy governance itself, not merely energy production and consumption, has been placed on the core agenda of planning. The modernization of the governance system involves improving regulatory capacity, perfecting the legal framework, strengthening market mechanisms, and coordinating multiple actors [4]. This is a systematic project that transcends sectoral boundaries and involves deep changes in governance structure.

Second, rigid constraints are replacing flexible guidance as the policy tone. The 15th Five-Year Plan places core quantitative indicators at the outset, strengthening rigid total-volume constraints [9,49]. On the supply side, the target for comprehensive energy production capacity has been raised from 4.6 billion tons of standard coal in the 14th Five-Year Plan to 5.8 billion tons of standard coal, and total power installed capacity from 3.0 billion kW to 5.4 billion kW. The number of transition and carbon reduction indicators has increased from 3 to 5, with carbon emissions per unit of electricity generation added as a binding indicator requiring a reduction of more than 10% during the 15th Five-Year Plan period [45,47]. From expected to binding, from recommendation to assessment, the hardness of policy instruments is being significantly upgraded. As one commentary noted, targets are progressive layer by layer and indicators are interlocking, jointly forming a complete assessment system for new energy development under the guidance of the “dual carbon” goals, reflecting the systematic nature and execution capacity of policy design [48,82].

Third, reliable substitution is replacing scale expansion as the core proposition. The main line of renewable energy development during the 15th Five-Year Plan period is “expanding volume and improving quality, and reliable substitution”. Expanding volume and improving quality requires maintaining a reasonable development scale and pace while continuously improving the comprehensive efficiency of development, transmission, and utilization [83–85]. Reliable substitution requires adhering to the principle of establishing the new before abolishing the old, promoting renewable energy to “stand up” and “be reliable” faster, and gradually achieving safe and reliable substitution of traditional energy [86]. The plan sets a reliable substitution target for renewable energy for the first time: the national average confidence output of wind and solar power reaches 8%, the share of wind and solar power in evening peak load during summer and winter reaches over 20%, and during the 15th Five-Year Plan period, new reliable peak power generation capacity of renewable energy exceeds 300 million kW [7,31]. The shift from scale expansion to reliable substitution means that the evaluation criterion for energy transition is shifting from “how much is installed” to “whether it can deliver” [87]. This shift itself is an institutional response to the management challenges described earlier. However, achieving deep decarbonization requires more than target-setting. It demands institutional arrangements that can sustain long-term investment, coordinate across sectors and regions, and manage distributional consequences. Key governance requirements include: a stable and predictable carbon price signal; a functioning capacity mechanism to ensure supply adequacy; a cross-provincial coordination mechanism for renewable energy transmission and consumption; a just transition framework for coal-dependent regions and workers; and a regulatory system capable of overseeing increasingly complex and decentralized energy systems. These requirements are further elabo-

rated in Section 6.5.

6.2. Computing-Energy Coupling Governance: An Emerging Issue

Within the governance framework of the new energy system, an issue that was previously rarely included in the energy policy horizon is rapidly emerging: the deep coupling of computing power and energy.

Computing power is becoming the fastest-growing new variable in China's energy consumption structure. In 2025, China had built 42 10,000-card-level intelligent computing clusters, and total electricity consumption of national computing centers reached approximately 170 billion kWh, accounting for about 1.6% of total electricity consumption [71]. The eight hub nodes of the national integrated computing network have become core areas of electricity consumption growth, with computing electricity consumption growing at an average annual rate of 39.5% over the past three years, far exceeding the average growth rate of total electricity consumption [88]. According to projections by competent authorities, by 2030, national computing center electricity consumption may reach approximately 800 billion kWh, accounting for about 6% of total electricity consumption [72]. Computing power is transforming from information infrastructure into a veritable large energy consumer.

This trend has given rise to a new policy issue: "computing-energy coordination." In 2026, "computing-energy coordination" was written into the Government Work Report for the first time and incorporated into the Outline of the 15th Five-Year Plan [71,88]. The Action Plan for Promoting Two-Way Empowerment of Artificial Intelligence and Energy was issued as a supporting document, delineating key tasks such as energy-saving retrofitting of computing power, local consumption of green electricity, and interactive load dispatch. The 15th Five-Year Plan for Building a New Energy System incorporates computing-energy coordination and integrated generation-grid-load-storage comprehensive energy into normalized and large-scale development tasks [9]. The 15th Five-Year Plan for Renewable Energy Development explicitly proposes guiding the coordinated planning and layout of new data centers and renewable energy power generation, classifying and tapping the spatiotemporal regulation potential of computing load, innovating methods such as green electricity direct connection and integrated generation-grid-load-storage, and steadily increasing the green electricity consumption level of digital infrastructure [7,72].

The governance logic of "computing-energy coordination" transcends traditional energy-saving thinking. It is not merely about making computing centers use less electricity, but about making computing load an adjustable power resource: absorbing surplus wind and solar power during low-demand periods and moderately reducing non-core computing tasks during peak demand periods [88]. Computing centers are transforming from pure electricity consumers into grid regulation resources with flexible load functions [72]. The State Grid and China Southern Power Grid are simultaneously building computing-energy data interconnection platforms, opening real-time interactive channels between grid operation data and computing load data, and using AI algorithms to precisely predict computing electricity consumption curves and renewable energy generation output curves [70]. This "bits regulating watts" two-way empowerment model is reshaping the traditional paradigm of power system operation.

From a governance perspective, "computing-energy coordination" also poses profound challenges. The layout of computing centers often follows talent, market, and network conditions rather than the distribution of energy resources [70]. This leads to a geographical mismatch between computing load and clean energy [71]. Breaking down the industry barriers between grid planning and computing park planning to achieve syn-

chronous compilation, synchronous approval, and synchronous construction is not only a technical coordination issue but also a cross-departmental and cross-industry governance coordination issue. The rapid growth of computing electricity consumption also imposes urgent institutional demands on power system expansion, distribution network upgrading, and improvement of green electricity trading mechanisms [72]. Computing-energy coupling governance is becoming an unavoidable frontier issue in building a new energy system. Addressing this issue requires governance responses at multiple levels. At the planning level, grid planning and computing park planning should be coordinated, with synchronized approval and construction. At the market level, flexible load products and demand response mechanisms should be developed to allow computing centers to participate in electricity markets. At the data level, common standards for computing load data and grid operation data should be established, with clear rules on data sharing, privacy, and security. At the regulatory level, cross-departmental coordination mechanisms are needed to align the objectives of energy, digital, and industrial policies. Without these governance innovations, computing-energy coupling may remain a technical concept rather than a scalable practice.

6.3. Zero-Carbon Industrial Parks: Policy Experimentation at the Micro-Governance Level

If “computing-energy coordination” is a cross-border integration of energy and the digital economy, then zero-carbon industrial parks are integrated experiments of energy transition at the micro-spatial scale.

In July 2025, the National Development and Reform Commission and other departments issued the Notice on Carrying Out Zero-Carbon Industrial Park Construction, systematically deploying key tasks, indicator systems, and accounting methods for zero-carbon industrial parks [81]. In December of the same year, the first batch of 52 national-level zero-carbon industrial parks was announced, covering 31 provinces (autonomous regions and municipalities) across the country [89]. In 2026, the Government Work Report of the National People’s Congress and the Chinese People’s Political Consultative Conference upgraded the expression on zero-carbon industrial parks from “establishing a batch” to “deepening advancement,” explicitly proposing to build about 100 national-level zero-carbon industrial parks during the 15th Five-Year Plan period [82]. The 15th Five-Year Plan Action Plan for Carbon Peaking further requires “guiding new projects to preferentially cluster in zero-carbon industrial parks” and deploys the goal of building 500 zero-carbon factories [90]. The policy side has pushed zero-carbon industrial parks to the main stage of energy transition and industrial upgrading.

The governance significance of zero-carbon industrial parks lies in the fact that they constitute a relatively closed governance unit. Within the park boundary, energy supply (distributed photovoltaics, wind power, energy storage), energy consumption (industrial production, building energy use), and carbon management (accounting, trading, offsetting) can be planned, dispatched, and assessed in an integrated manner [89]. Parks are the main battlefield for implementing the “dual carbon” strategy and the main front for cultivating new quality productive forces [82]. Zero-carbon industrial parks require a clean energy share exceeding 90% and green electricity direct supply of no less than 50%, and need to coordinate eight major tasks: energy transition, energy conservation and carbon reduction, industrial optimization, resource intensification, infrastructure, technology application, energy-carbon management, and reform and innovation [81]. This governance model of “small-scale planning and small-scale balancing” provides an observable, evaluable, and replicable policy experimentation field for China’s energy transition.

However, the implementation of zero-carbon industrial parks also faces severe chal-

lenges. “Active application, blocked implementation” is a stage characteristic of current zero-carbon industrial park development. The Indicator System for National-Level Zero-Carbon Industrial Park Construction (Trial) requires that parks with annual comprehensive energy consumption of 200,000 to 1 million tons of standard coal have unit energy consumption carbon emissions ≤ 0.2 tons per ton of standard coal, and parks above 1 million tons of standard coal have ≤ 0.3 tons per ton of standard coal, equivalent to one-tenth of the current average unit energy consumption carbon emission level of China’s parks [89]. Time is tight and tasks are heavy, with enormous challenges in economic feasibility, technological integration, and management coordination. Among the first batch of 52 national-level parks, only 6 are overall parks, and the remaining 46 are “parks within parks”, relatively independent areas demarcated within existing mature parks for zero-carbon retrofitting [82]. Some parks face dilemmas such as mismatched source-load matching, difficulties in clean energy transmission and certification, deviation in energy consumption curves, difficulties in cost reduction and grid connection for direct connection projects, and imbalances in input-output, with park enterprises facing difficulties in financing and profitability. As one analysis pointed out, the core dilemma can be summarized in one sentence: roles, interests, and risks are not aligned. Park management committees must meet assessments, resident enterprises must reduce costs, grid companies must ensure safety, and energy service providers must make profits. The success or failure of zero-carbon industrial parks will, to a large extent, test China’s energy governance capacity for institutional design and multi-stakeholder interest coordination at the micro level. Promising governance responses include: establishing a multi-stakeholder coordination platform within each park; designing risk-sharing and benefit-sharing mechanisms among park management committees, resident enterprises, grid companies, and energy service providers; providing targeted fiscal and financial incentives for zero-carbon retrofitting; and developing standardized accounting and certification systems that are compatible with international rules. These responses would help align roles, interests, and risks, which is the core challenge identified in the current pilot stage.

6.4. International Dimension of Energy Governance

Energy issues have never been purely domestic affairs. The 15th Five-Year Plan lists a multi-dimensional energy international cooperation system as one of the six major systems [2,9,83,86]. Against the backdrop of profound reshaping of the global energy landscape, the international dimension of China’s energy policy is moving from passive adaptation to active shaping.

At present, the global energy governance landscape is undergoing profound changes. After the escalation of the Middle East conflict in 2026, blocked transportation through the Strait of Hormuz once again highlighted the dependence of global energy supply chains on key chokepoints [50,91]. More than 30 countries or regions worldwide have proposed local content requirements and exclusionary restrictive measures for new energy equipment [83,85]. The trend toward bloc-based and regionalized energy trade has accelerated, and competition over energy control, trade route dominance, and market pricing has intensified [84,92]. Meanwhile, China’s global leading position in renewable energy, the world’s largest and most complete new energy industrial chain, gives it both the capacity and the responsibility to participate in shaping global energy governance rules [2,51]. In 2025, China’s electrification rate reached approximately 29.5%, up 1.4 percentage points year-on-year, surpassing major developed economies in Europe and the United States. China has contributed over 80% to the global increase in electrification rate since 2015 [93]. At the regional level, electrification rates in eastern, central, western, and northeastern China reached approximately 30.9%, 27.2%, 30.4%, and 17.2%

respectively.

The international dimension's impact on China's energy governance is bidirectional. On the one hand, international rules and standards are forcing improvements in domestic governance capacity. External carbon pricing mechanisms such as the EU Carbon Border Adjustment Mechanism (CBAM) impose higher requirements on carbon footprint accounting for Chinese export products. The construction of zero-carbon industrial parks also responds, to some extent, to the pressure of international green trade barriers [83,91]. On the other hand, China's technical standards and institutional designs in renewable energy equipment, green power certificates, and carbon emission accounting are gradually gaining international influence. The 15th Five-Year Plan proposes deepening high-level international cooperation on renewable energy, and the 15th Five-Year Plan for Building a New Energy System proposes building a multi-dimensional energy international cooperation system [9,92]. The upgrading of these expressions reflects the strategic shift of China's energy governance from following international rules to participating in rule shaping.

From the perspective of governance research, the core question raised by the international dimension is: how can domestic energy governance effectively connect and interact positively with international rules? Carbon market interconnection, international mutual recognition of green certificates, international coordination of zero-carbon standards, and security cooperation in critical mineral supply chains [83,86,94]. These issues require both the improvement of domestic institutions and the capacity for international negotiation. Energy governance is moving from national governance to the overlapping zone of global governance and national governance, which places higher demands on governance capacity. A comparative perspective helps situate China's experience within global debates. Compared with the European Union, which relies heavily on carbon pricing and market-based coordination, China's approach combines market mechanisms with strong state planning and industrial policy. Compared with the United States, where energy governance is more fragmented and market-driven, China's system emphasizes national targets, five-year planning, and centralized coordination. Compared with India, another large emerging economy, China has moved faster in renewable energy deployment but faces similar challenges in integration, storage, and just transition. These comparisons suggest that China's pathway is neither a universal model nor a unique exception; rather, it offers a distinctive combination of state capacity, market experimentation, and iterative institutional learning that may be relevant to other countries with strong developmental states and similar energy security concerns.

6.5. Governance Requirements for Deep Decarbonization: Integrating Renewables, Storage, Digital Systems, and AI

Achieving deep decarbonization is not only a technological challenge but also a governance challenge. The integration of renewable energy, energy storage, digital energy systems, and artificial intelligence creates new coordination demands that existing institutional arrangements may not fully accommodate [95]. This section outlines key governance requirements in these areas.

First, renewable energy integration requires governance mechanisms that go beyond grid expansion. Spatial mismatch between generation and load centers calls for strengthened inter-provincial transmission planning and coordinated market design. Temporal mismatch requires flexible resources—including storage, demand response, and flexible generation—to be properly priced and dispatched. Institutional mismatch calls for improved price mechanisms, ancillary services markets, and cross-provincial coordination. Governance responses include: establishing a national renewable energy

consumption responsibility system with binding targets; developing inter-provincial spot markets and transmission rights trading; and creating a comprehensive flexibility market that values regulation, ramping, and reserve capacity [96].

Second, energy storage development requires a governance framework that supports investment while ensuring safety and efficiency. Current challenges include unclear cost recovery mechanisms, insufficient price signals for flexibility, and fragmented safety standards. Governance responses include: establishing a capacity compensation mechanism for storage; incorporating storage into ancillary services markets; developing technical standards for grid connection and safety; and creating financing instruments that reduce investment risk. These measures would allow storage to play its dual role as a flexibility provider and a reliability backstop.

Third, digital energy systems require governance of data, platforms, and cybersecurity. As energy systems become increasingly data-driven, issues of data ownership, sharing, privacy, and security become critical [97]. Governance responses include: developing common data standards and interfaces across energy subsystems; establishing rules for data access and benefit-sharing; strengthening cybersecurity protection for grid operations; and creating regulatory oversight for digital platforms that manage energy transactions. Without these governance arrangements, digitalization may create new silos and vulnerabilities rather than improving system efficiency.

Fourth, artificial intelligence applications in energy require governance of algorithms, accountability, and ethics. AI can improve forecasting, dispatch, and maintenance, but it also raises concerns about transparency, bias, and accountability [98]. Governance responses include: requiring explainability for AI systems used in critical dispatch decisions; establishing human-in-the-loop review for safety-critical applications; developing ethical guidelines for AI use in energy; and building capacity for regulators to audit and supervise AI systems. These measures would ensure that AI enhances rather than undermines the legitimacy and reliability of energy governance.

Finally, deep decarbonization requires a coherent institutional framework that integrates carbon pricing, green finance, and just transition policies. Carbon pricing provides a cost-effective signal for emission reduction but must be coordinated with electricity market design to avoid distortions. Green finance can mobilize private capital for renewable energy and storage but requires robust standards and disclosure rules. Just transition policies can address the distributional consequences of decarbonization but must be integrated into regional development and social protection systems. Together, these institutional arrangements form the governance foundation for achieving deep decarbonization in a manner that is efficient, equitable, and durable.

7. Conclusions

This paper has examined the transformation of China's energy governance from the 14th to the 15th Five-Year Plan period. The analytical framework encompasses policy evolution, management challenges, and institutional restructuring. The analysis reveals a clear causal pathway. Policy evolution defines the objectives and paradigm shifts. Management challenges identify the tensions and barriers that emerge during implementation. Institutional restructuring provides the responses that enable the transition from capacity expansion-oriented management to structural transformation-oriented governance. This integrated framework explains not only what has changed but also why and how China's energy governance is transforming.

The paper makes three contributions to the literature on energy governance and sustainability transitions. It proposes "governance logic transformation" as an analytical concept that captures third-order change—a shift not merely in policy settings or instru-

ments but in the underlying rationale that defines what energy governance is for and how it should operate. This concept extends existing frameworks of socio-technical transitions, energy governance regimes, and policy paradigms by explicitly linking governance structures, institutional arrangements, and policy instruments in a causal chain. It also identifies three analytical trajectories—from scale expansion to systemic restructuring, from politically driven regulation to rule-based governance, and from energy consumption control to carbon emission control—as categories constructed through inductive analysis rather than borrowed from official policy terminology. These trajectories are shown to interact through concrete governance mechanisms, including five-year planning, dual control systems, carbon markets, and electricity market reform.

The analysis yields four principal findings. First, China's energy governance has undergone a fundamental shift from capacity expansion-oriented management to structural transformation-oriented governance. During the 14th Five-Year Plan period, China built the world's largest renewable energy system at the fastest pace globally, completing the energy structure leap from "coal-dominated" to "diversified and clean" [8]. The promulgation and implementation of the Energy Law brought energy governance from policy-driven to rule-of-law-based [6]. At the opening of the 15th Five-Year Plan, policy targets have been set: a 25% share of non-fossil energy in primary energy consumption, a 50% share in electricity generation, and wind and solar installed capacity exceeding 50% [9]. The comprehensive rollout of binding indicators marks that energy transition has entered a new period from encouragement and guidance to rigid constraints [7]. New energy is accelerating its leap from a supplementary power source to a main power source in the electricity system, and the energy management system is undergoing a comprehensive transition from dual control over energy consumption to dual control over carbon emissions [43]. This is not only an upgrade of targets but also a fundamental shift in governance logic: from pursuing quantitative growth to pursuing qualitative improvement, from single-point breakthroughs to systemic integration, and from administrative promotion to institutional governance. Second, the transition from dual control over energy consumption to dual control over carbon emissions represents a third-order change in governance logic, shifting the focus from "how much energy is used" to "how much carbon is emitted" and cascading into new institutional arrangements and policy instruments. Third, the three institutional pathways—rule of law, marketization, and systematization—are mutually embedded and mutually reinforcing. The rule of law provides a stable regulatory framework; marketization injects efficiency through price signals and competition; systematization builds coordination across sectors, levels, and objectives. Together they constitute the institutional foundation for governance modernization. Fourth, managing the trade-offs among energy security, economic development, and low-carbon transition requires hybrid governance arrangements rather than reliance on any single mechanism. Carbon pricing, capacity compensation, green certificates, just transition policies, and regulatory oversight must operate in a coordinated manner.

However, clear policy targets do not equal smooth governance practice. At the opening of the 15th Five-Year Plan, China's energy management faces profound tensions among the triple objectives of security, low-carbon development, and economic efficiency. The bottom-line thinking on energy security continues to tighten due to international geopolitical conflicts. The systemic bottleneck of renewable energy integration has become increasingly prominent due to rapid installed capacity growth. The social costs of traditional energy role transition have become heavier due to accelerated transition. Moreover, the digital and intelligent transformation of energy management also faces deep challenges from technological upgrading to governance reform [50,60]. These challenges do not exist in isolation. They are intertwined and mutually reinforcing, forming

a complex governance network that requires continuous adjustment rather than one-time design. Several institutional challenges also remain unresolved. The rule-of-law process is incomplete, with supporting regulations for the Energy Law still under formulation and revisions of the Electric Power Law and the Renewable Energy Law requiring time. Market-based coordination faces persistent tensions between “unification” and “regional coordination,” and the boundary between government regulation and market incentives continues to evolve. The integration of renewable energy, storage, digital systems, and AI applications creates new governance demands—data standards, cybersecurity, algorithmic accountability, and cross-departmental coordination—that existing institutional arrangements may not fully accommodate. The just transition for coal-dependent regions and workers remains a pressing social and political challenge that cannot be resolved through technical or market measures alone.

This case offers three insights for future energy governance research. First, governance logic transformation should be understood as a political-institutional process, not merely a techno-economic one. Assessment systems, legal frameworks, and market designs co-evolve, and their interaction determines the direction and pace of transition. Second, managing multiple objectives—security, economic development, and decarbonization—requires analytical frameworks that explicitly address trade-offs rather than assuming simultaneous maximization. Third, iterative institutional learning and policy experimentation are essential features of effective energy governance. China’s pilot markets, zero-carbon parks, and computing-energy coordination experiments illustrate how governance systems can adapt through feedback and adjustment. For international energy transition research, China’s experience contributes in three ways. First, it demonstrates that governance logic transformation is not merely a techno-economic process but a political-institutional one, in which assessment systems, legal frameworks, and market designs co-evolve. Second, it shows that managing trade-offs among security, economic development, and decarbonization requires hybrid governance arrangements rather than reliance on any single mechanism. Third, it highlights the importance of iterative institutional learning and policy experimentation, as seen in pilot markets, zero-carbon parks, and computing-energy coordination. At the same time, the specific forms these arrangements take—five-year planning, dual control systems, and state-coordinated infrastructure—are deeply embedded in China’s institutional context. International readers should therefore distinguish between the general analytical framework and the context-specific mechanisms. This distinction enhances the comparative value of the Chinese case for global energy governance debates.

Looking ahead, the deep coupling of computing power and energy is giving rise to a new governance issue of “computing-energy coordination”. Zero-carbon industrial parks, as policy experiments at the micro-governance level, are testing the institutional capacity for coordinating multiple interests. The profound reshaping of the global energy governance landscape is pushing China from a rule follower to a rule shaper. Beyond the frontier of institutional design, there are deeper questions worthy of continued inquiry: How should the costs of energy transition be shared fairly across regions, industries, and generations? As new business forms of distributed energy reshape the energy power structure, how is energy democratization possible? How do energy narratives compete in the policy agenda and shape public perception? How can the resilience of the energy system be transformed from an abstract concept into operable institutional principles? These questions go beyond the boundaries of the current policy framework but are precisely the academic space that forward-looking research can explore.

China’s energy transition is not only a technological revolution and industrial transformation but also a deep governance revolution concerning development models, inter-

est patterns, and value prioritization. Policy texts can set targets, and technical solutions can optimize pathways, but what ultimately determines the success of the transition is whether the governance system has sufficient institutional flexibility to accommodate the tensions among multiple objectives, sufficient coordination capacity to balance the demands of multiple interests, and sufficient foresight to leave institutional space for uncertainty. From scale expansion to systemic restructuring, what changes are policy targets and technological pathways? What remains unchanged is the continuous pursuit of the triple objectives of security, low-carbon development, and economic efficiency? The success of China's energy transition will depend not on maximizing any single objective, but on designing governance mechanisms that can manage the tensions and trade-offs among them in a dynamic and adaptive manner. In this pursuit, the modernization of energy governance capacity, rather than the expansion of installed capacity or the improvement of technical indicators, is the key variable determining the ultimate effectiveness of China's energy transition. Understanding this is essential to truly understanding the past, present, and future of China's energy policy and energy management.

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