Executive Summary

Background

During China's 14th Five-Year Plan period, China strengthened the role of its "dual carbon" targets as a guiding framework for social development. The power sector, serving as both a pillar and catalyst for the national economy, carries the critical responsibility of securing electricity supply, driving transformation, generating economic momentum, and improving quality and efficiency. The Chinese government's comprehensive carbon peaking and carbon neutrality framework has charted a clear course for power system development and reform. This includes accelerating the transformation of coal-fired power from a primary energy source to a provider of reliable capacity and auxiliary services such as peak shaving and frequency regulation, while ensuring a safe and orderly transition, balancing high renewable energy penetration with grid stability, and enhancing the flexibility and responsiveness of the new power system.

Driven by both policy guidance and market reforms, China's new power system construction has achieved remarkable progress. By June 2025, China's combined wind and solar capacity reached 1,670 GW, marking a historic milestone by surpassing the 1,470 GW of thermal power capacity[1]. China also achieved its target of 1,200 GW of wind and solar capacity six years ahead of schedule in 2024. This rapid capacity growth has significantly boosted generation output—in the first half of 2025, wind and solar generated an additional 247 billion kWh compared to the previous year, exceeding total electricity demand growth. These dual breakthroughs in capacity and generation demonstrate renewable energy's increasingly dominant role in the system.

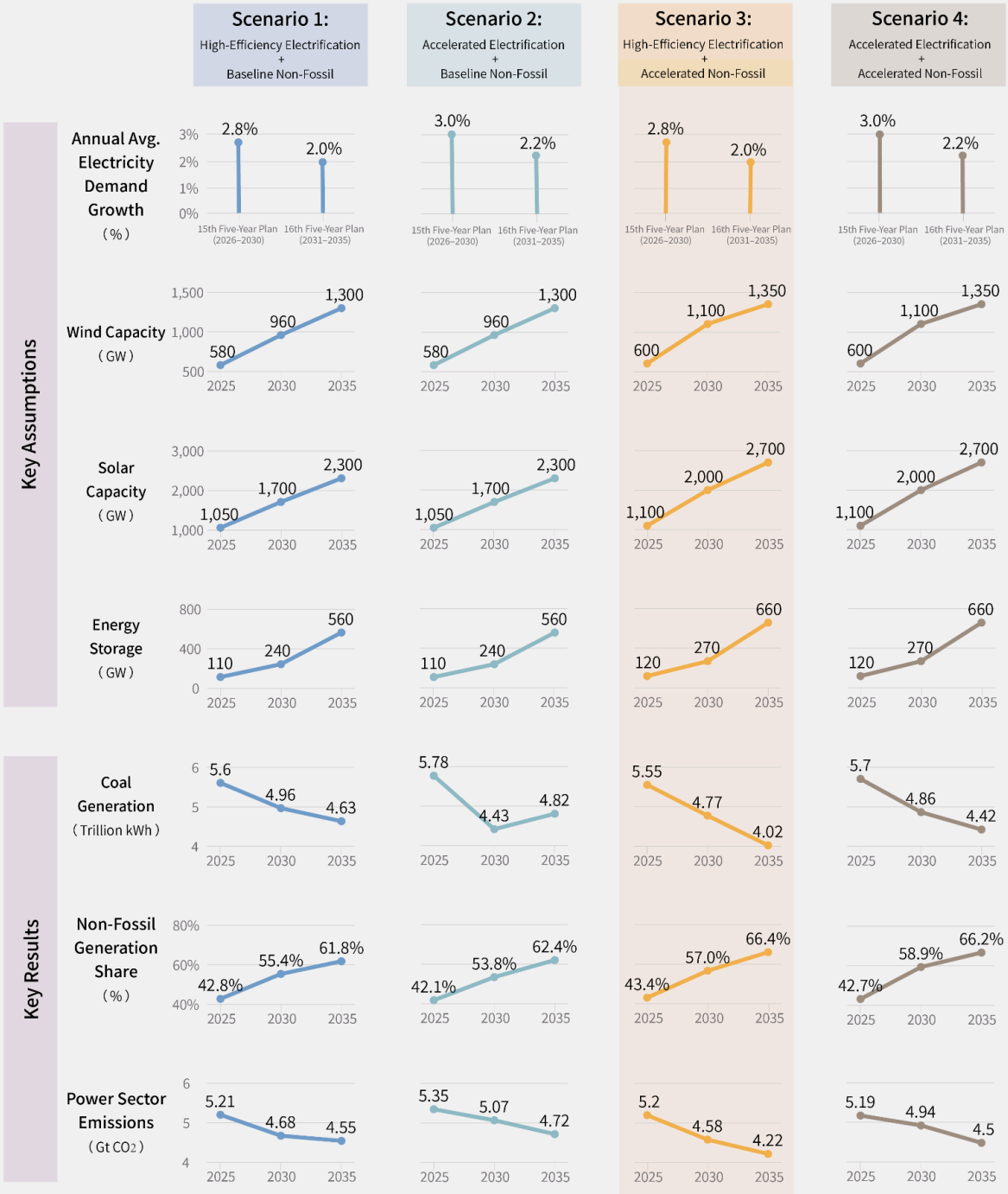
However, explosive renewable energy growth has intensified compatibility issues with existing power infrastructure. System flexibility improvements have lagged behind renewable deployment, consumption challenges persist, and structural gaps continue to widen. Current flexible resource deployment cannot meet the regulatory demands from over 200 GW of annual renewable additions. National wind power utilization rates fell to 93.2% and solar to 94% in the first half of 2025, highlighting these tensions. Since 2023, provinces including Shandong and Zhejiang have experienced zero or negative electricity prices in spot markets. As China builds a power system compatible with high renewable penetration, coal power's role transformation and functional restructuring will be crucial for addressing these compatibility gaps.

This report employs an integrated resource strategic planning model, considering China's 2025-2035 low-carbon transition goals and national power supply-demand dynamics. We establish four power transition scenarios, quantify coal power development potential, and design transition pathways that balance near-to-medium-term emission reduction targets with

[1] National Energy Administration. Transcript of Q3 2025 Press Conference [EB/OL]. July 31, 2025. https://www.nea.gov.cn/20250731/83ffa46373ec42dd99e0e3271028c151/c.html

high-renewable system regulation requirements. We also provide recommendations for green, low-carbon power system transformation during the 15th Five-Year Plan toward dual carbon goals.

Table 1. 2025-2035 Key Differences and Outcomes Across the Four Power Transition Scenarios



Key Findings

1. Scenario Analysis and Optimal Pathway

We developed four power transition scenarios based on electrification speed (electricity demand growth) and non-fossil energy deployment pace. Considering supply security, emission reduction effectiveness, and economic viability, we find that high-efficiency electrification combined with accelerated non-fossil energy deployment (Scenario 3) offers the most efficient low-carbon transition pathway. This pathway features 2.8% annual electricity growth during the 15th Five-Year Plan, 3,100 GW of wind and solar capacity by 2030, and 270 GW of energy storage (Table 1).

Emission Reduction Performance: Under Scenario 3, peak coal power generation is projected to remain below 5.55 trillion kWh, with power sector emissions peaking at 5.2 billion tons in 2025 before entering a plateau period. This reduces emissions by 150 million tons compared to the accelerated electrification combined with baseline non-fossil energy deployment (Scenario 2), providing additional time and flexibility for deep decarbonization. By 2030, non-fossil generation share is expected to reach 57% (with wind and solar at 35.8%), and power sector emissions are expected to decline 11.9% from 2025 levels to 4.58 billion tons.

Economic Viability: Scenario 3 demonstrates significant cost advantages. Compared to baseline non-fossil scenarios, reduced coal power requirements under equivalent electricity demand not only offset investments in renewable capacity and flexible resources but also generate 110-400 billion RMB in power sector savings during 2025-2035. Compared to accelerated electrification scenarios, the high-efficiency approach avoids excessive resource development and operational costs, saving approximately 670-970 billion RMB over the same period.

System Reliability: Scenario 3 effectively reduces pressure on coal power for backup capacity and seasonal/temporal supply-demand balancing through demand-side efficiency measures and steady supply-side clean energy substitution.

2. Drivers of Post-Peak Emissions Decline

System efficiency improvements and clean electrification driven by accelerated non-fossil energy deployment are essential for achieving a steady power sector emissions decline after the 2025 peak. From 2016-2024, coal generation increased by 1.55 trillion kWh, driven primarily by GDP growth, energy intensity per unit GDP[2], and increased electrification, while rising non-fossil generation shares provided crucial offset effects. With continued economic growth, energy use for electricity generation and electricity generation efficiency will advance further, making increased non-fossil electricity shares and energy intensity per unit GDP key to controlling coal generation.

[2] Unit GDP energy consumption calculations use National Bureau of Statistics constant-price GDP and total energy consumption data, differing methodologically from national planning energy intensity indicators (which exclude raw material energy use and non-fossil consumption).

The transformation should prioritize efficiency improvements throughout, combining industrial restructuring, technological progress, clean energy development, and electrification in phased fossil-to-non-fossil substitution. The 1.4 trillion kWh of electricity substitution from 2016-2024 roughly equals the 1.55 trillion kWh coal generation increase, essentially transferring emissions from other sectors to power. Therefore, in the decade following power sector peak emissions, improving system efficiency and accelerating non-fossil-driven clean electrification represent the critical pathway for steady power sector decarbonization.

3. Transition Challenges

Looking toward the 15th Five-Year Plan period, China's power system transition faces three major challenges: risks of excessive electrification combined with insufficient coal power constraints, which could drive up power sector emissions; technical and institutional bottlenecks in renewable energy scaling; and economic constraints on existing coal power transition.

Future success requires coordinated policy guidance, target constraints, and market incentives, as well as building diversified, long-term coordination mechanisms based on regional coal power and renewable energy service characteristics. This includes strengthened coordination and rolling management of coal power and renewable investment, exploring power sector carbon "dual control" mechanisms, implementing effective capacity compensation mechanisms, and advancing inter-provincial power sharing arrangements.

Policy Recommendations

1. Top-Level Design for Coal Generation Control

China should develop a comprehensive framework for controlling coal power generation, preparing proactive deployment strategies for accelerated clean power substitution during the 15th Five-Year Plan period after the power sector’s peak. China must work within system safety margins through dual-sided approaches: supply-side accelerated clean power substitution and demand-side efficiency improvements, in the meantime, deepening high-efficiency clean electrification while avoiding unchecked expansion of electricity substitution. This alleviates supply pressures from rapid demand growth, creates favorable conditions for safe, efficient, reliable clean electricity substitution, prevents using electricity demand as justification for coal power expansion, promotes gradual coal generation decline, and balances supply security with low-carbon objectives to enable phased emission reduction targets.

2. Coordinated Capacity Planning Framework

China should establish effective capacity coordination and rolling optimization systems for generation investment and construction, strengthening risk warning mechanisms for coal power and renewable planning (extending beyond the 13th Five-Year Plan coal power warning system). First, flexibly optimize capacity allocation and comprehensive dispatch systems across regions and timeframes, steadily advancing renewable capacity development while transforming

coal power roles. Second, prioritize addressing structural shortfalls in peak capacity and flexibility while reducing geographical constraints on inter-provincial resource sharing, strengthening supply-demand monitoring, developing large-scale bidirectional dispatch capabilities, and flexibly adjusting construction timelines to enhance system reliability and climate resilience.

3. Grid Integration and Support Capabilities

Low-carbon transition's "establish before dismantling" approach requires simultaneously strengthening the grid's capability to support renewable energy as it gradually replaces conventional sources. Currently, renewable generation passively "follows" grid operations, with its volatility creating system burdens. Future ultra-high renewable penetration systems require renewables with active support and flexible regulation capabilities.

Short-term solutions include grid-forming inverters and operational controls enabling active frequency regulation, coordination with storage for voltage support during fluctuations, and participation in grid restoration during extreme events—delivering functions equivalent to conventional sources. Long-term objectives involve overcoming technical challenges of high renewable and power electronics penetration, achieving fundamental transformation from renewable "grid-following" to "grid-forming" capabilities, and enabling participation as primary regulation resources in grid safety systems.

Footnotes:

[1] National Energy Administration. Transcript of Q3 2025 Press Conference [EB/OL]. July 31, 2025. https://www.nea.gov.cn/20250731/83ffa46373ec42dd99e0e3271028c151/c.html

[2] This report's 2025 electricity consumption projections are more conservative than recent China Electricity Council forecasts, reflecting complex domestic and international energy-economic conditions requiring dual-sided transformation approaches—demand-side conservation and efficiency alongside steady supply-side restructuring—to maximize clean power supply while ensuring safe, economic high-renewable integration.

[3] Considering power system absorption capacity and market development pace, renewable development scenarios were based on flexible resource deployment schedules.

[4] Unit GDP energy consumption calculations use National Bureau of Statistics constant-price GDP and total energy consumption data, differing methodologically from national planning energy intensity indicators (which exclude raw material energy use and non-fossil consumption).