Research on the Evaluation Indicator System for Dynamic Transition in Grid Enterprises' Economic Activities

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Abstract. Under the strategic backdrop of China's deepening supply-side structural reform and energy revolution, the dynamic transition between traditional and new driving forces has emerged as a crucial pathway for achieving high-quality development in the energy and power sector. This study constructs a dynamic transition evaluation system comprising seven first-level indicators (security and supply reliability, low-carbon transition, reform effectiveness, technological innovation, operational efficiency, service quality, and international cooperation) and forty second-level indicators. The fuzzy analytic hierarchy process (FAHP) was employed for weight assignment, with subsequent application to corporate data analysis. The results demonstrate that the comprehensive dynamic transition index of grid enterprises increased from 37.2 to 92.6 during 2010-2022, achieving an average annual growth rate of 7.9%. This sustained upward trajectory indicates steady progress in dynamic transition processes, with significant contributions from advancements in security and supply reliability, technological innovation, operational efficiency, and low-carbon transition domains.

Keywords: Grid enterprises; Economic activities; New and old driving forces; Evaluation system.

1. Introduction

Driven by the global restructuring of energy systems and China's high-quality economic development strategy, the energy and power sector is undergoing historic transformation[1]. Since the explicit proposal of supply-side structural reform and energy revolution in the 13th Five-Year Plan, the dynamic transition between traditional and new driving forces has become a pivotal academic and industrial focus for industrial upgrading. As a foundational sector of the national economy characterized by technology and capital intensiveness, this transition not only determines the clean energy transition but also critically influences national economic restructuring and carbon neutrality objectives.

Current research on energy transition evaluation reveals significant gaps in systematic measurement of dynamic transition[2]. Existing studies predominantly concentrate on singular dimensions or theoretical macro-level discussions, lacking industry-specific comprehensive evaluation frameworks. This research deficiency hinders accurate assessment of energy enterprises' transition effectiveness and quantitative decision-making support for strategic adjustments.[3] Particularly under deepening power sector reforms and accelerated construction of new-type power systems, there is an urgent need to establish systematic and operational evaluation frameworks to scientifically elucidate the intrinsic mechanisms of energy enterprises' dynamic transition.

This study develops a dynamic transition evaluation system for grid enterprises, incorporating seven first-level indicators (including security and supply reliability, low-carbon transition, and reform effectiveness) and forty second-level indicators. By introducing fuzzy analytic hierarchy process (FAHP) to address uncertainty in weight determination and conducting empirical analysis with 2010-2022 operational data, we effectively overcome the ambiguity and subjectivity limitations of traditional evaluation methods in complex system assessments. The research not only reveals temporal evolution patterns of grid enterprises' dynamic transition but also identifies key driving factors through contribution analysis, establishing a quantifiable reference framework for optimizing transition pathways in comparable energy enterprises.

2. Evaluation System Construction for Dynamic Transition Assessment in Grid Enterprises' Economic Activities

2.1 Fundamental Framework

Aligned with the high-quality development requirements of grid enterprises, this study establishes a comprehensive dynamic transition evaluation system based on power big data repositories. The framework incorporates multidimensional corporate indicators to construct a dynamic transition index, enabling quantitative measurement of transition effectiveness. The system ensures operational feasibility, strategic alignment, and effective reflection of national policy orientations regarding dynamic transition.

The construction process involves three key phases:

First, indicator screening through holistic business analysis of grid enterprises. By synthesizing expert consultations, referencing national dynamic transition performance evaluation frameworks, reviewing energy industry literature, and analyzing corporate strategic documents, we established a dynamic transition indicator database.

Second, weight assignment using fuzzy analytic hierarchy process (FAHP) for both first-level and second-level indicators, addressing inherent uncertainties in multi-criteria decision-making.

Third, empirical implementation through data synthesis. Historical data underwent per-unit normalization (distinguishing positive and negative indicators), followed by weighted aggregation based on assigned weights to derive both the composite dynamic transition index and sub-indices for each first-level indicator.

2.2 System Construction Principles

The evaluation system adheres to four fundamental principles:

(1) Systematicity Principle: Holistically reflects the essential characteristics of evaluated entities, ensuring the integrated assessment capability exceeds mere summation of individual indicators.

(2) Consistency Principle: Maintains strict alignment between indicator hierarchy and evaluation objectives throughout system architecture.

(3) Measurability Principle: Guarantees direct observational verification and unambiguous conclusion derivation for all indicators.

(4) Independence Principle: Ensures conceptual clarity and mutual exclusivity among indicators, eliminating overlaps and causal relationships to achieve comprehensive assessment coverage.

2.3 System Architecture Outcomes

The finalized system comprises seven first-level indicators—security and supply reliability, low-carbon transition, reform effectiveness, technological innovation, operational efficiency, service quality, and international cooperation—supported by forty second-level indicators. Notably, while some first-level indicators (e.g., power supply security) traditionally represent fundamental corporate functions, their corresponding second-level indicators specifically capture emerging dynamics within these domains. This design acknowledges that traditional operational areas evolve under new developmental paradigms, incorporating novel requirements from renewable energy integration and climate change adaptation. The architecture thus avoids oversimplified categorization of "traditional" versus "new" driving forces, instead providing nuanced measurement of transitional progress across all critical operational dimensions.

Table 1. Assessment Indicator System for Enterprise Transformation Between Old and New Growth Drivers

Primary Indicator	Secondary Indicator	Unit	Indicator Definition
Security and Supply Assurance	Pumped Storage Grid-Connected Capacity Ratio	%	Ratio of pumped storage grid-connected capacity in the company's operational area = (Pumped storage grid-connected capacity / Total grid-connected capacity in operational area) × 100%
	Utilization Level of Pumped Hydro Storage	Hours	Utilization level = Pumping utilization hours + Power generation utilization hours
	New Energy Storage Grid-Connected Capacity Ratio	%	Ratio of new energy storage grid-connected capacity in the company's operational area = (New energy storage grid-connected capacity / Total grid-connected capacity in operational area) × 100%
	Inter-Provincial Trading Electricity Ratio	%	Ratio of inter-provincial trading electricity in the company's operational area = (Inter-provincial trading electricity / Total electricity consumption in operational area) × 100%
	UHV Investment Completion Ratio	%	Ratio of UHV investment completion = (UHV investment amount / Total grid infrastructure investment) × 100%
	Utilization Hours of UHV DC Channels	Hours	Utilization hours of operational UHV DC channels
	Adjustable Load Ratio	%	Ratio of adjustable load to maximum social load in the company's operational area
	Flexible Thermal Power Unit Capacity Ratio	%	Ratio of flexible thermal power unit capacity to total thermal power unit capacity in the company's operational area
Low-Carbon Transition	Renewable Energy Grid-Connected Capacity Ratio	%	Ratio of renewable energy grid-connected capacity in the company's operational area = (Renewable energy grid-connected capacity / Total grid-connected capacity in operational area) × 100%
	Renewable Energy Power Generation Ratio	%	Ratio of renewable energy power generation in the company's operational area = (Renewable energy power generation / Total power generation in operational area) × 100%
	Renewable Energy Utilization Rate	%	Renewable energy utilization rate = (Wind power generation + Solar power generation) / (Wind power generation + Solar power generation + Curtailed electricity) × 100%
	Renewable Energy Grid Connection Investment Ratio	%	Ratio of renewable energy grid connection investment = (Renewable energy grid connection investment /

			Total infrastructure investment) × 100%
	Electricity Share in Terminal Energy Consumption	%	Electricity share in terminal energy consumption = (Electricity terminal consumption / Regional total energy consumption) × 100%
	Clean Energy Trading Electricity Ratio	%	Ratio of clean energy trading electricity = (Clean energy trading electricity / Total trading electricity) × 100%
	Charging Pile Investment Ratio	%	Ratio of charging pile investment = (Charging pile investment / Total fixed asset investment) × 100%
	Energy Consumption Intensity	tce/¥10k	Energy consumption intensity = Total energy consumption (10,000 tons of standard coal) / Total output value (main business revenue, ¥100 million)
	High-Efficiency Energy-Saving Transformer Ratio	%	Ratio of high-efficiency energy-saving transformers = (Number of high-efficiency energy-saving transformers / Total number of transformers) × 100%
Reform Effectiveness	Market-Oriented Trading Electricity Ratio	%	Ratio of market-oriented trading electricity = (Market-oriented trading electricity / Total electricity consumption in operational area) × 100%
	Transmission and Distribution Tariff Implementation Index	/	Transmission and distribution tariff implementation index = (Tariff realization rate score × 50%) + (Approved effective asset recognition index score × 50%)
Technological Innovation	R&D Expenditure Intensity	%	R&D expenditure intensity = (Total R&D expenditure / Operating revenue) × 100%
	Completion Rate of Major R&D Tasks	%	Completion rate of "bottleneck" technology R&D tasks in terms of progress and quality
	Digitalization Development Index	%	Digitalization development index = (Equipment networking rate + Industrial digitalization rate + Digital industrialization rate + Industrial driving coefficient) / 4
	Patent Authorization Density	No./¥bn	Cumulative number of patents / Total company assets
	Standards Formulated	Items	Number of national and industry standards led and formulated
	National-Level Awards	No.	Number of national-level scientific and technological awards
	Online Monitoring Rate of Transmission Networks	%	Ratio of transmission lines with online monitoring capabilities = (Length of monitored transmission lines / Total transmission line length) × 100%
	Automation Coverage Rate of Distribution Networks	%	Ratio of automated distribution lines = (Length of automated distribution lines / Total distribution line length) × 100%
Operational Efficiency	Revenue Share of	%	Revenue share of emerging businesses

	New Kinetic Businesses		= (Emerging business revenue / Total operating revenue) × 100%
	Profit Share of New Kinetic Businesses	%	Profit share of emerging businesses = (Emerging business profit / Total operating profit) × 100%
	Overall Labor Productivity	¥10k/Person-Year	Overall labor productivity = (Labor production value / Average number of employees)
Service Quality	Ratio of Planned Outage Time	%	Ratio of planned outage time to total outage time
	Contribution of Non-Outage Operations to Power Supply Reliability	%	Contribution of non-outage operations to power supply reliability = (Outage time reduced by non-outage operations / Total outage time) × 100%
	Quality of Financial Services for Core Business	---	Evaluated via satisfaction surveys: Quality = (∑ Evaluation results from core business units / Number of core business units × 40%) + (Finance department evaluation × 40%) + (Yingda Group evaluation × 20%)
	Scale of Green Financial Services	¥bn	Growth rate of green financial services (e.g., green credit, bonds, insurance): Green financial service scale growth rate = (Current year scale - Previous year scale) / Previous year scale × 100%
	Customer Satisfaction of Industrial Subsidiaries	---	Scores from periodic customer satisfaction surveys
	Overseas Project Satisfaction (CEEG)	---	Client satisfaction with overseas engineering projects
International Cooperation	Export Share of New Kinetic Businesses	%	Export share of new kinetic businesses = (Export value of new kinetic businesses / Revenue of new kinetic businesses) × 100%
	Growth Rate of Overseas Assets Under Management	%	Growth rate = (Current year overseas assets under management - Previous year overseas assets) / Previous year overseas assets × 100%
	Number of Chinese Standards Applied Overseas	No.	Number of Chinese standards applied in overseas projects

The first-level indicator for Secure Supply comprises 8 second-level indicators, reflecting the new measures adopted and new kinetic energy injected by the company to shoulder its primary responsibility and ensure a safe and reliable power supply. Specifically, it reflects the following aspects of information: First, the construction of peak shaving and frequency regulation capacity (proportion of pumped-hydro storage connected capacity, utilization level of pumped-hydro storage, proportion of new-type energy storage connected capacity, proportion of flexible thermal power generating unit capacity); Second, the construction and utilization of Ultra High Voltage (UHV) channels and inter-provincial surplus-deficit mutual assistance (proportion of completed UHV investment, utilization hours of UHV DC channels, proportion of inter-provincial electricity transaction volume); Third, the utilization of demand-side resources (proportion of adjustable load).

The first-level indicator for Low-carbon Transition encompasses 10 second-level indicators, reflecting the new measures adopted and new kinetic energy injected by the company to achieve the "dual carbon" goals and construct a new type of power system. Specifically, it reflects the following aspects of information: First, the development and utilization of new energy or clean energy (proportion of new energy grid-connected capacity, proportion of new energy power generation, utilization rate of new energy power generation, proportion of investment in new energy grid connection, proportion of clean energy transaction volume); Second, the promotion of increased end-use electrification (proportion of electricity in final energy consumption, proportion of charging pile investment); Third, the company's energy saving and consumption reduction efforts (energy consumption intensity, proportion of high-efficiency energy-saving transformers).

The first-level indicator for Reform Effectiveness includes 2 second-level indicators, reflecting the company's efforts in implementing national requirements for reform effectiveness. Specifically, it reflects information related to assisting in the implementation of electricity market reform policies (proportion of market-based electricity transaction volume, implementation index of transmission and distribution tariffs).

The first-level indicator for Technological Innovation comprises 7 second-level indicators, reflecting the breakthroughs made by the company in technological innovation, which serve as new kinetic energy for the company's development. Specifically, it reflects the following aspects of information: First, the company's R&D expenditure (intensity of R&D expenditure); Second, the company's significant achievements in projects, patents, standards, and awards (completion rate of major research tasks, patent authorization density, number of standards formulated, number of national-level awards); Third, the company's digital development (digital development index, online monitoring rate of the transmission network, automation coverage rate of the distribution network).

The first-level indicator for Operating Benefits includes 3 second-level indicators, specifically reflecting the new kinetic energy injected by the company in terms of operating benefits. Specifically, it includes the following aspects of information: First, the optimization level of the power grid enterprise's business structure (proportion of operating revenue from new kinetic energy businesses, proportion of profit from new kinetic energy businesses, where new kinetic energy businesses refer to strategic emerging industries within the narrow sense of the new-old kinetic energy conversion evaluation system); Second, the degree of improvement in the power grid enterprise's efficiency and quality (all-staff labor productivity).

The first-level indicator for Service Quality includes 6 second-level indicators, specifically reflecting the new kinetic energy injected by the company in terms of service quality. Specifically, it includes the following aspects of information: First, new kinetic energy for improving service quality in power grid operations (proportion of pre-scheduled outage time, contribution of live-line work on distribution networks to power supply reliability); Second, new kinetic energy for improving service quality in financial operations (quality of financial services for the core business, scale of green financial services); Third, new kinetic energy for improving service quality in industrial units (customer service satisfaction of industrial units); Fourth, new kinetic energy for improving service quality in international business (overseas project satisfaction (China Electric Power Equipment)).

The first-level indicator for Opening Up includes 3 second-level indicators, specifically reflecting the new kinetic energy injected by the company in terms of opening up. Specifically, it includes the following aspects of information: First, the degree of opening up of new kinetic energy businesses (proportion of export value from new kinetic energy businesses); Second, the growth rate of overseas assets (growth rate of managed overseas assets); Third, the internationalization level of Chinese standards (number of Chinese standards applied overseas).

2.4 Weight Calculation Method

Given the need to assign weights to each indicator within the comprehensive evaluation index system described earlier, this study employs the Fuzzy Analytic Hierarchy Process (FAHP) to determine experts' assessment weight values for each indicator of the corporate new and old kinetic energy conversion index. This methodology effectively mitigates subjective influences and enables scientific quantification of judgmental impacts. The specific implementation steps for applying FAHP to assign indicator weights are as follows:

(1) Hierarchical Structure Construction The corporate new and old kinetic energy conversion index system comprises three hierarchical levels:

- Top-level indicator (Composite Index of Corporate New and Old Kinetic Energy Conversion)
- Middle-level indicators (Safe Supply Assurance, Low-Carbon Transition, Reform Effectiveness, Technological Innovation, Operational Efficiency, Service Quality, and Open Development)
- Bottom-level indicators (40 specific metrics including Proportion of Pumped Storage Grid-Connected Capacity)

(2) Formation of Preference Relation Matrix A precedence relationship matrix $B=(b_{ij})_{m\times n}$ is constructed to represent the relative importance of indicators within each hierarchical level with respect to their corresponding upper-level indicator. The determination method for elements b_{ij} follows the criteria specified in the subsequent table.

Table 2. Weight Assignment of the Assessment Indicator System for Enterprise Transformation Between Old and New Growth Drivers

Comparison of Indicator Importance	b~ij~ Value
i > j	1
i = j	0.5
i < j	0

3. Practical Application of Dynamic Transition Assessment System for Grid Enterprises' Economic Activities

3.1 Weight Calculation Results

The normalized weights of all indicators in the evaluation system were derived through standardized processing, with detailed calculation outcomes presented in Table X below.

Table 3. Scaling Principles of the Fuzzy Analytic Hierarchy Process (FAHP)

First-Level Indicators	First-Level Weight	Second-Level Indicators	Second-Level Weight
Security and Supply Assurance	0.23	Pumped Storage Grid-Connected Capacity Ratio	0.033
		Utilization Level of Pumped Hydro Storage	0.016
		New Energy Storage Grid-Connected Capacity Ratio	0.041
		Inter-Provincial Trading Electricity Ratio	0.025
		UHV Investment Completion Ratio	0.025
		Utilization Hours of UHV DC Channels	0.033
		Adjustable Load Ratio	0.041
		Flexible Thermal Power Unit Capacity Ratio	0.016
Low-Carbon Transition	0.22	Renewable Energy Grid-Connected Capacity Ratio	0.022
		Renewable Energy Power Generation Ratio	0.022
		Renewable Energy Utilization Rate	0.025
		Renewable Energy Grid Connection Investment Ratio	0.018

		Electricity Share in Terminal Energy Consumption	0.054
		Clean Energy Trading Electricity Ratio	0.018
		Charging Pile Investment Ratio	0.019
		Energy Consumption Intensity	0.026
		High-Efficiency Energy-Saving Transformer Ratio	0.016
Reform Effectiveness	0.08	Market-Oriented Trading Electricity Ratio	0.038
		Transmission and Distribution Tariff Implementation Index	0.042
Technological Innovation	0.17	R&D Expenditure Intensity	0.048
		Completion Rate of Major R&D Tasks	0.016
		Digitalization Development Index	0.030
		Patent Authorization Density	0.014
		Standards Formulated	0.012
		National-Level Awards	0.020
		Online Monitoring Rate of Transmission Networks	0.017
		Automation Coverage Rate of Distribution Networks	0.013
Operational Efficiency	0.15	Revenue Share of New Kinetic Businesses	0.043
		Profit Share of New Kinetic Businesses	0.053
		Overall Labor Productivity	0.054
Service Quality	0.09	Ratio of Planned Outage Time	0.011
		Contribution of Non-Outage Operations to Power Supply Reliability	0.016
		Quality of Financial Services for Core Business	0.015
		Scale of Green Financial Services	0.010
		Customer Satisfaction of Industrial Subsidiaries	0.022
		Overseas Project Satisfaction (CEEG)	0.016
International Cooperation	0.06	Export Share of New Kinetic Businesses	0.017
		Growth Rate of Overseas Assets Under Management	0.015
		Number of Chinese Standards Applied Overseas	0.028

3.2 System Application

Empirical implementation of the evaluation system was conducted using operational data from 2010 to 2022.

The dynamic transition composite index of grid enterprises demonstrated sustained growth from 37.2 in 2010 to 92.6 in 2022, achieving an average annual growth rate of 7.9%. This upward trajectory underscores the continuous advancement of dynamic transition initiatives within the sector. Sub-indices exhibited differentiated growth patterns, with annual growth rates for security and supply reliability, low-carbon transition, reform effectiveness, technological innovation, operational efficiency, service quality, and international cooperation reaching 11.5%, 4.4%, 13.6%, 11.0%, 7.9%, 9.9%, and 5.2%, respectively. Corresponding contribution rates to the total index growth were quantified as 26.7%, 14.4%, 10.6%, 20.2%, 15.1%, 10.0%, and 3.0%, revealing four dominant drivers: security and supply reliability (26.7%), technological innovation (20.2%), operational efficiency (15.1%), and low-carbon transition (14.4%), which collectively accounted for 76.4% of the progress.

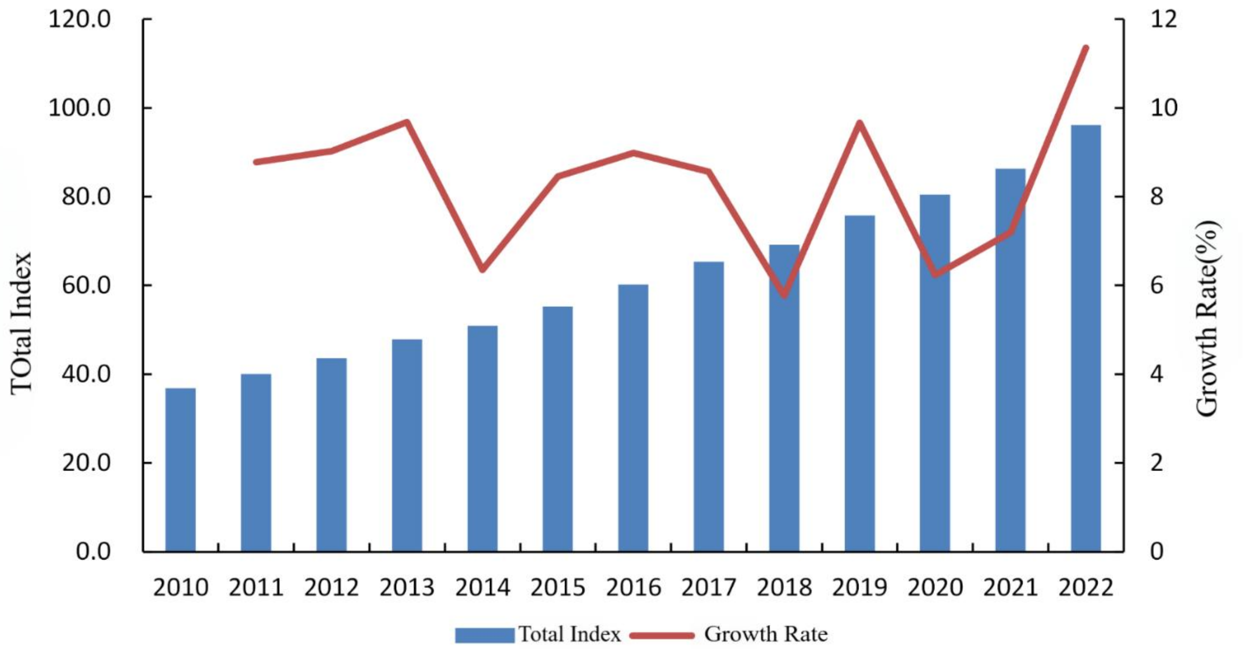

Figure 1 Historical Evolution of the Total Index for Old and New Growth Drivers Transformation in Power Grid Enterprises

Periodic analysis reveals distinct growth phases. During the 12th Five-Year Plan (2011–2015), 13th Five-Year Plan (2016–2020), and the initial two years of the 14th Five-Year Plan (2021–2022), the composite index grew at annualized rates of 8.5%, 7.9%, and 9.3%, respectively. The accelerated growth post-2021 aligns with emerging operational imperatives, including enhanced power supply security demands, dual-carbon targets, new-type power system strategies, and technological innovation requirements. Specifically, the contribution rates of security and supply reliability, low-carbon transition, and technological innovation to total index growth during 2021–2022 reached 36.5%, 16.1%, and 19.4%, respectively, representing increases of 13.2, 2.8, and 0.2 percentage points compared to the 2016–2020 period. These shifts reflect the sector's strategic realignment toward resilient infrastructure, decarbonization pathways, and innovation-driven development under evolving national energy policies.

4. Summary

This study constructs a dynamic transition evaluation system comprising seven first-level indicators—security and supply reliability, low-carbon transition, reform effectiveness, technological innovation, operational efficiency, service quality, and international cooperation—alongside forty specific second-level indicators. The fuzzy analytic hierarchy process (FAHP) was adopted for weight assignment, with empirical implementation conducted through corporate operational data analysis. Key findings demonstrate that the composite dynamic transition index of grid enterprises exhibited sustained growth, increasing from 37.2 in 2010 to 92.6 in 2022, achieving an average annual growth rate of 7.9%. This upward trajectory signifies the continuous and steady advancement of dynamic transition processes within the sector.

Furthermore, the analysis identifies four principal domains driving total index growth: security and supply reliability (26.7%), technological innovation (20.2%), operational efficiency (15.1%), and low-carbon transition (14.4%). These domains collectively account for 76.4% of the observed progress, quantitatively validating their critical roles in accelerating the sector’s transition dynamics. The methodological framework demonstrates robust applicability in capturing multi-dimensional transition patterns, while the empirical outcomes align with strategic priorities in energy system modernization and sustainable development agendas.

5. Acknowledgement

Relying on the State Grid Technology Research Service Project "Key Technology Research Support for High-quality Development of Power Grids", Contract No. SGZB0000FCIS2400419.

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