# Evaluation System of Economic and Social Benefits of Power Grid Investment under the New Development Pattern

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**Abstract.** Based on the "14th Five-Year Plan" and the focus and scale of medium and long-term power grid investment, this paper analyzes the mechanism of corporate power grid investment on expanding domestic demand, increasing kinetic energy, improving circulation, improving efficiency and improving environment, and establishes the evaluation index system and evaluation method of economic and social benefits of power grid investment under the new development pattern. In this paper, a variety of energy technology models and energy economic models are coupled, and a comprehensive benefit evaluation model of power grid investment is established to reflect the characteristics of the new development pattern and the gradual internalization of environmental costs and other energy transformation characteristics, so as to provide methods and tools for the value evaluation and strategic decision-making of power grid investment. This paper uses the model to analyze the company's future power grid investment plan. The results show that the company's power grid investment can not only effectively improve the safety, reliability, flexibility and cleanliness of the power system, but also promote the economic and social benefits of national economic growth, job creation, regional coordination, resource conservation and environmental protection.

**Keywords:** New Development Pattern; Power Grid Investment; Evaluation Index System; Comprehensive Benefit Evaluation Model

## 1 Introduction

### 1.1. research background

Power grid is an important infrastructure related to the national economy and people's livelihood, shouldering the important mission of ensuring economic and social development, serving the improvement of people's livelihood, and promoting energy transformation and upgrading[1]-[3]. With the establishment of the new power system, the high-quality development of the electric power industry is conducive to the high-quality development of China's economy, and will be in a strategic position and role in the new stage of

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development[4]-[6]. As an important state-owned backbone enterprise related to the national energy security and the lifeline of the national economy, the power grid investment decision should not only consider the economic benefits of the enterprise, but also comprehensively consider the improvement of the power grid's supporting capacity for national economic and social development[7]-[8].

From the perspective of macroeconomic environment, the power industry has a long industrial chain and strong investment driving ability, and it is urgent to expand domestic demand and promote domestic economic and social development through power grid investment. From the perspective of external supervision and social expectations, the government's supervision of power grid enterprises is becoming stricter, the energy authorities' management of power grid planning and investment and the approval of new power grid investment are becoming stricter, and the society's expectations of reducing energy consumption costs and releasing the dividends of power system reform are gradually increasing. Social benefit evaluation becomes the key to obtain policy support[9]-[10]. From the company level, in order to implement the transmission and distribution electricity price reform requirements, the electricity price space narrowed; Amid the outbreak of COVID-19, China has introduced policies to reduce electricity costs in stages. Affected by multiple profit reduction factors, the company's profitability has declined significantly, the power grid investment capacity has been significantly weakened, and the operating pressure has been unprecedented[11]. To achieve precise investment and maximize the economic and social benefits of power grid investment is an important part of the company's three responsibilities[12]-[13].

### 1.2. Research purpose and significance

This study aims to explore how power grid investment influences the new development pattern and establish an evaluation system and model. It investigates the role of such investment in driving economic growth, expanding domestic demand, and forming economic policies. The research intends to reveal its mechanisms for enhancing production, resource use, and sustainability. Additionally, it creates an assessment system that gauges economic, social, and environmental benefits, aiding decision-making. This study holds theoretical and practical importance. It enables a deeper understanding of power grid investment's effects, fostering high-quality economic development, structural upgrades, and sustainable growth. The evaluation system holistically measures investment impact on demand, circulation, and efficiency, aiding resource allocation and benefiting investments. Moreover, the research underscores power grid investment's environmental significance, facilitating clean energy adoption and emissions reduction. Ultimately, findings inform policy-making, supporting the new development pattern and sustainable economic progress.

### 1.3. Research content and method

This study examines how power grid investment shapes the new development pattern and evaluates its economic and social benefits. It delves into mechanisms fostering domestic demand, innovation-driven growth, and efficient resource allocation. It investigates grid investment's role in enhancing circulation, security, and urban-rural coordination. The research combines literature review, quantitative analysis, case studies, expert interviews, and questionnaires to understand grid investment's impact. It constructs an evaluation index system, weighing indicators, collecting data, and analyzing relationships. The study creates an economic and social benefit evaluation model, comprehensively considering power system benefits, socio-economic effects, and environmental gains. This model quantifies grid investment's holistic benefits, offering decision-making support (Figure 1).

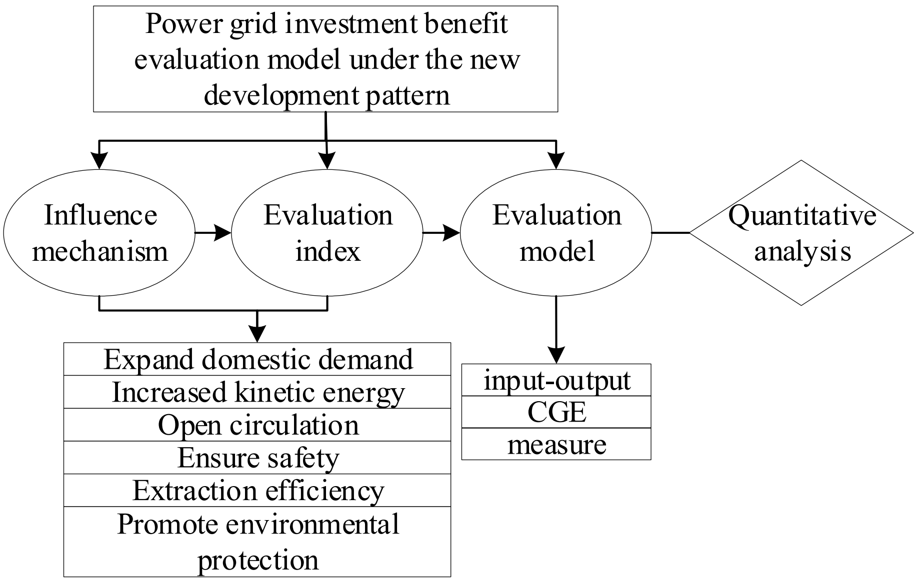


**Figure 1** Research technology roadmap

## 2 The influence mechanism of power grid investment on the construction of new development pattern

### 2.1. Expand domestic demand and increase growth momentum

In the new development pattern, power grid investment promotes high-quality economic growth by focusing on green initiatives, smart enhancements, security, and value creation. Major projects include extending UHV networks, bolstering connectivity, and establishing energy Internet zones. This investment strategy expands domestic demand through infrastructure's multiplier effect on national income, spurring upstream and downstream industries, enhancing regional investment appeal, and generating employment opportunities, raising incomes, and increasing consumption power (Figure 2).

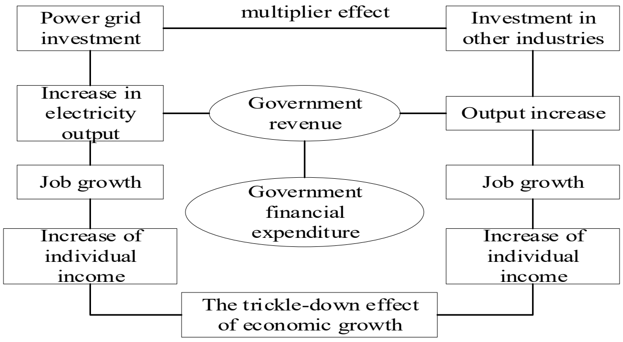


**Figure 2** Transmission path of influence of power grid investment on market entities

Driven by the new technological revolution, power grid investment reshapes China's energy advantage through innovation. It integrates data tech with energy systems, advancing smart multi-energy setups. It accelerates 5G, IoT, and industrial Internet development, fostering energy intelligence. Addressing energy tech gaps, it spurs smart grid, renewable energy, and hydrogen tech. It establishes modern energy standards, propelling energy Internet, flexible DC, and hydrogen standards. Standardization projects drive energy tech, hydrogen, and integrated services standardization, yielding promotable outcomes (Figure 3).

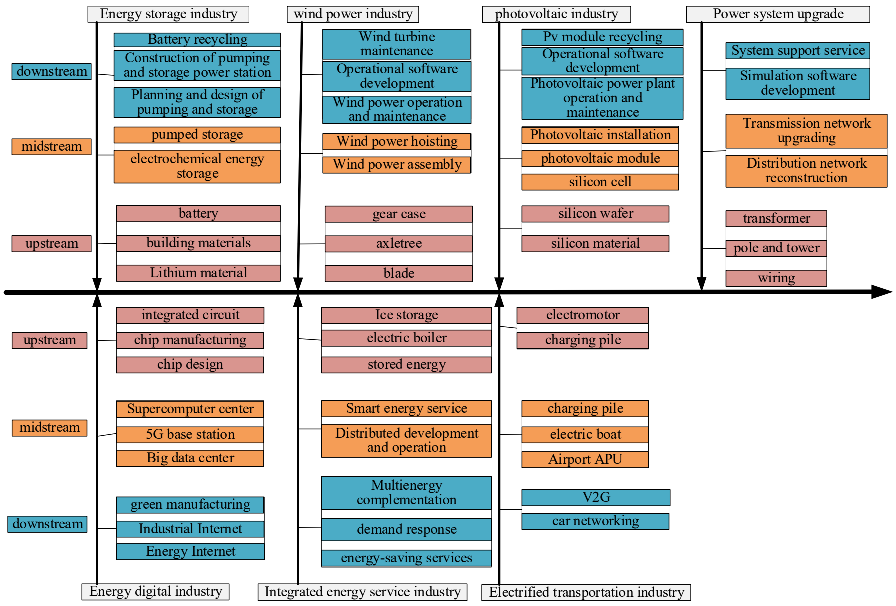


**Figure 3** The driving role of power grid investment on the industrial chain

## 2.2. Smooth circulation and improve efficiency

In the "14th Five-Year Plan," power grid investment will address regional disparities, enhancing interconnectivity and supporting the new development pattern. Investments will optimize supply by linking grids across regions, ensuring efficient resource allocation, and facilitating supply-demand circulation. Infrastructure upgrades and peak regulation improvements will bolster grid security and element circulation. National electricity market enhancements will foster better business environments and market flow. Rural distribution network investments will bridge urban-rural gaps, encouraging coordinated development. Regional-specific investments will diminish regional disparities, enhancing coordination and circulation, aligning with the new development strategy[14]-[15].

### 2.3. Promoting pollution reduction and carbon reduction

With the rapid development of China's social economy and the steady improvement of energy cleanliness, China is committed to promoting the strategic transformation of reducing pollution and carbon. As a major contributor to carbon emissions, the power sector's efforts to reduce emissions are crucial. The following are the key measures to promote carbon reduction:

- Optimize the allocation of clean energy and promote the upgrading of the power grid into an energy Internet;
- We will support the development of distributed power sources and microgrids, and promote integrated energy services

## 3 Results & Discussion

### 3.1. Model frame design

This study creates a comprehensive benefit evaluation model for power grid investment. By integrating energy technology and economic models, it reflects the new development pattern and environmental considerations. The model assesses value and informs decisions. It analyzes differences between new and traditional energy in all stages and evaluates large-scale new energy integration's effects on power systems and transmission. The model links energy planning, production simulation, and 3E-CGE (energy-economic-environment) model, connecting power grid investment with energy, environment, economy, and society effectively (Figure 4).

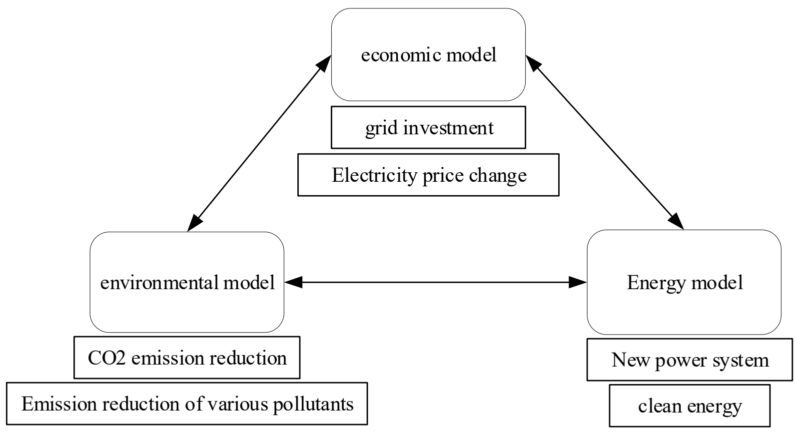


**Figure 4** Grid investment benefit evaluation model framework

The power grid investment's economic and social benefit evaluation model incorporates macroeconomic, energy transition, and environmental aspects. The CGE model integrates environmental and energy factors into production and utility functions, simulating policies like emission trading and energy consumption control. The pricing module reflects policy control over non-competitive commodities like electricity. The energy technology and economic models are interlinked, analyzing diverse energy development's influence on regional economy, industries, and the energy system.

### 3.2. Power system benefit evaluation model

Based on the principle of pressure-state-response model, this study constructs a Measure-State-Response-Benefit (MSRB) evaluation model to evaluate the comprehensive benefit of the power system. The model describes and reflects the logic of "what kind of means guide the system construction, how the state of the system has changed under the corresponding means, what benefits such changes bring, and what dimensions can be used to measure these benefits". Starting from the key technology of constructing the future power system, this paper evaluates the possible benefits of power system construction by establishing reasonable relations between technology and benefits.

Through the application of various new technologies and related means in the power supply side, the grid side and the load side, the operation efficiency of the power system is improved, and the benefits of all parties are brought. In this process, the key technologies and measures of energy and power system construction and development can be regarded as "means", which promote and promote the development of the whole energy and power system; The improvement of the overall system performance is a phenomenon that occurs and can be regarded as a "state". The improvement of the performance of the power system promotes the reduction of supply costs, energy conservation and emission reduction, and improves the efficiency of energy use. These are the reactions produced, that is, the "response"; The "response" of each dimension can ultimately be boiled down to the "benefit" of economy, reliability, environmental protection and efficiency. Means, state, response and benefit are interrelated and interact with each other, which constitute the MSRB model of power system comprehensive benefit evaluation(Figure 5).

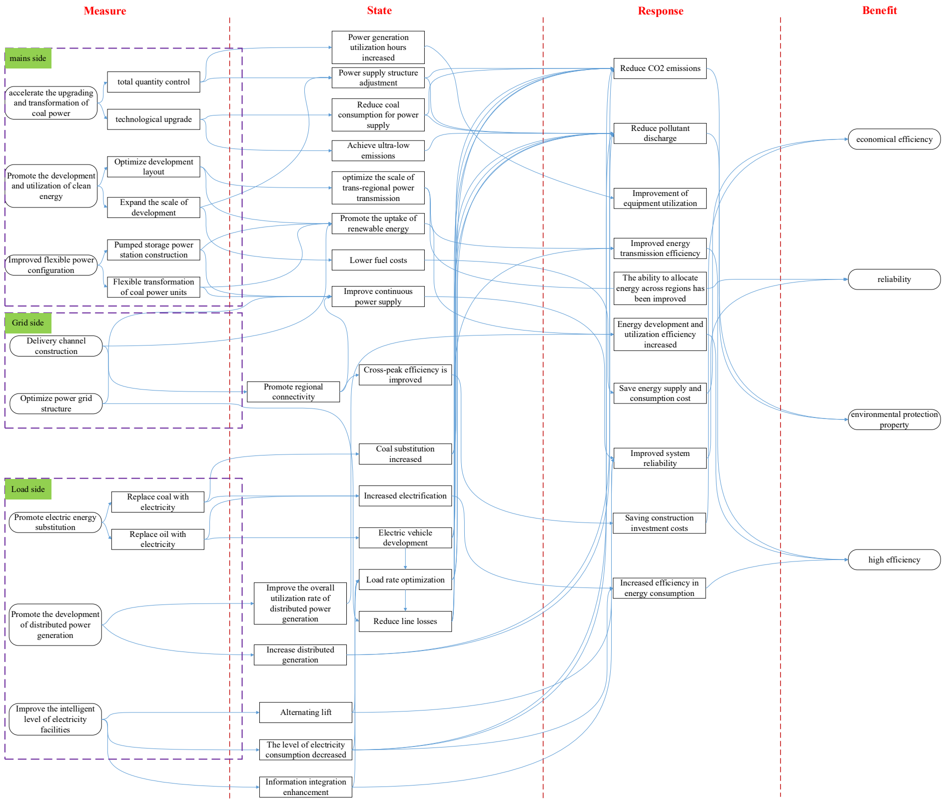


**Figure 5** Power system benefit evaluation framework based on pressure-state-response model

### 3.3. Power system benefit evaluation model

This study uses a multi-regional CGE model (Figure 6), including 28 production sectors, covering areas such as resource restoration, pollution control, resource industry and traditional production. The model considers six production factors: labor, land, capital, energy resource assets, non-energy resource assets, and environmental assets. Income distribution involves residents, enterprises, local governments, the central government and off-budget accounts. The model simulates the driving role of new energy development by assuming that investment in the new energy sector is exogenous.

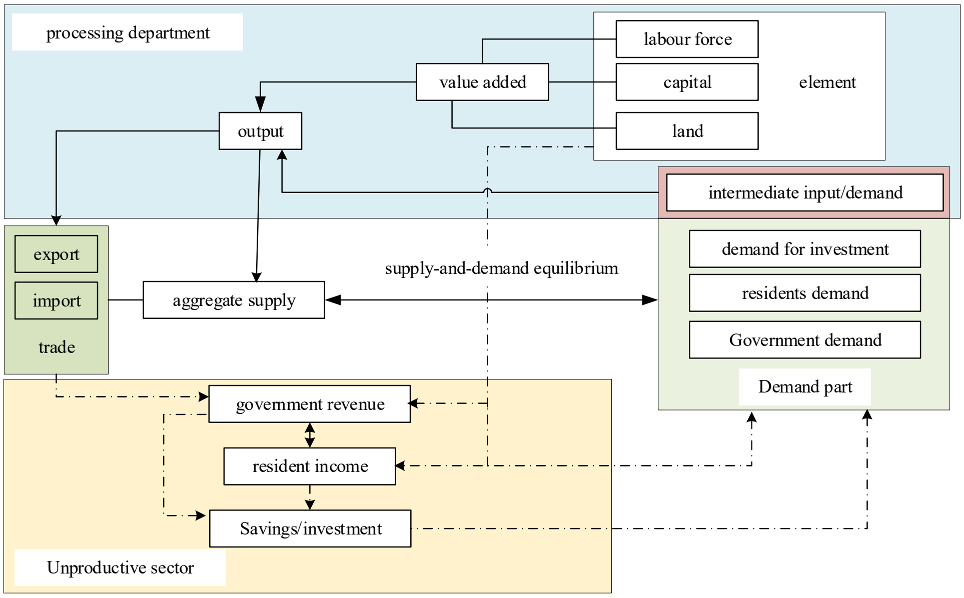


**Figure 6** CGE model framework

### 3.4. Environmental benefit assessment model

This study employs Data Envelopment Analysis (DEA) to assess emission reduction benefits of power grid investment nationwide and in provinces. DEA compares the relative efficiency of Decision Making Units (DMUs) by maintaining their input-output balance. Utilizing mathematical programming and data, it establishes efficient production frontiers without requiring input-output function knowledge or parameter estimation, eliminating subjective bias. DEA determines DMU efficiency through weighted ratios, avoiding subjective influence (Figure 7).

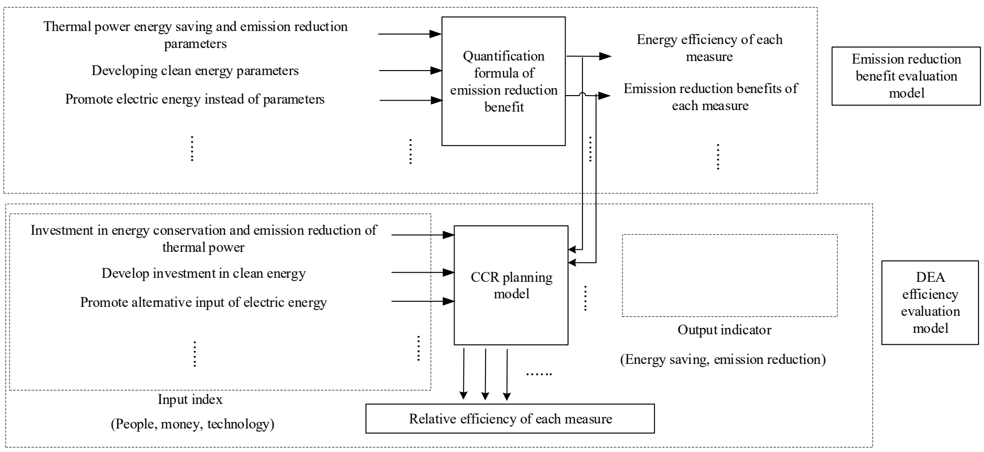


**Figure. 7** Comparative analysis model of environmental benefits of regional power grid investment

The traditional DEA model only considers economic indicators such as capital, labor, output and income as inputs and outputs when evaluating the efficiency of DMU[16]-[18]. It is generally expected that the smaller the input, the better, and the larger the output, the better, and these indicators are called expected input/output. However, in environmental efficiency assessments, we often consider both desired and undesired inputs/outputs. For example, the output of pollutants as decision units should be minimized from the perspective of production efficiency. Therefore, in the environmental efficiency analysis, the traditional DEA model can not simply deal with the unexpected indicators, so it is necessary to consider a new method to evaluate the environmental efficiency of DUS.

In DEA, constant returns to scale CCR model and variable returns to scale BCC model are often used to compare the efficiency of different departments. To evaluate the evolutionary change of efficiency, the commonly used method is the Malmquist index method, which is used to measure the total factor productivity of time series. The Malmquist index represents the change in total factor productivity relative to the previous period, rather than the actual total factor productivity. It first introduced the scaling factor concept and then constructed the consumption quantity index, the original Malmquist index. As a non-parametric analysis method, the improved Malmquist index of data envelopment analysis can be used to study the technical form of multi-output and multi-input, and is suitable for panel data analysis and multi-input output analysis, without setting specific production function form and distribution, which can relax the theoretical constraints to a certain extent.

The form of Malmquist index representing the difference of total factor productivity in adjacent periods is as follows (Formula 2):

$$M_i(x^{t+1}, y^{t+1}; x^t, y^t) = \left[\frac{D_{ci}^t(x^{t+1}, y^{t+1})}{D_{ci}^t(x^t, y^t)} \times \frac{D_{ci}^{t+1}(x^{t+1}, y^{t+1})}{D_{ci}^{t+1}(x^t, y^t)}\right]^{1/2} \tag{1}$$

$x^t$,$y^t$ are input and output vectors of t period; $D_{ci}^t$ ($x^t$,$y^t$) is the distance function value of the i th decision unit under the production front in period t, representing the distance between the actual function value in period t and the front plane.

DEA-Malmquist index can decompose the change of total factor productivity, which provides a possibility for studying the effect of technological progress and technical efficiency, and is an ideal analysis method to realize the quantification of industrial technological progress. It is broken down into technical efficiency （Effch） and technological （Techch） progress in the following form (Formula 2):

$$M_i(x^{t+1}, y^{t+1}; x^t, y^t) = \text{Effch} \times \text{Techch} = [\frac{D_{ci}^{t+1}(x^{t+1}, y^{t+1})}{D_{ci}^t(x^t, y^t)}] \times \left[\frac{D_{ci}^t(x^{t+1}, y^{t+1})}{D_{ci}^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_{ci}^t(x^t, y^t)}{D_{ci}^{t+1}(x^t, y^t)}\right]^{1/2} \tag{2}$$

Effch is the change of technical efficiency from t period to t+1 period, which measures the ability of the research object to maximize the output under a certain input. Techch is the change of technology level, which represents the advance and retreat of the research object in technology.

When the Malmquist index is greater than 1, it indicates that the total factor productivity has increased over the previous year; when it is less than 1, it indicates that the total factor productivity has decreased over the previous year.

## 4 Conclusions

By exploring the influence mechanism of power grid investment on the new development pattern and establishing the evaluation index system and model of economic and social benefits, this study draws the following conclusions: Power grid investment plays an important role in promoting high-quality economic development, and promotes economic growth and structural upgrading through high-quality investment and technological innovation; Strengthening infrastructure construction and market reform will help optimize resource allocation and promote market circulation. Strengthening the investment in the distribution network in rural areas will help narrow the gap between urban and rural areas. Upgrading the grid to a clean energy Internet can promote energy cleanliness and environmental protection.

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