# Study on Adaptive Evaluation of Power Grid Investment

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**Abstract.** Power grid investment is not only the key to driving regional economy and promoting regional balanced development, but also the important content of maintaining and increasing value of enterprises. This paper focuses on the adaptability of power grid investment, and selects AHP, entropy method and TOPSIS to comprehensively evaluate the power grid investment of companies in different cities. The evaluation result shows that overall investment adaptability of each subsidiary power grid company in xinjiang autonomous is relatively balanced, but Changji and Hotan is high while urumchi is relatively low by region, which is maybe caused by the unique geographical location and role of urumchi. This paper can provide reference for improving the power grid investment model and realizing the high quality development of power grid enterprises.

**Keywords:** power grid · investment · adaptive evaluation

## 1 Introduction

Due to its unique geographical location and cultural environment, Xinjiang has a special and important strategic position in the overall work of the Party and the state. It is a strategic barrier in the northwest of China, an important gateway to the outside world, a key area of the western development and an important base of strategic resources, and the core area of the construction of the Silk Road Economic Belt.

As a key infrastructure related to national energy security and the lifeblood of the national economy, the power grid will continue to play an important role as a 'ballast stone' and 'stabilizer' in implementing the decisions and arrangements of the central government, ensuring economic and social development, serving the improvement of people's livelihood, and promoting clean and low-carbon energy transition. Power grid companies should, on the basis of ensuring the security of power grid supply, continuously improve the grid structure at all levels, enhance the absorption capacity of clean energy, give play to the role of power grid in driving local economic and social development, promote balanced regional development, and support the economic and social development of cities at all levels to achieve comprehensive green and low-carbon high-quality development [1].


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The adapting of the development of power grid to economic development is not only constrained by the development of power grid itself, but also influenced by the economic environment. The adaptability evaluation between power grid investment and economic and social development aims to make a scientific and reasonable index system to comprehensively evaluate the investment effect of enterprises, and then support the decision of power grid investment scale [2].

Based on the above considerations, this paper studies the regional investment differences of power grid companies in the main regions of Xinjiang Autonomous Region, and focuses on the efficiency problems in power grid investment decisions, in order to optimize investment to the regions with low development level as far as possible, which promotes the balanced development of Xinjiang Autonomous Region. Thus, this paper designs a comprehensive evaluation model to evaluate the power grid investment differences of regional power grid companies. The evaluation tool consists of AHP, entropy method and TOPSIS, and evaluation index system is composed by two dimensions of power grid operation and enterprise operation, which specifically includes the indicators of power supply like power supply reliability, abundance degree, power quality, customer satisfaction, as well as indicators such as electricity sold by unit assets to reflect the level of enterprise development.

## 2 Evaluation Index System

### 2.1 Index Selection Principle

(1) Consistent evaluation objectives. The evaluation of power grid investment adaptability reflects the synergistic and interactive relationship between regional development level and power grid investment through a systematic and comprehensive index system [3].
(2) The combination of qualitative and quantitative. Adaptability evaluation indexes should reflect the adaptability between power grid development and economic development systematically and comprehensively.
(3) Operability. The physical and economic significance of indicators should be clear and easy to understand, and the corresponding quantitative indicators should be easy to quantify.
(4) Independence. The indexes should have the characteristics of non-correlation or low correlation, and the index system is composed of several multi-dimensional indexes with strong mutual independence.

### 2.2 Establishment of Evaluation Index System

The evaluation index system of power grid investment adaptability mainly considers from two aspects: to meet the demand of clean and green development of economy and society for electricity, and to maintain and increase the value of assets of power grid enterprises [4]. Therefore, according to the survey data, the evaluation index system of power grid investment adaptability can be preliminarily established as follows in Table 1.

**Table 1.** Margins and print area specifications

| Target layer | Rule layer | Measures layer |
|---|---|---|
| Power grid investment adaptability | Electricity demand | GDP growth |
| | | Growth rate of electricity consumption |
| | | Ratio of power grid investment to GDP growth (%) |
| | | Power grid length per unit GDP |
| | | Power conversion capacity per unit GDP |
| | Grid security | N-1 pass (%) |
| | | Ratio of heavy duty equipment (%) |
| | | Reliability of power supply (%) |
| | | Comprehensive voltage pass rate (%) |
| | | Qualified rate of urban comprehensive voltage (%) |
| | | Qualified rate of comprehensive rural power grid voltage (%) |
| | | Number of level 5 or above incidents (time) |
| | Green energy | Province variable capacitance load ratio (%) |
| | | Average load ratio (%) |
| | | Proportion of light load equipment (%) |
| | | Integrated line loss rate (%) |
| | | Substitution contribution of electrical energy (%) |
| | Business performance | Electricity sold per unit of grid assets (KWH/RMB) |
| | | Contribution increase of electricity sold (%) |
| | | Total asset turnover |
| | | Total labor productivity |
| | | Return on total assets |
| | | Return on equity |

(*continued*)

**Table 1.** (*continued*)

| Target layer | Rule layer | Measures layer |
|---|---|---|
| | Service quality | Market share (%) |
| | | Power supply quality complaints |
| | | Composite industry expansion index |

# 3 Comprehensive Evaluation Method

Due to different evaluation purposes, various evaluation methods are adopted, such as weighted scoring method, principal component analysis method, analytic hierarchy process, TOPSIS method, gray evaluation method, etc. These evaluation methods have their own characteristics, and all of them can be used for adaptability evaluation [5].

1) Principal component analysis. Principal component analysis aims to transform multiple indexes into a few comprehensive indexes by using the idea of dimensionality reduction.
2) Analytic hierarchy process. The decision-making method, which decomposes the relevant elements into the levels of objective, criterion and scheme, and conducts qualitative and quantitative analysis on this basis, is especially suitable for the occasions where it is difficult to measure the decision-making results directly and accurately.
3) The entropy value method. Entropy method is a mathematical method used to judge the degree of dispersion of an index. The greater the dispersion degree, the greater the influence of this index on the comprehensive evaluation.
4) TOPSIS. TOPSIS is a method to sort the limited evaluation objects according to their proximity to the ideal target, which is to evaluate the relative advantages and disadvantages of the existing objects.

From the perspective of convenient operation, this paper selects AHP and entropy method to assign weights to the evaluation indexes of power grid investment adaptability, and carries out comprehensive evaluation of power grid investment adaptability through TOPSIS.

# 4 Case Study

## 4.1 Indicator Initial Data

Based on the data collection of each indicator, a brief indicator system is constructed. The following table lists the statistical representation of the initial value of each indicator after data standardization, as shown in Table 2.

**Table 2.** Statistical representation of the initial value of each indicator

| | maximum | average | minimum | variance |
|---|---|---|---|---|
| GDP growth | 0.738 | 0.599 | 0.121 | 0.028 |
| Growth rate of electricity consumption | 50.300 | 15.545 | 3.030 | 154.941 |
| N-1 pass (%) | 86.170 | 58.979 | 21.970 | 337.190 |
| Ratio of heavy duty equipment | 99.850 | 82.102 | 57.900 | 152.525 |
| Reliability of power supply | 96.220 | 75.933 | 49.000 | 153.328 |
| Comprehensive voltage pass rate | 97.500 | 88.162 | 66.300 | 108.090 |
| Province variable capacitance load ratio | 2.785 | 2.279 | 1.850 | 0.055 |
| Average load ratio (%) | 44.280 | 34.354 | 15.030 | 60.402 |
| Proportion of light load equipment | 32.028 | 23.218 | 6.922 | 60.034 |
| Integrated line loss rate | 10.410 | 5.408 | 2.560 | 5.146 |
| Substitution contribution of electrical energy | 13.780 | 5.293 | 1.790 | 14.351 |
| Electricity sold per unit of grid assets | 56.270 | 23.208 | 4.330 | 205.670 |
| Contribution increase of electricity sold | 8.780 | 2.409 | 0.320 | 4.533 |
| Market share | 100.000 | 84.803 | 41.240 | 434.817 |
| Power supply quality complaints | 5.850 | 1.021 | 0.000 | 2.382 |
| Composite industry expansion index | 1.570 | 1.079 | 0.950 | 0.034 |

### 4.2 Index Weight

According to AHP method and entropy method, the weight of each indicator is determined respectively. On this basis, the final weight value of each indicator is obtained by integrating the two types of weights by weighting. The calculation formula of index weighting is shown as follows.

$$W = \alpha * w1 + \beta * w2 \tag{1}$$

where, *w1* is the index weight value determined by AHP method, *w2* is the index weight value determined by entropy method, $\alpha$ and $\beta$ are the weighting coefficients, and $\alpha + \beta = 1$. In this study, the values of $\alpha$ and $\beta$ are 0.7 and 0.3 respectively (Table 3).

### 4.3 Evaluation Results

The vectors composed of the distance between each scheme and positive or negative ideal solutions are respectively:

$$S+ = [0.093\ 0.061\ 0.075\ 0.099\ 0.102\ 0.097\ 0.094\ 0.079\ 0.086\ 0.107\ 0.093\ 0.095\ 0.111]$$

**Table 3.** Combined weights

| | AHP | Entropy value method | Combined weights |
|---|---|---|---|
| GDP growth | 0.1633 | 0.032 | 0.124 |
| Growth rate of electricity consumption | 0.1101 | 0.165 | 0.127 |
| N-1 pass (%) | 0.089 | 0.033 | 0.072 |
| Ratio of heavy duty equipment | 0.0817 | 0.153 | 0.103 |
| Reliability of power supply | 0.0755 | 0.009 | 0.055 |
| Comprehensive voltage pass rate | 0.0646 | 0.005 | 0.047 |
| Province variable capacitance load ratio | 0.0593 | 0.001 | 0.042 |
| Average load ratio (%) | 0.0489 | 0.006 | 0.036 |
| Proportion of light load equipment | 0.0486 | 0.007 | 0.036 |
| Integrated line loss rate | 0.0447 | 0.065 | 0.051 |
| Substitution contribution of electrical energy | 0.0428 | 0.087 | 0.056 |
| Electricity sold per unit of grid assets | 0.0421 | 0.111 | 0.063 |
| Contribution increase of electricity sold | 0.0409 | 0.194 | 0.087 |
| Market share | 0.0374 | 0.072 | 0.048 |
| Power supply quality complaints | 0.0308 | 0.050 | 0.037 |
| Composite industry expansion index | 0.0206 | 0.008 | 0.017 |

$$S- = [0.051\ 0.091\ 0.100\ 0.052\ 0.053\ 0.052\ 0.063\ 0.064\ 0.065\ 0.057\ 0.055\ 0.055\ 0.044]$$

Furthermore, the closeness vector of each scheme is calculated:

$$C* = [0.352\ 0.598\ 0.570\ 0.344\ 0.342\ 0.350\ 0.402\ 0.445\ 0.430\ 0.347\ 0.373\ 0.365\ 0.286]$$

According to the evaluation results, it can be seen that: (1) overall, the overall investment adaptability of each subsidiary power grid company in xinjiang autonomous region is relatively balanced, and the current investment allocation experience has good continuation and reference value; (2) by region, the investment adaptability of Changji and Hotan is high, while urumchi is relatively low. It is necessary to conduct further systematic analysis on the investment efficiency and benefit of Urumchi power grid, in order to improve investment accuracy, and enhance the service and support role of power grid investment in economic development and social people's livelihood.

## 5 Conclusions

In this paper, a comprehensive evaluation model based on the combination of mixed weighting and TOPSIS is designed to evaluate 13 municipal companies in Xinjiang Region. The main conclusions can be summarized as follows: (1)there is not much difference in overall investment adaptability among regional power grid companies in Xinjiang Autonomous Region, which has certain significance and value for reference; (2) there is still a certain gap between different regions, which is mainly affected by multiple factors such as the level of economic development, financial capacity and political status of different regions. Among them, urumqi and other regional power grid investment adaptability ranks lower, indicating that in order to ensure the quality of power supply service, the marginal effect of power grid investment in these regions gradually decreases, so the efficiency and benefit of new investment is lower than those of changji, Hotan. In terms of the future work, the marginal effect of power grid investment should be fully considered to improve investment precision.

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