Research on Evaluation Indicator of Effective Assets Investment Efficiency of Power Grid Enterprises under Lean Operation Mode

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Abstract. In 2019, State Grid Corporation proposed the strategic goal of “three-type, two-network, world-class”, requiring all units to focus on the company's investment effectiveness and focus on promoting the high-quality development of the company and the power grid. Based on the analysis of the electricity reform policy and the company's strategy, this paper establishes an effective asset investment performance evaluation index for the three-tier power grid enterprises in provinces, cities and counties. Through the research on the quantitative method of indicators, a three-level evaluation model of provinces, cities and counties was established to support the evaluation of investment effectiveness of power grid enterprises. This paper takes the province, city and county three-level units as an example, and extracts data to measure and verify. The evaluation results objectively reflect the effectiveness of power grid assets investment of power supply companies at all levels, and propose investment management based on the calculation results.

1. Introduction

With the goal of actively adapting to electricity reform and practicing the development strategy of State Grid Corporation, we select the investment indicators such as capital and cost, the output indicators such as management benefit, employment efficiency, operational efficiency, safety, reliability, power supply quality, power supply capability, equipment level, intelligence level, service quality, environmental protection and social responsibility to establish a three-level investment evaluation index system for provinces, cities and counties of power grid enterprises; Then by analyzing the characteristic of each indicator, we establish the quantitative methods of indicators, and finally build the evaluation model. We analyze the types of indicators, develop quantitative methods for indicators, and finally build evaluation models. In the practical stage, the data is collected for measurement, and the results of the calculation are analyzed, and investment management recommendations are proposed.

2. Evaluation System

Based on the economic interaction analysis, the benchmarking of asset management, the development diagnosis of power grid, etc., considering the relationship between the indicators and power grid reform policies, company operating efficiency, power grid function positioning, and company strategic
objectives, we select 86 indicators from the capital class and cost class, and established a library of asset evaluation indicators for power grid enterprises, as shown in the table below.

Table 1. Effective evaluation indicator system for effective assets investment of provinces, cities and counties

| One class indicator | Indicator name                                      | Provincial company | City company | County company |
|---------------------|----------------------------------------------------|--------------------|--------------|----------------|
| Capital             | Effective fixed assets ratio                      | ●                  | ●            |                |
|                     | Effective fixed assets growth rate                | ●                  | ●            |                |
|                     | Investment plan transfer completion rate          | ● ● ●             | ●            |                |
|                     | Fixed assets investment growth rate ratio         | ● ● ●             | ●            |                |
|                     | Proportion of overage assets                      | ● ● ●             | ●            |                |
| Cost                | 10000 yuan fixed assets operation and maintenance fee | ● ● ●             | ●            |                |
|                     | Cost over-supervised upper limit ratio            | ●                  | ●            | ● ● ●         |
| Business benefit    | Fixed asset yield                                 | ● ● ●             | ●            |                |
|                     | Unit fixed assets electricity sales               | ● ● ●             | ●            |                |
|                     | Unit fixed assets electricity sales volume change | ● ● ●             | ●            |                |
|                     | Maximum load per unit of assets                   | ● ● ●             | ●            |                |
|                     | Unit asset load change                            | ● ● ●             | ●            | ● ● ●         |
|                     | Unit fixed asset investment market share change   | ● ● ●             | ●            |                |
| Operating efficiency| 10kV distribution network light load ratio        | ● ● ●             | ●            |                |
|                     | 10kV line light load ratio                        | ● ● ●             | ●            |                |
| Safety              | Grid and equipment events                         | ● ● ●             | ●            |                |
| Reliability         | Urban user power supply reliability rate          | ● ● ●             | ●            |                |
|                     | Rural network user power supply reliability rate  | ● ● ●             | ●            |                |
| Power quality       | Urban comprehensive power supply voltage pass rate| ● ● ●             | ●            |                |
|                     | Agricultural network comprehensive power supply voltage pass rate | ● ● ●             | ●            |                |
|                     | Low voltage users ratio in substation area        | ● ● ●             | ●            | ● ● ●         |
|                     | Low voltage substation area ratio                 | ● ● ●             | ●            | ● ● ●         |
| Power supply capability | Heavy overload equipment ratio                    | ● ● ●             | ●            |                |
| Equipment level     | High loss distribution transformer ratio           | ● ● ●             | ●            |                |
| Intelligent level   | Smart meter coverage                              | ● ● ●             | ●            |                |
|                     | Intelligent substation ratio                      | ● ● ●             | ●            |                |
| Service quality     | Customer satisfaction                            | ●                  | ●            |                |

3. Index quantification method

3.1. Gross indicator

One indicator in the indicator library is EVA. Since the gross indicator is an absolute value, which is mainly related to the management level of each company, we use the non-segment linear scaling method to map directly to 0-100 according to the value. One strategy is to use segmentation, but each segment is directly mapped to between 0-100 using linear scaling.
3.2. Average indicator
There are 15 average indicators in the indicator library, which are per capita management expense, fixed asset return rate, unit asset sales, 10(20/35/110) kV distribution transformer average load rate, 10(20/35/110) kV line average load rate, number of misoperation events per capita, average low voltage time of the station, the average power supply radius of 10(20) kV line, the average life of decommissioned equipment, the average number of repairs per household.

The grid enterprise asset evaluation indicators are mostly used for comparative analysis between units, and the average indicators can well reflect the differences between units. In order to truly reflect the actual gap between unit, we recommend a linear scaling method. The max and min parameters in the linear scaling method here can be determined based on the data itself, but are recommended based on the development goals of the grid company for the indicator.

3.3. Relative indicator
(1) Comparative relative indicator
The comparative relative indicators are the scale difference ratio between actual investment and approved investment, the actual cost and the supervised upper limit cost, which both reflect the investment difference between the grid enterprise and the regulatory authorities. The indicators respond to differences in the form of ratios, eliminating the scale effect and being comparable. In order to truly reflect the actual gap between each unit, a liner scaling method is recommended.

Dynamic relative indicator
The dynamic relative indicators are the growth rate of effective fixed asset ratio, the growth rate of operating and maintenance expenses, unit asset electricity sales change, unit asset load change, unit investment increased electricity sales, unit investment increased load, unit investment reduced power outage time, unit asset market change. The dynamic relative indicators all indicate the level of change of indicators caused by investment reason in different years. Some indicators are expressed in the form of growth rate, and some are reflected in form of the amount of change. Among them, the growth rate indicator eliminates the scale effect. In order to truly reflect the actual gap between each unit, it is recommend to adopt the linear scaling method. The indicators in the form of change are related to the size of each company’s asset. In order to better reflect the reasonable development level of each company under different asset scales, it is recommended to adopt the fitting curve method. Fit the relationship curve, determine the standard curve, and then calculate the indicator score based on the difference between the actual value and the standard curve value, combined with the linear scaling method or the N-digit method.

(3) Structural relative indicator
There are 43 structural relative indicators, all of which are indicators of proportion. According to characteristic of the indicator itself, it is recommended to adopt to the linear scaling method when considering the actual difference of the indicators. The fuzzy membership method is adopted when considering the actual difference within the degree of discrimination, and exponential log scaling method is adopted when considering the discrimination of the indicator score.

(4) Strength relative indicator
There are 4 strength relative indicators. The characteristics of the strength indicators vary widely, and the connotations are different. The quantitative methods cannot be generalized. The strength indicators are suggested to be quantified as follows: fixed asset investment growth rate and sales growth rate ratio, 10,000 yuan fixed assets operation and maintenance fee, unit power transmission and distribution cost, Cost-to-income ratio and maximum load per unit of assets indicators use the fitting curve method; asset-liability ratio, per capita business households, per capita power capacity, per capita transmission line, per capita distribution line, per resident distribution transformer capacity, regional average clean energy replacement and the proportion of electric vehicle charging station indicators use the linear scaling method; uni asset grid and equipment events indicator uses logarithmic scaling method.
4. Effectiveness evaluation model

According to the effectiveness evaluation indicator of effective asset investment, the quantitative method of indicators, considering the flexibility and practicability of model use, an investment evaluation model of multi-quantitative method with optional quantitative method is established. Among them, the secondary indicator quantization methods mainly include linear scaling method, n-digit method, exponential scaling method and logarithmic scaling method, and the first-level indicator and final score are weighted summation. Among them, the indicator weights are determined by the Delphi method and the coefficient of variation method.

The multi-quantization method investment performance evaluation model include a data input table, a parameter setting table, an indicator score calculation table, and an indicator result analysis table. These tables are as follows,
- Base data input table: input the evaluation object basic data
- Parameter setting table: set the quantization method of each indicator and related parameters, weights, etc.
- Indicator score calculation table: calculate the value of each indicators under the corresponding method and parameters, and the final score of each evaluation object.
- Calculation results analysis table: compare and analyse the measurement results under different parameter scenarios, and compare and determine the optional solution.

5. Case Analysis

5.1. Data collection

Through the investigation of the current status of the data of the provinces, cities and counties, the data storage system and management level are also quite different due to the differences in the actual management levels of the provinces, cities and counties. In order to ensure the integrity of the data in this calculation process, this measurement temporarily selects some indicators to collect data and conduct measurement and verification.

5.2. Score calculation

The indicator value obtained from the business data of each province company in 2016. The indicator weights are calculated based on the indicator values. The indicator weights are determined by combined weights of the Delphi method and the coefficient of variation method.

According to the indicator value and the indicator weight, the evaluation model is used to calculate the investment performance level of each company. As shown in the table below.

| Company name | Capital | Cost | Business benefit | Reliability | Power quality | Power supply capability | Investment effectiveness | Rank in |
|--------------|--------|------|------------------|-------------|---------------|------------------------|-------------------------|--------|
| NUM1         | 41.8   | 0.0  | 29.4             | 100.0       | 98.3          | 51.0                   | 42.5                    | 21     |
| NUM2         | 55.2   | 69.6 | 32.4             | 98.9        | 99.8          | 61.0                   | 54.4                    | 5      |
| NUM3         | 36.9   | 7.7  | 34.9             | 96.5        | 91.2          | 47.4                   | 43.4                    | 18     |
| NUM4         | 38.4   | 27.6 | 13.0             | 96.1        | 88.7          | 76.4                   | 38.9                    | 24     |
| NUM5         | 43.1   | 100.0| 22.2             | 92.1        | 95.6          | 88.5                   | 52.3                    | 7      |
| NUM6         | 75.9   | 100.0| 26.8             | 96.1        | 88.7          | 76.4                   | 57.6                    | 2      |
| NUM7         | 30.2   | 92.4 | 31.2             | 91.3        | 98.7          | 64.8                   | 50.5                    | 10     |
| NUM8         | 40.2   | 70.1 | 27.7             | 92.6        | 92.7          | 91.8                   | 51.3                    | 8      |
| NUM9         | 45.2   | 98.0 | 19.0             | 95.5        | 87.4          | 71.3                   | 49.1                    | 11     |
| ...          | ...    | ...  | ...              | ...         | ...           | ...                    | ...                     | ...    |
5.3. Result analysis
Judging from the evaluation results of provincial companies’ investment effectiveness, the highest and lowest levels of each unit differ by 33 points, which is relatively large. From the perspective of the first-level indicators, the investment performance of each unit is mainly reflected in the quality of power supply and reliability of power supply. In terms of the performance of these indicators, except for the low scores of a few companies, the overall average is better. The overall performance of the operating efficiency indicators is low, with an average of only 29.5 points. The average level of the primary indicators of capital and cost is also low, with an average of less than 50 points. However, the score of capital, cost and power supply capability have a large difference in each unit. From the ranking of the calculation results, there is also a big contrast with the results of peer benchmarking. The No. 10 company and the No. 11 company ranked higher in the benchmark, but from the results of the investment effectiveness evaluation, due to the high cost of expenditure, the investment efficiency ranked lower.

From the score of the second-level indicators of operating benefits, the changes in the electricity sales per fixed assets, the maximum load change per unit of assets, and the change in the market share per fixed assets investment, 24, 23, and 19 companies respectively scored 0. As a result, the operating efficiency scores of the companies are low. Drilling down from indicator score to indicator value, we found that the correspond indicators are negatively increased. It can be seen that the investment has not been reflected in the benefits.

5.4. Investment management advice
(1) Strictly control the investment outside the approved scope
From the calculation results, the ratio of increase in the proportion of effective assets of each unit is zero. Excluding companies with 100% of effective assets, other companies must strictly control the investment outside the approved scope to ensure that all investment participate in the approval of the permitted income.

(2) Reasonably spend the operation and maintenance fee
After the power grid reform, the regulatory authorities set a strict upper limit on the operation and maintenance expenses of the grid enterprise. From the calculation results, some companies have exceeded the upper limit, but some companies have too low fees. It is recommended to re-calculate the standard cost and reasonably control the cost level. When the cost is too high, there should be strong supporting materials in order to verify the price policy.

(3) Arrange investment according to electricity growth and load growth
The grid reform policy makes it clear that the grid investment should be compatible with load growth and power consumption growth. However, from the results of this calculation, the investment growth and power consumption growth of each unit are quite different. The follow-up analysis should closely analyze the relationship between investment growth and power consumption growth to ensure that the investment is effective.

(4) Efficiently use stock asset
The maximum load per unit of assets of some companies is moderate, but the degree of heavy load is relatively large. Therefore, it should be considered that the follow-up investment focuses on the combing of the grid, the transfer of the load, giving full play to the grid operation efficiency and improving the investment efficiency.
6. Conclusion
The study combines the regulatory requirements of power reform and the companies development strategy. It selects the evaluation of investment effectiveness of power grid enterprises from the perspective of input and output, establishes an evaluation indicator system through multiple screenings, and formulates an indicator quantitative method by analyzing the types and characteristics of indicators. Establish an investment evaluation model for the three tier power grid enterprises in provincial, cities and counties. Through the calculation of the data extracted from the pilot companies of the provincial, cities and county levels, the scientific and rationality of the model is demonstrated. The calculation results are consistent with the actual situation of each company, and the result are analyzed to practical suggestion for the investment management of each company.

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