Research on distribution network investment allocation method considering actual demand and investment benefit

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Abstract: under the new situation, improving the quality and efficiency has become an important means to enhance the core competitiveness of power grid enterprises and ensure the steady improvement of business efficiency. Distribution network is an important part of the power grid of power grid enterprises, and the current distribution network investment distribution lacks scientific quantitative basis. Therefore, how to scientifically plan the scale of power grid investment and improve the efficiency and efficiency of power grid investment is the foundation to ensure the safe and stable, efficient and economic operation of power grid, and it is also a practical problem to be solved.

1. Introduction
The construction of distribution network is an important public infrastructure guarantee in the decisive stage of building a moderately prosperous society in an all-round way. As an important part of the company's power grid, the distribution network is not only the end of the power grid, but also the front-end of the service. With a large amount of assets and a large number of personnel engaged in the operation and service of the distribution network, the distribution network internally is the main link affecting the company's safe production and enterprise benefits. It represents the company's image and level of serving the economic and social development externally, and its role and position are extremely important and prominent. For a long time in history, there has been a tendency of "attaching importance to the main network, neglecting the distribution network, and attaching importance to equipment and services", which has resulted in many uncoordinated and inadaptable contradictions and problems in the management of distribution network. In recent years, with the gradual increase of distribution network investment scale, the construction and management of distribution network has been paid more and more attention. Due to the severe internal and external business situation, the input-output level and refined management level of distribution network construction are facing severe challenges.

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To sum up, the current relevant scholars pay more attention to the level of distribution network investment efficiency, while the research on how to make the distribution network investment scientific and reasonable is relatively lacking. Therefore, it is necessary to study the multi-dimensional investment allocation method of distribution network.

2. Research on Distribution Network Investment Distribution Model

2.1. Basic principle of distribution method

The distribution network investment allocation model mainly includes two parts: basic allocation investment and deduction investment, which are adjusted through adjustment coefficients. The basic distribution investment is comprehensively evaluated for the development of the distribution network in each region from the three indicator dimensions of economic society, distribution network development status, and operating efficiency level, so as to determine the investment distribution ratio of the distribution network of the company in each city, and comprehensively convert it into the preliminary investment distribution result, afterwards, adjustment coefficients are set according to regional development to form the final investment distribution model.

- From the three dimensions of economy and society, distribution network development status, and operating efficiency level, construct a distribution network investment demand evaluation index system for companies in various regions and cities.
- Calculate the score of each city company, and on this basis, calculate the investment distribution ratio of companies in each city.
- Calculate the distribution network investment allocation quota of companies in various cities and regions based on the total planned investment of provincial companies.
- Combined with the adjustment factor, calculate the final distribution.

Figure 1. Basic principle of the allocation method.
2.2. Construction of evaluation index system

In order to accurately grasp the investment scale of the power grid company’s distribution network and establish a scientific investment allocation model, the evaluation index system mainly considers the economic and social status of the power supply company in each city and the status of the distribution network (including the scale of the grid stock, the growth of electricity consumption, and the operation of the grid), and the operating conditions of companies in various cities and regions, using 5 categories and 16 indicators for calculation. The names and weights of indicators are shown in Table 1:

| Index category                          | Indicator name                                      | Index Weight |
|-----------------------------------------|----------------------------------------------------|--------------|
| Economic and social indicators          | Power supply population (10,000 people)             | 0.20         |
| (Weights 0.4)                           | Power supply area (square kilometers)               | 0.20         |
|                                         | Increased supply load (ten thousand kVA)            | 0.15         |
| Distribution network operation index    | Number of overloaded distribution lines (pieces)    | 0.05         |
|                                         | Number of overloaded distribution transformers (a)  | 0.05         |
|                                         | "Low voltage" households (households)               | 0.05         |
| Operating efficiency indicators         | Net profit of the enterprise for the year (ten      | 0.30         |
| (Weights 0.30)                          | thousand yuan)                                      |              |
| Adjust the investment part              | National policy trends, regional development        | The adjustment | positioning, local government support, |
|                                         | stock control coefficients are generally controlled | coefficients are | shortcomings of local power grids    |
|                                         | between 1-1.2                                       |              |

2.3. Distribution model construction

(1) Processing of indicator data In the index system established in this chapter, there are different dimensions between the indicators, and the values are very different. For example, the asset-liability ratio is in percentage, and the number of overloaded trunk lines is reflected in the form of numbers. If these data with different dimensions are used for direct analysis, the data will not be comparable, and it will directly affect the accuracy of the evaluation results. Therefore, corresponding methods must be used to non-dimensionally process the indicator data before comprehensive evaluation. Methods are as below:

\[
x^*_j = \frac{x^* - \min_{1 \leq i \leq n} x^*}{\max_{1 \leq i \leq n} x^* - \min_{1 \leq i \leq n} x^*} \quad (1 \leq i \leq n, 1 \leq j \leq m)
\]

In the formula: \(n\) represents the number of evaluation objects, that is, the number of city companies; \(m\) represents the number of indicators for each evaluation object; \(x^*_j\) is the observed value.

(2) Comprehensive evaluation of prefectural and municipal power grid companies Based on the above analysis, by evaluating the economic and social indicators of the county-level power supply enterprises, the inventory scale indicators of the county-level distribution network, the county-level distribution network incremental development indicators, the county-level distribution network operation indicators, and the county company operating indicators, a qualitative and quantitative performance is obtained. Combined comprehensive evaluation results. Through the evaluation results,
the operating conditions of each subsidiary can be accurately analyzed, and then the investment scale can be estimated. This article uses linear weighted summation method for comprehensive evaluation, namely:

\[ F_i = \sum_{j=1}^{m} w_j x_{ij} \] (2)

Where:
- \( w_j \) (i = 1, 2, … , n, j = 1, 2, … , m) is the weight of the indicator;
- \( x_{ij} \) (i = 1, 2, … , n, j = 1, 2, … , m) is standardized data for indicators.

(3) Investment distribution model of provincial power grid companies

The above has obtained the comprehensive evaluation score of each city company. Assuming that the investment amount of the provincial company in the year is \( Q \), then the investment amount \( Q \) allocated to each city company is:

\[ Q_i = \frac{F_i}{\sum_{i=1}^{n} F_i} \times Q \times k \] (3)

Where:
- \( Q_i \) represents the distribution network investment allocation quota of the company in each city;
- \( Q \) represents the total investment planning quota of the provincial company;
- \( k \) represents the adjustment coefficient.

3. Empirical analysis

This study takes a provincial power company as an example to conduct empirical analysis and research. It is known that the provincial power company has 11 prefecture-level power supply companies. The basic data collected is shown in Table 2:

| Indicator name | A  | B  | C  | D  | E  | F  | G  | H  | I  | J  | K  |
|----------------|----|----|----|----|----|----|----|----|----|----|----|
| Power supply population (10,000 people) | 77 | 15 | 22 | 10 | 6  | 100| 52 | 27 | 55 | 56 | 29 |
| Power supply area (square kilometers) | 3  | 8  | 8  | 2  | 2  | 10 | 10 | 6  | 18 | 100| 3  |
| Increased supply load (ten thousand kVA) | 85 | 94 | 100| 97 | 98 | 95 | 94 | 95 | 93 | 100| 92 |
| Number of overloaded distribution lines (pieces) | 77 | 98 | 100| 99 | 96 | 100| 100| 61 | 100| 100| 95 |
| Number of overloaded distribution transformers (a) | 88 | 90 | 100| 89 | 90 | 88 | 89 | 92 | 88 | 68 | 93 |
Determined through comprehensive evaluation, the distribution network investment distribution ratios of companies in various cities are shown in Table 3 below:

| Project | A     | B     | C     | D     | E     | F     | G     | H     | I     | J     | K     | L     |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Quota   | 84.7  | 93.9  | 10    | 96.6  | 97.6  | 95.0  | 94.0  | 95.4  | 92.9  | 99.7  | 92.3  | 84.7  |
| system  | 2     | 4     | 0     | 3     | 1     | 2     | 1     | 3     | 5     | 5     | 6     | 72    |

4. Conclusion
Improving the rationality of distribution network investment allocation is of great significance to improve the operating efficiency of power grid companies. Starting from the current distribution network investment distribution, this paper constructs a comprehensive evaluation index system for the development level of the distribution network based on the economic and social conditions, the development status of the distribution network, and the operation status of the power supply companies in each city. The proportion of power grid investment allocation, and through empirical analysis, verifies the rationality of the model. The research results can effectively improve the investment efficiency of power distribution network and the efficiency of capital utilization of power grid enterprises.

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