

Research on Construction and Evaluation Method of Comprehensive Evaluation Index System for Investment Benefit of Distribution Network

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Abstract: Under the new situation, the improvement of investment efficiency and efficiency will be the basic criteria for evaluating the quality of power supply enterprises' investment activities in the distribution network. To this end, based on the characteristics of distribution network construction, combined with the internal and external development trends of power supply enterprises and development and promotion needs, this paper constructs a scientific comprehensive evaluation index system and evaluation method for the investment benefits of distribution networks, which is useful for scientifically grasping the investment needs and investment capabilities of power supply enterprises. It is of great significance to achieve a more precise and lean level of investment in the distribution network.

1 Introduction

At present, relevant scholars are very concerned about the benefit evaluation of power grid investment projects. Li Ming et al. [1] built an evaluation index system and evaluation model for the whole process of power grid project investment based on variable weights to provide reference for power grid companies to carry out fixed asset investment evaluation. Ma Qian et al. [2] established the investment ranking evaluation index system of power grid planning projects under the new power reform environment from the three dimensions of technology, benefit, and project maturity; then, the fuzzy analytic hierarchy process was used to obtain the weights of the above three indicators, and The comprehensive utility value of investment ranking is obtained based on the vector distance merging rule algorithm.

Liu Yinghan [3] constructed the economic benefit evaluation index system of power grid investment projects from the dimension of financial benefit level. Dong Xiaojun et al. [4] optimized the design of the implementation process for the post-evaluation of distribution network projects, and provided reference and reference for grid companies to improve the precise investment management of the distribution network. Wang Zheng [5] constructed a comprehensive evaluation index of power grid investment benefits from four aspects: functional benefits, economic benefits, environmental benefits and social benefits, and constructed an evaluation and analysis model based on DEA theory.

In summary, the current research results involve the evaluation of power grid investment benefits, the evaluation dimension focuses more on the management of the whole process of project construction and the achievement of financial and economic benefits. The evaluation index system lacks a certain degree of systematicness and comprehensiveness. Therefore, it is necessary to study the comprehensive evaluation index system and evaluation method of the investment benefit of the distribution network.

2 Analysis of influencing factors of distribution network investment demand

2.1 Index system construction and weight determination method

This article combines the characteristics of distribution network investment projects, combined with the current situation and development needs of power grid enterprise distribution network investment management evaluation, after combing, summarizing, and refining many indicators involved in the process of power grid enterprise distribution network investment management, and at the same time, fully considering the indicators Factors such as the repeatability and correlation between indicators and the relationship between indicators and investment benefits have built a distribution network investment performance evaluation index system that

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includes four dimensions: reliable operation, clean and efficient, high-quality service, and benefit contribution.

Table 1. Comprehensive benefit evaluation index system of distribution network investment.

Serial number	Evaluation dimension	Evaluation index
1		N-1 pass rate
2	Reliable operation	Proportion of heavy-duty equipment in distribution network
3		Power supply reliability rate
4		Comprehensive voltage qualification rate
5	Clean and efficient	Equivalent average load rate of the whole network (10kV)
6		The proportion of light load equipment (10kV)
7		Line loss rate
8	Quality service	Market share
9		Ten thousand households' voltage quality complaints
10		Number of complaints about power outages in 10,000 households
11		Comprehensive Industry Expansion Index
12	Outstanding performance	Electricity sales per unit of grid assets

In order to make the setting of indicator weights more reasonable and scientific, this article uses a combination of subjective weighting method and objective weighting method to set indicator weights. The specific index weight determination method is shown in Figure 1 below.

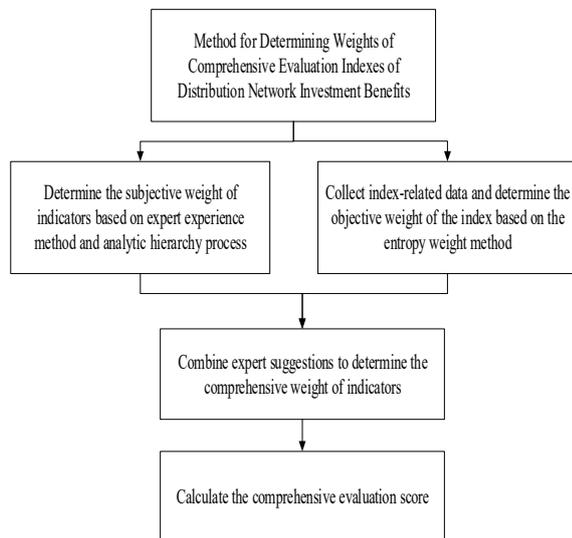


Figure 1. Evaluation index weight determination process.

2.2 Matter element extension evaluation model

The matter-element extension model is based on matter-element theory, extension set, correlation function and correlation degree. It is a method to quantitatively evaluate various indicators and systematically reflect the

comprehensive evaluation results. The calculation steps of the matter-element extension model are as follows:

(1) Determine the matter element matrix of the classical domain. The matter-element matrix composed of thing N , the characteristic C_n of thing N and the standard range of the characteristic is the classical domain matter-element matrix, denoted as R_j , then there is:

$$R_j = \begin{bmatrix} c_1 & (a_{j1}, b_{j1}) \\ c_2 & (a_{j2}, b_{j2}) \\ N_j & c_3 & (a_{j3}, b_{j3}) \\ \vdots & \vdots \\ c_n & (a_{jn}, b_{jn}) \end{bmatrix} \quad (1)$$

Among them, N_j represents the j -th evaluation level j of the target thing N ; $j = 1, 2, \dots, m$ is the E -th evaluation index F ; J represents the value range of the index K in the level H .

(2) Determine the node area matter element matrix. The matter-element matrix composed of thing N , the characteristic c_n of thing N and the extended range of the characteristic is the node-domain matter-element matrix, denoted as R_p , then there is:

$$R_p = \begin{bmatrix} c_1 & (a_{p1}, b_{p1}) \\ c_2 & (a_{p2}, b_{p2}) \\ N_p & c_3 & (a_{p3}, b_{p3}) \\ \vdots & \vdots \\ c_n & (a_{pn}, b_{pn}) \end{bmatrix} \quad (2)$$

Among them, N_p represents the overall evaluation level of things; C_i is the i -th evaluation index ($i = 1, 2, \dots, n$); $V_{pi} = (a_{pi}, b_{pi})$ represents the value range of the index i on the overall level, obviously $V_{pi} \subset V_{ji}$.

(3) Determine the element matrix to be measured. For a certain thing N to be evaluated, the value of the i -th evaluation index c_i is v_i , then the matrix to be measured is:

$$R_0 = \begin{bmatrix} \dots & c_1 & v_1 \\ & c_2 & v_2 \\ N & c_3 & v_3 \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix} \quad (3)$$

(4) Find the degree of relevance according to the relevance function. The correlation function represents the extent to which the matter element meets the requirements when the value of the matter element is a point on the real axis. Correlation function is a transformation tool for quantitative changes of things, which can quantitatively express qualitative problems.

$$K_j(v_i) = \begin{cases} -\frac{\rho(v_i, V_{ji})}{|V_{ji}|} & v_i \in V_{ji} \\ \frac{\rho(v_i, V_{ji})}{\rho(v_i, V_{ji}) - \rho(v_i, V_{ji})} & v_i \notin V_{ji} \end{cases} \quad (4)$$

among them,

$$\rho(v_i, V_{ji}) = \left| v_i - \frac{a_{ji} + b_{ji}}{2} \right| - \frac{b_{ji} - a_{ji}}{2} \quad (5)$$

$$\rho(v_i, V_{pi}) = \left| v_i - \frac{a_{pi} + b_{pi}}{2} \right| - \frac{b_{pi} - a_{pi}}{2} \quad (6)$$

$$|V_{ji}| = (b_{ji} - a_{ji}) \quad (7)$$

In the formula: $\rho(v_i, v_{ji})$ represents the distance v_i from each index value to the classical domain interval V_{ji} , a_{ji} and b_{ji} are the two end points of the interval respectively; $\rho(v_i, V_{pi})$ represents the distance from the index value v_i value to the node domain interval V_{pi} , a_{pi} and b_{pi} are the two endpoints of the interval; the calculation result $K_j(v_i)$ is the degree of association. The degree of relevance is similar to the degree of membership in fuzzy comprehensive evaluation. According to the criterion of maximum relevance:

$$K_j(v_i) = \max K_j(v_i), \quad j = 1, 2, \dots, m \quad (8)$$

Then the evaluation level of the identified index c_i is j , and the formula (5-44) can realize the evaluation and analysis of each index. Combining the correlation degree of each index with the index weight can get:

$$K_j = \sum_{i=1}^n w_i K_j(v_i), \quad i = 1, 2, \dots, n, \quad j = 1, 2, \dots, m \quad (9)$$

Among them: w_j is the index weight, $K_j(v_i)$ is the correlation degree of the index i on the j level, K_j is the correlation degree of the evaluation target, and the final comprehensive evaluation level is determined according to the formula (5) to realize the investment in the distribution network project Overall evaluation of benefits.

3 Empirical analysis

This paper takes my country's Z county-level power supply company's distribution network investment as an example to carry out empirical analysis and research. The basic data and scores are shown in Table 2 below:

Table 2. Basic data and evaluation score table.

Evaluation dimension	Evaluation index	Index value	Score	Provincial average score
Reliable operation	N-1 pass rate	92.87%	92.87	91.53
	Proportion of heavy-duty equipment in distribution network	96.30%	96.30	80.52

Clean and efficient	Power supply reliability rate	99.96%	99.96	99.90
	Comprehensive voltage qualification rate	99.991%	99.99	99.96
	Equivalent average load rate of the whole network (10kV)	64.14%	64.14	75.13
	The proportion of light load equipment (10kV)	92.74%	92.74	93.56
Quality service	Line loss rate	74.1%	92.74	90.25
	Market share	89.66%	89.66	85.33
	Ten thousand households' voltage quality complaints	0	100	100
	Number of complaints about power outages in 10,000 households	0.57	81	72
Outstanding performance	Comprehensive Industry Expansion Index	100%	100	100
	Electricity sales per unit of grid assets	2.18	100	90

Through the evaluation, we can know: (1) Reliable operation. The N-1 pass rate, the proportion of heavy-duty equipment in the distribution network (10kV), the power supply reliability rate, and the comprehensive voltage qualification rate are all above the average level, and other indicators are below the average level. (2) Quality service. Except for tens of thousands of households with power outage complaints that scored below average, other indicators were above average. (3) Clean and efficient aspects. The indicator scores are all below average. (4) Significant aspects of performance. The indicator score is higher than average. Therefore, the future investment in the distribution network of County Z should focus on strengthening the safety and reliability of the distribution network and improving the efficiency of equipment utilization.

4 Conclusion

In order to further improve the investment benefit level of the distribution network, this article combines the investment characteristics and development needs of power grid enterprises to construct a comprehensive distribution network investment benefit based on multiple dimensions such as the development of the enterprise, the safe and reliable operation of the power grid, and the contribution of operating benefits Evaluation index system and evaluation methods. Through empirical analysis, the validity of the method model is verified. The research results can provide reference and reference for power grid companies to

improve the investment efficiency of distribution network projects.

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