Research on Distribution Network Capital Investment Allocation Optimization Technology Considering Enterprise Development and Policy Constraints

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Abstract. In addition to the characteristics of general capital-intensive investment projects, power grid capital investment also has some of its own characteristics, such as long-term investment, economic dependence, regional limitations, and constraints that include resources, environment, policies and other factors. Therefore, power grid enterprises need to establish a set of scientific and reasonable methods for optimizing the control of capital investment, and effectively and reasonably control the scale and direction of power grid investment. Based on the analysis of the constraints of capital investment in power grid enterprises, this paper constructs a model of capital investment evaluation method based on the expansion of the material element to guide enterprises to formulate a reasonable capital investment plan.

Keywords: enterprise development · policy constraints · power grid enterprises · investment distribution · optimization technology

1 Introduction

With the reform of China's power system, "double carbon" and other policies, it will have a significant impact on the future operating environment of power grid enterprises, and further optimize and improve the efficiency and efficiency of capital utilization of power grid enterprises, so as to become one of the important issues that power grid enterprises will face.

Considering the impact of power system reform, literature [1–3] systematically analyzes the main factors that affect the investment decisions of power grid enterprises based on the current regulatory situation faced by power grid enterprises. Literature [4–5] establishes a power grid investment benefit evaluation method that adapts to the reform of transmission and distribution prices, and provides a powerful tool for power grid enterprises to achieve accurate investment distribution. Literature [6–7] using the three indicators of return on total assets, predicted electricity sales in a given period of time in the future, and the ratio of investment to electricity sales, the initial investment

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allocation plan of the power grid company in the future is comprehensively determined under the premise of giving priority to efficiency (efficiency). Then, the capacity-to-load ratio and reliability were selected as the control indicators, and the investment allocation model based on the Gini coefficient was developed, and the final investment allocation plan was optimized and determined from the perspective of improving the fairness of distribution based on the initial allocation plan of the investment. Literature [8–10] combines the current regulatory situation faced by power grid enterprises, and on the basis of analyzing investment impact factors, investment benefit evaluation indicators and methods have been established.

To sum up, the capital investment of power grid enterprises is one of the current research priorities of relevant scholars, so the research on the distribution technology of power grid capital investment can further improve the capital utilization efficiency of power grid enterprises and improve the operating efficiency of enterprises.

2 This Article Method Ideas Principle

Based on the development trend of grid management, comprehensive consideration of asset value and different grid of multidimensional management development asset operation comprehensive evaluation results as the main basis of asset investment allocation, fully consider the main purpose and principle of asset investment, build the basic distribution and adjust distribution two stage operational investment allocation optimization technology. The flow of model construction, as shown in the figure below.

As shown in Fig. 1, the process of building the model studied in this article mainly includes five steps: grid attribute analysis, building a multi-attribute evaluation indicator system, determining indicator weights, calculating comprehensive evaluation results, and calculating the allocation ratio.

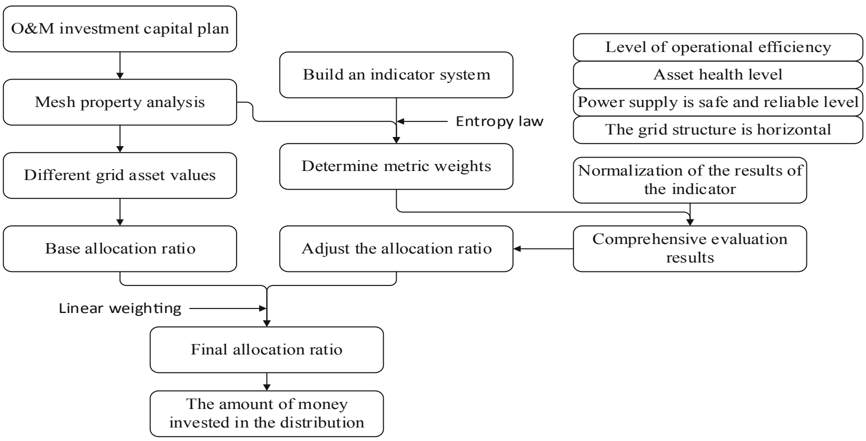

Fig. 1. Technical idea of optimizing capital investment allocation of distribution network.

Table 1. Evaluation Index System.

Level 1 indicators	Secondary indicators	Level 3 indicators
Comprehensive evaluation of the distribution network fund investment	Operating efficiency level	Electricity sold by unit assets
		line loss rate
	Health level of assets	Average operating life of the main transformer
		Average operating life
		Equipment defect rate
		equipment failure rate
	Safe and reliable level of power supply	Average user fault outage time
		Power supply reliability rate
		Qualified rate of comprehensive voltage
	Network structure level	Line reload ratio
		Main transformer reload ratio
		Line contact rate

3 Construction of a Comprehensive Evaluation Index System

The comprehensive evaluation index system constructed in this article is shown in Table 1.

As can be seen from Table 1, this article mainly constructs an evaluation index system from four dimensions: operating efficiency level, asset health level, power supply safety and reliability level, and network structure level.

4 Construction of Comprehensive Evaluation Model Based on the Extensible Nature of Things

Based on the theory of the meta-element, the extensible set, the correlation function and the correlation, the material-element extensible model is a method for quantitatively evaluating each index and systematically reflecting the comprehensive evaluation results. The calculation steps for the meta-element extension model are as follows:

(1) Step 1: Determine the matrix of the classical domain of matter-elements.

The matter-element matrix composed of the standard range of things N, the characteristics c_n of things N, and their characteristics is the classical domain thing-element matrix R_j, which is described, and is:

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

Among them, N_j represents the $j-th$ evaluation level of the target thing N ($j = 1, 2, ..., m$); c_i is the first evaluation index ($i = 1, 2, ..., n$); $V_{ji} = (a_{ji}, b_{ji})$ indicates the range of values for indicator i in level j.

(2) Determine the domain object element matrix.

The matter-element matrix composed of thing N, the characteristic c_n of thing N and the extended range of its characteristics is a node-domain matter-element matrix, which is recorded as R_p and there are:

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

where N_p represents the totality of the evaluation level of things; c_i is the $i-th$ evaluation indicator ($i = 1, 2, ..., n$); $V_{pi} = (a_{pi}, b_{pi})$ indicates the range of values taken by indicator i on the level as a whole.

Step 3: Determine the object element matrix to be measured.

For a certain thing to be evaluated, the value of the $i-th$ evaluation index c_i is v_i, and the matrix to be measured is:

For something to be judged N, the $i-th$ evaluation index is the index c_i The value is vi. The matrix to be measured is:

$$R_0 = \begin{bmatrix} & c_1 & v_1 \\ & c_2 & v_2 \\ N & c_3 & v_3 \\ & \cdots & \cdots \\ & c_n & v_n \end{bmatrix} \tag{3}$$

Step 4: Find the correlation degree based on the correlation function.

The correlation function represents the degree to which the object meets the required range when the object value is a point on the real axis. Correlation function is a transformation tool of quantitative change, which can quantitatively represent qualitative problems.

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

Among,

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

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

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

where: $\rho(v_i, V_{ji})$ represents the distance from the measured value of each indicator v_i to the classical domain interval V_{ji}, and a_{ji} and b_{ji} 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 a fuzzy composite evaluation, according to the maximum relevance criterion:

$$K_j(v_i) = \max K_j(v_i), j = 1, 2, ..., m \tag{8}$$

Combining the correlation degree of each indicator with the weight of the indicator can obtain:

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

Among them: w_i is the index weight, $K_j(v_i)$ is the correlation degree of index i on level j, and K_j is the correlation degree of the evaluation target, and the final comprehensive evaluation level is determined to achieve the overall evaluation of the power grid project.

5 Empirical Analysis

The distribution investment of power grid enterprises includes technical transformation investment, operation and maintenance cost input, overhaul cost input, etc. This empirical analysis selects operation and maintenance input as the analysis object. Statistics of 6 grids in a certain area as empirical research objects, and the planned operation and maintenance cost of 6 grids is 80 million yuan. The relevant index data are shown below.

To verify the effectiveness of the model, the data in Table 2 are the actual data collected from a power grid enterprise to verify the effectiveness of the model. Combined with the above principle, the standard treatment value and corresponding weight of each index are obtained through normalized treatment and weight calculation.

Table 3 shows the evaluation index weights calculated based on the collected actual data. According to the calculation steps of the above formula (1–9), the following investment allocation results are obtained.

Table 2. Basic Data Sheet

order number	name of index	unit	Grid 1	Grid 2	Grid 3	Grid 4	Grid 5	Grid 6
1	original value of fixed assets	100 million	45.43	34.81	38.21	49.01	54.40	31.18
2	Electricity sold by unit assets	One hundred million kWh / 100 million yuan	4.59	2.99	2.81	4.26	2.80	2.87
3	line loss rate	%	2.40	2.71	3.55	2.79	2.69	3.23
4	Average operating life of the main transformer	year	7.09	5.47	9.36	9.03	8.33	7.35
5	Average operating life of the line (more than 20 years' ratio)	%	9.25	7.40	9.37	10.76	8.99	7.92
6	Equipment defect rate	%	21.33	32.05	26.49	12.93	15.99	16.03
7	equipment failure rate	%	12.73	14.92	15.99	15.99	16.46	18.09
8	Average user fault outage time	hour	2.40	0.90	3.55	0.64	1.92	2.13
9	Power supply reliability rate	%	99.9083	99.9077	99.9135	99.9796	99.8886	99.8954
10	Qualified rate of comprehensive voltage	%	99.997	99.9982	99.9988	99.996	99.9965	99.9976
11	Line reload ratio	%	4.83	3.22	4.75	6.55	6.62	3.60
12	Main transformer reload ratio	%	2.43	2.57	3.28	1.56	2.90	1.65

(*continued*)

Table 2. (*continued*)

order number	name of index	unit	Grid 1	Grid 2	Grid 3	Grid 4	Grid 5	Grid 6
13	Line contact rate	%	37.00	33.82	32.80	34.15	31.65	36.24

Table 3. Weight setting and standardization results

order number	name of index	weight	Grid 1	Grid 2	Grid 3	Grid 4	Grid 5	Grid 6
1	Electricity sold by unit assets	0.03	1.00	0.65	0.61	0.93	0.61	0.62
2	line loss rate	0.16	1.00	0.76	0.10	0.69	0.78	0.35
3	Average operating life of the main transformer	0.02	0.76	0.58	1.00	0.97	0.89	0.79
4	Average operating life of the line (more than 20 years' ratio)	0.01	0.86	0.69	0.87	1.00	0.84	0.74
5	Equipment defect rate	0.05	0.67	1.00	0.83	0.40	0.50	0.50
6	equipment failure rate	0.01	0.70	0.82	0.88	0.88	0.91	1.00
7	Average user fault outage time	0.14	0.68	0.25	1.00	0.18	0.54	0.60
8	Power supply reliability rate	0.13	0.81	0.81	0.75	0.10	1.00	0.93
9	Qualified rate of comprehensive voltage	0.18	0.68	0.29	0.10	1.00	0.84	0.49
10	Line reload ratio	0.04	0.73	0.49	0.72	0.99	1.00	0.54
11	Main transformer reload ratio	0.04	0.74	0.79	1.00	0.48	0.88	0.50
12	Line contact rate	0.19	0.10	0.63	0.81	0.58	1.00	0.23

Table 4. Operation and maintenance input allocation results

order number	name of index	Grid 1	Grid 2	Grid 3	Grid 4	Grid 5	Grid 6
1	Base ratio	17.95%	13.76%	15.10%	19.37%	21.50%	12.32%
2	Adjust the proportion	19.80%	17.68%	17.91%	17.71%	25.00%	15.47%
3	allocation proportion	18.88%	15.72%	16.51%	18.54%	23.25%	13.90%

As can be seen from Table 4, based on the calculation of the model constructed in this article, the actual investment allocation ratios of the grid enterprise Grid 1 to Grid 6 are 18.88%, 15.72%, 16.51%, 18.54%, 23.25%, and 13.90%, respectively.

6 Conclusion

Based on the systematic analysis of the mechanism of national policy on the allocation of capital investment in power grid enterprises, the effectiveness of the model.

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