Research on Decision-making Method of Distribution Network Project Operation and Maintenance Investment Considering Regional Rigid Needs and Benefits

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Abstract: With the continuous advancement of the power system reform, strengthening the lean management of operation and maintenance investment has become one of the key points to ensure the sustainable operation and development of power grid enterprises. Therefore, combined with the current situation of power grid operation and maintenance investment distribution management, this paper constructs the input distribution model considering the rigid needs and economic benefits of operation and maintenance input, and verifies the effectiveness of the model in combination with empirical analysis. The distribution model can further promote the rationality of the operation and maintenance investment allocation of power grid enterprises and the scientific decision-making, and improve the lean management level of enterprises.

1 INTRODUCTION

With the continuous advancement of power market-oriented reform, it is very important for power grid enterprises to strengthen the lean management of operation and maintenance cost in order to obtain the ability of sustainable development in the open market.

At present, relevant scholars have done a lot of research on how to optimize the lean management of operation and maintenance investment. For example, literature (Guo, Deng, Wei, Pan, 2020) puts forward the method of improving the lean management of enterprise asset operation and maintenance cost from the budget management level of power grid equipment operation and maintenance. Literature (Wang, 2020) focuses on innovating the strategy of distribution network operation and maintenance management, and analyzes the specific methods of distribution maintenance cost management, so as to improve the operation efficiency of power grid. Literature (Yang, 2021) attempts to establish an organic relationship between the cost investment of key production equipment and the contribution of power grid resources, so as to provide decision-making information for the company's investment strategy, so as to maximize the comprehensive benefits of power grid resources under reasonable investment. literature (Yin, 2021) takes X power supply company as the research object, based on the idea of multi-dimensional lean management system, sorts out and analyzes the existing ideas and experience of operation and maintenance management cost improvement, and develops the multi-dimensional lean management framework design of X power supply company's operation and maintenance cost, and integrates X power supply The company is divided into five major operation centers: maintenance and operation, operation, marketing, operation support, and enterprise management. Through the collection and allocation of operation and maintenance costs, it can meet the needs of accurate accounting of operation and maintenance costs, and deeply mine data value to realize maintenance and operation. The multi-dimensional lean management of maintenance operations, marketing operations, and other operating expenses verifies the effectiveness of the proposed multi-dimensional lean management framework design, and promotes X Power Supply Company to gradually realize the multi-dimensional lean management system reform of operation and maintenance costs. Literature (Yu, 2021) puts forward relevant suggestions on equipment asset operation and

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maintenance investment management from the perspective of comprehensive performance and risk management of distribution network equipment. Aiming at improving the operation efficiency of the company's power grid assets.

To sum up, at present, relevant scholars consider how to improve the lean management of operation and maintenance investment from the aspects of benefit evaluation, activity-based cost management and financial management, while the research on the allocation of operation and maintenance cost investment of provincial and municipal power grid enterprises is relatively weak.

2 ANALYSIS OF CURRENT SITUATION OF DISTRIBUTION NETWORK OPERATION AND MAINTENANCE INVESTMENT

2.1 Status Quo of Operation and Maintenance Investment Management of Distribution Network

The investment in distribution network operation and maintenance is an important part of the economic activities of power grid enterprises, and it is an important and effective means for enterprises to ensure the safe operation of the distribution network and improve the output efficiency of the power grid.

Distribution network operation and maintenance investment is also an important measure for power grid companies to continuously optimize physical asset management. Therefore, for the increasing number of power grid operation and maintenance investment projects, how to reasonably determine the operation and maintenance investment strategy, reduce the operation risks of various power grids, and maximize the benefits of operation and maintenance funds It is of great significance to realize the sustainable development of power grid enterprises.

However, in reality, the cost budget management of power grid enterprises for distribution network operation and maintenance investment lacks certain scientificity. In actual work, the power grid enterprise distribution network operation and maintenance investment is mainly based on the principle of the distribution system, that is, from the province to the local level. However, this task distribution system has certain drawbacks in work management: due to the lack of corresponding overall management, when the superior assigns the task of distribution network operation and maintenance investment, due to the lack of overall overall planning, the task distribution is uneven, and the task is not fully considered. The actual operation and demand of equipment in various prefectures and cities, so that there is often a phenomenon of inconsistent policy implementation in work, resulting in serious regional differences in distribution network operation and maintenance investment.

2.2 Distribution Network Operation and Maintenance Investment Management Problems

Combined with the analysis of the current situation of the company's operation and maintenance investment, the current operation and maintenance investment management still has the following problems. (1) Under the new situation, the company is facing greater pressure on investment in operation and maintenance With the continuous deepening of the new round of power system reform, especially the change in the pricing model of transmission and distribution prices, the liberalization of the electricity sales side and the introduction of competition, the liberalization of incremental power distribution business investment, and the approval of the company's allowable income on the basis of effective assets. The investment in asset operation and maintenance has a profound impact. After the electricity reform, the permitted cost of power grid enterprises consists of depreciation and operation and maintenance costs. The identification of effective assets includes two parts: stock and increment. Specifically, the constraints of electricity reform on the stock and new costs are mainly reflected in the following two aspects: First, the stock cost is determined by the cost supervision and review, and the key point of the cost supervision and review is the “unreasonable” cost of materials and repair costs. factor" is eliminated. Second, in the incremental cost, the material cost is determined at 1% of the original value of the newly added fixed assets in the current year, and the repair cost is determined at 1.5% of the original value of the newly added fixed assets in the current year. The incremental cost is subject to rate constraints. From 2014 to 2016, the company's operation and maintenance costs accounted for 2.97% of the original value of fixed assets on average, which exceeded the approved standard of 2.5% for incremental costs by 18.8%. (2) To meet the needs of policy development, deepen the implementation of lean management of operation and

maintenance investment At present, the pressure on control of operation and maintenance costs of power grid enterprises is prominent. Strengthen the lean management of operation and maintenance costs. The first is to pay attention to process control and strengthen the compliance and rationality review of operation and maintenance investment, so as to adapt to the trend of gradual refinement of cost supervision and review in the context of electricity reform. The second is to strengthen the basic ledger management of operation and maintenance investment, enrich and improve the basic database of operation and maintenance investment big data, and support the research, formulation and implementation of operation and maintenance cost investment strategy. Thirdly, by collecting relevant data and adopting standard sorting, data mining, model construction and other means, carry out analysis and diagnosis of the current situation of the province's power grid maintenance and operation cost, and establish a standard cost based on asset life cycle management. The fourth is to form a lean supervision and review strategy for power grid maintenance and operation and maintenance costs based on historical cost and impact analysis, further optimize the level and structure of maintenance and operation costs, and achieve continuous cost reduction. (3) At this stage, the company's operation and maintenance cost allocation method needs to be further improved In actual work, the scale of operation and maintenance investment of power grid enterprises is mainly based on the principle of distribution system, that is, distribution from provinces and cities to local levels. However, this task distribution system has certain drawbacks in work management: due to the lack of corresponding overall management, when the superiors assign tasks, due to the lack of overall overall planning, the task distribution is uneven, and the actual equipment of each prefecture and city is not fully considered. operation and demand. As a result, inconsistent policy implementation often occurs in work, resulting in serious regional differences in technical renovation and overhaul.

3 CONSTRUCTION OF DISTRIBUTION NETWORK OPERATION AND MAINTENANCE INVESTMENT ALLOCATION MODEL

3.1 Concept of Classified Investment in Distribution Network Operation and Maintenance

The relevant concepts involved in the distribution network operation and maintenance investment allocation decision model are defined as follows：

Total investment in distribution network operation and maintenance I_A : refers to the total investment in distribution network operation and maintenance that can be used for regional distribution by provincial and municipal power grid enterprises in that year.

Rigid operation and maintenance investment I_G^i : refers to the basic operation and maintenance investment required to meet the normal operation of the existing distribution network assets in region i .

Emergency operation and maintenance investment I_J^i : refers to the operation and maintenance investment reserved for region i by power grid enterprises to meet the emergency needs of distribution network.

Flexible operation and maintenance investment I_R^i : refers to the remaining operation and maintenance investment funds available for distribution after meeting the rigid investment and emergency investment in all regions. The calculation formula of flexible operation and maintenance investment is as follows:

$$I_R^i = I_A - I_G^i - I_J^i \quad (1)$$

3.2 Basic Idea of Distribution Network Operation and Maintenance Investment Allocation Decision Method

Distribution network operation and maintenance investment allocation decision is based on the analysis and research of existing methods, find the problems existing in existing methods, establish a reasonable allocation decision model, provide a scientific basis for the distribution network operation

and maintenance investment allocation decision-making in various regions, improve the utilization of resources, and improve the economic and social benefits of operation and maintenance investment.

The distribution decision of operation and maintenance investment of distribution network in each region should not only consider the current situation of regional power grid and load development demand, but also consider the economic benefits of operation and maintenance investment. Under the condition that the total operation and maintenance investment can be allocated in the whole planning area, the decision-making idea of distribution network operation and maintenance investment allocation in each region is as follows:

1)According to the existing scale of distribution network, the rigid operation and maintenance investment in each region is estimated by the simplified model.

2)Under certain conditions of electricity sales, electricity price and target rate of return, the internal rate of return method is used to inverse calculate the economic operation and maintenance investment of distribution network in each region according to the predicted electricity. Economic operation and maintenance investment can reflect the economic rationality of operation and maintenance investment under certain conditions.

3)According to the rigid operation and maintenance investment, economic operation and maintenance investment and planned operation and maintenance investment in each region, determine the upper and lower limits of the distribution range of operation and maintenance investment in each region, and give a reasonable operation and maintenance investment range.

4)Based on the rigid operation and maintenance investment, economic operation and maintenance investment, operation and maintenance investment distribution interval and operation and maintenance investment strategy, four practical distribution methods and models involving flexible total operation and maintenance investment (respectively according to the equal rate of return method, according to the rigid demand of distribution network, according to the relevant electricity distribution method and comprehensive distribution) are adopted to distribute the operation and maintenance investment in each region, Get the final operation and maintenance investment allocation scheme.

3.3 Decision Model Construction

When the total distributable capital is less than the sum of rigid investment in each district, it indicates that the total distributable investment of provincial and municipal power supply companies is relatively limited and can not meet the basic operation and maintenance investment demand of distribution network in theory; When the total distributable investment is greater than the sum of rigid operation and maintenance investment in each region, it shows that the total distributable investment of provincial and municipal power supply companies is sufficient. Under the condition of meeting the basic operation and maintenance investment demand of distribution network in theory, there is still remaining investment to improve the distribution network. In these two cases, the operation and maintenance investment allocation decision can be made according to the following schemes:

If the total allocable investment in the whole planning area is less than the sum of rigid O & M investment in each region, the investment allocated by each region shall be allocated according to its rigid O & M investment proportion, and the calculation formula of O & M investment allocation I_{RE}^{i} in region i is:

$$I_{RE}^{i} = I_A * \frac{I_R^i}{I_R} \tag{2}$$

If the total allocable capital of the whole region is greater than the sum of the rigid operation and maintenance investment of each region, each region still has some flexible operation and maintenance investment space on the premise of meeting its rigid operation and maintenance investment. The calculation formula of the total flexible operation and maintenance investment of the whole region can be expressed as:

$$I_F = I_A - \sum_{i=1}^{m} I_R^i \tag{3}$$

The amount of flexible investment allocated by each region will not produce direct benefits, but will help to improve its distribution network and improve its technical and economic indicators. In this case, the operation and maintenance investment can be allocated among regions according to the following four methods:

1) Distribution according to rigid demand of distribution network

The rigid operation and maintenance investment reflects the basic operation and maintenance needs of

the distribution network in each region. If the flexible total operation and maintenance investment is distributed to each region according to the proportion of the rigid operation and maintenance investment in the total rigid operation and maintenance investment, the distribution result will contribute to the coordinated development of the distribution network on the basis of meeting the rigid demand. If the flexible operation and maintenance investment allocated by each region is allocated according to the proportion of its rigid operation and maintenance investment in the total rigid operation and maintenance investment, the allocated operation and maintenance investment of region i can be obtained from the following formula.

$$I_{F1}^{i} = I_F * \frac{I_R^i}{\sum_{j=1}^{m} I_R^j} \tag{4}$$

$$I_{RE1}^{i} = I_R^i + I_{F1}^i \tag{5}$$

Where: I_{FI}^{i} is the flexible operation and maintenance investment in region i under the first distribution method; It is the allocated operation and maintenance investment of the second region under the first allocation method.

2)Distribution according to equal rate of return

The economic operation and maintenance investment reflects the economic rationality of the operation and maintenance investment of the distribution network in each region. If the distributable total operation and maintenance investment is distributed to each region according to the same economic benefits, the distribution result is conducive to the income balance of the distribution network in each region.

If the total allocable operation and maintenance investment is distributed according to the equal rate of return method, the allocated operation and maintenance investment in region i can be obtained by the following formula.

$$\frac{I_{RE2}^1}{I_E^1} = \frac{I_{RE2}^2}{I_E^2} = ... = \frac{I_{RE2}^m}{I_E^m} \tag{6}$$

$$I_{RE2}^1 + I_{RE2}^2 + ... + I_{RE2}^m = I_A \tag{7}$$

3) Distribution according to relevant electricity

If the flexible operation and maintenance investment allocated by each region is allocated according to the proportion of its power to the total power, the allocated operation and maintenance investment in region B can be obtained by the following formula:

$$I_{E3}^{i} = I_F * \frac{E_N^i + f * E^i}{\sum_{t=1}^{m} (E_N^i + f * E^t)} \tag{8}$$

$$I_{RE3}^{i} = I_R^i + I_{E3}^i \tag{9}$$

4) Weighted comprehensive distribution

Based on the first three distribution schemes, the expert opinion method is used to make the distribution network operation and maintenance investment distribution decision. The distribution operation and maintenance investment in region I can be expressed as:

$$\begin{aligned} I_{RE4}^{i} &= \varepsilon_1 I_{RE1}^i + \varepsilon_2 I_{RE2}^i + \varepsilon_3 I_{RE3}^i \\ &= \varepsilon_1 (I_R^i + I_{F1}^i) + \varepsilon_2 (\frac{I_A}{\sum_{j=1}^{m} I_E^i} * I_E^i) + \varepsilon_3 (I_R^i + I_{E3}^i) \end{aligned} \tag{10}$$

Where: $\varepsilon_1, \varepsilon_2, \varepsilon_3 (\varepsilon_1 + \varepsilon_2 + \varepsilon_3 = 1)$ $0 \le \varepsilon_1 \le 1, 0 \le \varepsilon_2 \le 1, 0 \le \varepsilon_3 \le 1)$ are the corresponding distribution weights of the three methods, which are given by experts according to the actual situation of the region. The factors affecting the weight are mainly the coordinated development goal of regional distribution network, the goal of input benefit and the goal of power sales coordination. If a goal has a high degree of attention, the greater the value of the corresponding weight.

4 EMPIRICAL ANALYSIS

4.1 Basic Data

This paper takes 15 cities of HN provincial power grid enterprises as the research object, analyzes the factors related to their distribution network operation and maintenance investment, and uses the distribution network operation and maintenance investment allocation decision algorithm proposed in this paper to verify the effectiveness of the model. The basic data of operation and maintenance investment of HN provincial power grid enterprises in 2019 are shown in the table below:

Table 1: Basic data table.

Area	Rigid input	Economic investment	Actual input
A	1.07	1.28	1.70
B	3.13	4.65	3.29
C	4.15	5	3.65
D	1.74	4.69	1.70
E	3.50	2.02	3.40
F	6.22	13.21	8.45

G	8.22	24.52	2.60
H	1.85	2.07	2.60
I	3.12	3.98	3.24
J	0.79	1.73	0.78
K	3.37	1.87	3.38
L	5.37	20.44	4.48
M	3.03	8.17	2.62
N	4.01	9.38	3.54
O	3.72	6.09	6.67
amount to	53.29	109.10	56.87

4.2 Allocation Plan

Combined with the income distribution calculation model proposed in this paper, the calculation results of operation and maintenance input allocation under different schemes are shown in the following table:

Table 2: Distribution results.

Area	Assign by economy	Assignment by rigid requirements	Distributed by electricity	Comprehensive allocation
A	1.07	1.27	1.12	1.15
B	3.13	3.57	3.32	3.34
C	4.15	4.73	4.36	4.41
D	1.85	1.99	1.94	1.93
E	2.02	2.02	2.02	2.02
F	6.22	7.10	6.87	6.70
G	9.69	9.38	9.26	9.44
H	1.85	2.07	1.93	1.95
I	3.12	3.56	3.29	3.33
J	0.79	0.91	0.87	0.86
K	1.87	1.87	1.87	1.87
L	10.15	6.13	6.24	7.51
M	3.23	3.46	3.37	3.35
N	4.01	4.58	4.41	4.33
O	3.72	4.25	6.09	4.69

To sum up, the model proposed in this paper can clearly analyze the rationality of the results of investment distribution in the historical years, find out the reasons for the unreasonable distribution, and provide reference for the investment distribution decision-making in the future years.

5 CONCLUSION

This paper comprehensively constructs the distribution network operation and maintenance investment allocation decision-making model from the dimensions of load growth, current grid operation and maintenance demand, investment benefit and so on. The main conclusions are as follows: (1) the operation and maintenance investment allocation model fully considers the current situation of power grid operation and maintenance investment demand; (2) the operation and maintenance investment allocation model can further ensure the safety of equipment operation; (3) the operation and maintenance investment allocation model can promote the operation efficiency of power grid enterprises.

In the future, when making the distribution network operation and maintenance investment allocation decision, we should further consider the data such as the economic development level of different regions and the operation health level of distribution network equipment, so as to further improve the scientificity of operation and maintenance investment allocation decision.

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