Research on Post-Evaluation Method of Local Power Grid Enterprise Distribution Network Project Based on Whole Process Management

Ping Du[1], Yuchen Wang[1], Ning Zhang[2], Xia Chang[2], Nan Shang[2], and Yuyang Jin[2](✉)

[1] Shanxi Regional Electric Power Group Co., Ltd., Xi'an, Shaanxi, China
[2] Shaanxi Energy Research Institute Co., Ltd., Xi'an, Shaanxi, China
1182306191@ncepu.edu.cn

Abstract. The post-project evaluation can promptly discover the problems in the management of the investment and construction of the distribution network project, so as to provide decision-making guidance and support for the investment and construction of the distribution network project of the local power grid enterprise. However, in actual work, many local power grid companies have not established a scientific and reasonable post-evaluation and implementation mechanism for distribution network projects due to their relatively lack of experience in organization and management. Therefore, based on the whole life cycle theory, combined with the actual construction and management of local power grid companies' distribution network projects, this article builds a reasonable post-evaluation index system and evaluation method for distribution network projects, and conducts empirical analysis with D local power grid company as an example. It is used to guide local power grid enterprises to scientifically carry out post-engineering evaluation work.

Keywords: Local grid company · Distribution network · The whole process · Post-evaluation method

1 Introduction

As one of the most important basic industries of the national economy, the electric power industry has always been highly valued by the government because it is related to all aspects of people's daily life and reflects the modernization of society. For the rapid development of all walks of life in my country's national economy, the power industry has played an indispensable role [1]. During the "13th Five-Year" construction period, my country's power industry developed rapidly. In order to effectively summarize the experience and lessons of distribution network construction projects and provide a reference for new distribution network projects, it is necessary to strengthen the post-evaluation work of distribution network projects [2].

S. H. B. D. M. Zailani et al. (Eds.): ICMSEM 2023, 259, pp. 19–25, 2024.
https://doi.org/10.2991/978-94-6463-256-9_3

In recent years, the pace of my country's power distribution network construction is becoming more and more rapid. At the same time, there are many distribution network projects in various parts of our country that need to be reconstructed or expanded, which requires more effective and reasonable construction management of network engineering projects [3]. However, some local power grid companies lack a corresponding post-project evaluation implementation mechanism, and cannot reasonably evaluate the construction effects and benefits of the project, which affects the improvement of the management efficiency of the distribution network engineering construction and the level of investment benefits. Therefore, it is necessary to study the corresponding post-evaluation method system of the distribution network project based on the characteristics of the investment and construction of the distribution network power project of the local power grid enterprises.

2 Construction of Post-Evaluation Index System Based on Life Cycle Theory

Based on the whole life cycle theory, combined with the characteristics of the distribution network project construction, and referring to the recommendations of relevant project management experts, the post-evaluation index system of the distribution network project under the whole life cycle theory is constructed. Among them: the first-level indicators specifically include four: evaluation indicators after early decision-making, evaluation indicators after implementation preparation, evaluation indicators after construction and implementation, and evaluation indicators after production and operation. The specific post-evaluation index system is constructed as shown in Table 1.

3 Post-Evaluation Method Model Construction

3.1 Determination of Index Weights Based on Analytic Hierarchy Process

AHP (Analytic Hierarchy Process, abbreviated as AHP) is a way to express and process people's subjective judgments in a quantitative form. It is an effective multi-criteria decision-making method. It is also the most common subjective weighting method. An effective method for objective description of subjective judgments. The basic principles of the analytic hierarchy process are as follows:

(1) According to the importance scale theory, construct a pairwise comparison judgment matrix A for the evaluation index system:

$$A = \left(a_{ij}\right)_{n \times n}(i, j = 1, 2, \cdots, n) \tag{1}$$

(2) Then normalize the judgment matrix A, the calculation formula is:

$$\overline{a}_{ij} = a_{ij} / \sum_{k=1}^{n} a_{kj}(i, j = 1, 2, \cdots, n) \tag{2}$$

Table 1. The evaluation index system after the distribution network project.

First-level index	Secondary indicators	Three-level indicators
Pre-decision and post-evaluation indicators	Feasibility Study Compilation Ability	Feasibility study preparation quality
		Load forecast accuracy
	Engineering decision-making ability	Project goal achievement rate
	Plan realization level	Project completion rate
		Project scale and production rate
Evaluation indicators after implementation preparation	Normative engineering bidding	Project bidding work
		Project investment work
	Engineering preliminary design level	Quality of preliminary design estimates
		Preliminary design depth quality
		Design changes
	Adequacy of project implementation preparation	Construction organization design quality
		Preparation of construction materials
Evaluation indicators after construction implementation	Progress control level	Project completion rate on schedule
	Quality control level	Pass rate of project acceptance
		Completion acceptance quality
	Safety control level	Personal safety management
		Equipment safety management
	Investment control	Project investment change rate
	Contract management level	Contract performance
		Contract performance rate

(*continued*)

Table 1. (*continued*)

First-level index	Secondary indicators	Three-level indicators
Evaluation index after production operation	Engineering operation capability	Main transformer load rate
	Reasonable level of grid structure	**Automation coverage**
		Line contact rate
	Power grid safety and reliability	Line insulation rate
		Average user outage time
		Comprehensive voltage qualification rate
	Social benefit	Impact on economic development
		Impact on industrial progress
	Economic benefit	Investment internal rate of return
		Payback period
	Energy saving and environmental protection	Proportion of energy-saving equipment
		Line loss rate

(3) Calculate the index weight:

$$w_i = \overline{w}_i / \sum_{i=1}^{n} \overline{w}_i (i = 1, 2, \cdots, n) \tag{3}$$

(4) Finally, the consistency is judged. If the consistency test is passed, the result is valid, and the result should be adjusted if it fails.

3.2 Construction of Post-Evaluation Model for Distribution Network Engineering Based on Fuzzy Theory

Fuzzy comprehensive evaluation method is based on the subordination principle of fuzzy mathematics, which takes into account the influence of multiple factors and transforms it into a quantitative evaluation method. The construction process of the fuzzy comprehensive evaluation model is as follows:

(1) Construct evaluation finger set

The evaluation factor set U is a hierarchical comprehensive evaluation index set. Its first level indicators are:

$$U = \{U_1, U_2, U_3, U_4, U_5\} \tag{4}$$

The corresponding secondary indicators are:

$$U_i = \left\{U_{i1}, U_{i2}, ..., U_{ij}\right\} \tag{5}$$

In the formula, U_{ij} is the i-th index of the j-th criterion layer.

(2) Create a comment set

The comment set is generally based on the evaluation results set by multiple experts based on the indicators that may occur in the distribution network project, and a set of comments is established:

$$V = \{V_1, V_2, V_3, V_4, V_5\} = \{\text{Excellent , Good , Middle , Qualified , Poor }\} \tag{6}$$

(3) Determine the weight set

$$W = \{W_1, W_2, W_3, W_4, W_5\} \tag{7}$$

(4) Establish evaluation affiliation matrix R

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \cdots \\ R_3 \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{21} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{8}$$

Among them, R_1 is the evaluation result of the $i-th$ factor; r_{ij} is the membership degree of the $i-th$ evaluation factor to the $j-th$ evaluation level, which reflects the fuzzy relationship between the evaluation factor and the evaluation level; m is the number of evaluated factors Number; n is the number of evaluation grades in the review set.

(5) Secondary fuzzy comprehensive evaluation

First, perform the first-level fuzzy comprehensive evaluation. Using fuzzy algorithm, the index weight obtained through the analytic hierarchy process is tested, the evaluation membership matrix R is established, and the comprehensive operation and normalization are carried out, so as to calculate the membership vector S1 of the factor clever to the comment set V.

$$S_i = W_i * R_i = (W_{i1}, W_{i2}, ..., W_{ij}) \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{21} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{9}$$

The second step is to carry out the second-level fuzzy comprehensive evaluation on the basis of the first-level fuzzy comprehensive evaluation. According to the principle of “fuzzy vector singularization”, the total evaluation vector A is obtained, and the comprehensive evaluation conclusion is obtained:

$$A = W * S \tag{10}$$

Finally, in order to facilitate the comparison of the evaluation results, the comprehensive evaluation results obtained above are converted into component values, and the evaluation grade score is taken as V, and the evaluation result is F:

$$F = A * V \tag{11}$$

4 Empirical Analysis

To determine the membership degree of the evaluation index after the 110kV power transmission and transformation project, the fuzzy evaluation comment set must be determined first, and then the index membership degree can be determined. Based on the evaluation of the existing research results after drawing on the distribution network project, this paper establishes the comment level of the distribution network project's full life cycle post evaluation after in-depth discussion with experts, as shown in the Table 2.

Invite 10 experts to score the evaluation indicators of the early-stage and post-decision-making of the distribution network Wangcheng project of Langfang City Distribution Network Project, and conduct comprehensive evaluation from the bottom layer to layer by layer by establishing a fuzzy matrix to obtain the evaluation results. Through calculation, the fuzzy membership degree set of the evaluation index of this project is:

$$Q = (0.1223, 0.2270, 0.2270, 0.4236) * \begin{bmatrix} 0.7305\ 0.2215\ 0.0491\ 0\ 0 \\ 0.8688\ 0.1064\ 0.0247\ 0\ 0 \\ 0.8243\ 0.1025\ 0.0732\ 0\ 0 \\ 0.7302\ 0.1755\ 0.1122\ 0\ 0 \end{bmatrix} \tag{12}$$
$$= (0.7830, 0.1412, 0.0758, 0, 0)$$

From the results of the multi-level fuzzy comprehensive evaluation, it can be concluded that the subordination degree of the evaluation index to the comment set (good, medium, poor, bad) after the whole life cycle of the distribution network project is A, and the evaluation result of the project can be obtained as excellent.

Table 2. Comment rating table

Comments	Grading	Instruction
excellent	90–100	Well done
good	80–90	The completion is better
middle	70–80	General completion
Difference	60–70	Poor completion
inferior	0–60	Very poor completion

5 Conclusion

This paper establishes a post-evaluation method system for local power grid companies' distribution network projects based on full-process management, and takes a local power grid company's project to be put into operation in 2020 as an example, and conducts a case empirical analysis to verify the feasibility of the evaluation method. This evaluation method can effectively guide local power grid enterprises to carry out post-evaluation management work, and provide reference and reference for improving the quality of distribution network project construction and investment benefits.

References

1. Yang Hua, Dong Zhen, Sun Yi, Geng Qian, Li Tianran. Design and implementation of post-evaluation system for power grid technical renovation and overhaul projects based on Spark framework[J]. Electrical Technology, 2021, 22(07): 19–25.
2. Wang Jingyi, Sun Haisen, Zhang Chenglin, Zhou Xiang. Research on post-evaluation of power transmission and transformation projects based on network analytic hierarchy process [J]. Journal of Electric Power, 2020, 35(06): 553–562.
3. Pang Bangkai. Research on the Post Evaluation Model of Power Grid Investment Projects [D]. Guangxi University, 2019.
4. Yuan Hai, Li Wei,Zhao Chenxu,Guo Haiyun,Li Kewen,Fan Hailong.Distribution network management status quo and countermeasures[J]. Rong Power Management, 2018(11):48–50.
5. Yin Wenqiang. UAV autonomous capability evaluation method based on improved analytic hierarchy process[J/OL]. Flight Mechanics: 1–6 [2021-08-13]. https://doi.org/10.13645/j.cnki.fd20210810.003.