Construction and Application of Investment Benefit Evaluation Model for Differential Distribution Network Project

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Abstract. In recent years, with the continuous improvement of the economic level of China's power grid, power grid enterprises have shown high enthusiasm for investment, which undoubtedly increases the investment benefits of enterprises, making the investment scale of power grid enterprises show a growing trend. Therefore, China has put forward higher requirements for the accuracy of the evaluation results of power grid investment benefits. In order to scientifically evaluate the expected construction objectives and expected investment benefits of distribution network infrastructure projects of 10 kV and below, and help improve the efficiency and benefits of distribution network investment, this project integrates massive data such as power grid development, equipment, dispatching and marketing, and actively applies the related construction achievements of "online power grid" and "project equipment". With the goal of "quantifiable, evaluable and testable", this project highlights the problem orientation, and constructs a differentiated evaluation index system for investment benefits of power grid infrastructure projects of 10 kV and below by distinguishing project categories. This study establishes an application model for investment benefit evaluation of power grid infrastructure projects of 10 kV and below considering multi-dimensional driving factors by distinguishing project attributes, setting differentiated indicator weights, and combining indicator scoring rules.

Keywords: Distribution network engineering · investment benefit · evaluation model

1 Introduction

With the reform of transmission and distribution electricity price moving forward in depth, the government regulation and price verification put forward clear requirements for the input and output of power grid development and construction based on the principle of promoting the high-quality development of power grid. The goal of "reaching the peak of carbon and being carbon neutral" forces the energy transformation to be accelerated, and the power grid upgrading is urgently required. Faced with huge operating

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pressure, the company urgently needs to change the traditional extensive grid development mode, adhere to "all factors contribute", establish and improve the investment efficiency evaluation mechanism, scientifically and effectively evaluate the company's input and output efficiency, and constantly improve the grid investment efficiency. The distribution network evaluation system often focuses on planning effectiveness, safety, reliability and other aspects [5]. The feasibility study report of distribution network projects only focuses on the demonstration of the necessity and feasibility of the project, lacking the demonstration of the investment benefits of the project. When studying the establishment and application of the urban distribution network asset performance evaluation system, [1] Haowen Lu and others took efficiency as one of the dimensions and established the distribution network asset performance evaluation system from three dimensions of risk, efficiency and cost for analysis and research [3]. Hui Zhang starts from the current situation of the power grid enterprise asset input-output evaluation system, and focuses on the analysis of the optional direction and method of the power grid enterprise asset input-output evaluation. In order to improve the investment benefit evaluation ability of power grid enterprises and promote the healthy and sustainable development of power grid enterprises, how to scientifically analyze and design the investment benefit evaluation model of power grid is a problem that technicians must consider and solve. According to the current situation, this research has built an evaluation model for the investment benefit of differential distribution network projects, carried out different dimensional analysis, and assisted in achieving investment accuracy.

2 Construction of Investment Benefit Evaluation Model for Differential Distribution Network Project

This research relies on the big data of electric power, distinguishes the types of projects, and [2] constructs a differential investment benefit evaluation index system. Based on the differentiation index system, this study constructs the evaluation model of the investment benefit of the differentiation distribution network project by distinguishing the project attributes. This study carries out comprehensive analysis on investment benefits and investment decision-making suggestions of distribution network of 10 kV and below from different dimensions to assist in accurate decision-making of distribution network investment. The research framework is shown in Fig. 1.

2.1 Construction of Evaluation Index System for Investment Benefit of Differential Distribution Network Infrastructure Projects

By distinguishing the line project and the substation area project, combining the characteristics of various projects, in accordance with the principle of "combining technology with economy, combining quantitative with qualitative, and combining responsibility with benefit", the evaluation index system for investment benefit of distribution network projects of 10 kV and below is established by comprehensively considering the five aspects of distribution network operation efficiency, power supply quality, power supply capacity, [6] implementation evaluation and [7] economic benefit, and considering the relationship between equipment and projects. [10] Delphi method is used to give weight

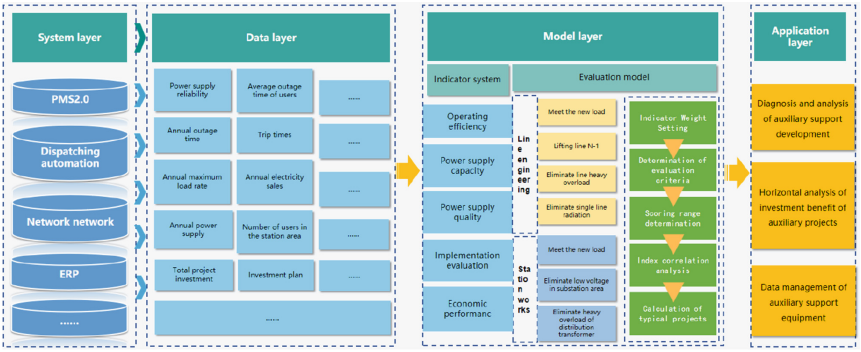

Fig. 1. Construction and geometrical dimensions of specimens

Level I indicators	Secondary indicators	Index weight	Index Meaning	Calculation formula
Operating efficiency	Average load rate	15%	Reflect the overall operation efficiency level of the line. Moderate indicators.	Average line current of this year/line transmission limit of this year
	Line loss rate	15%	Reflect the economic operation level of the line. Negative indicators.	(Current line electricity sales - current line power supply)/current line electricity sales
Power supply capacity	Proportion of light load lines	15%	It reflects the degree to which the line meets the load demand. Negative indicators.	Number of 10kV light load lines/total number of 10kV lines
	Maximum load rate	15%	Reflect the situation that the line meets the load demand, moderate index.	Direct access
Power supply quality	Average failure outage rate	5%	The expected outage rate of a load point within a certain period of time (usually one year) reflects the reliability of the load point. Negative indicators.	Outage rate=annual outage time/8760
	Trip times	5%	Reflect the safe operation level of the asset group. Negative indicators.	Statistical value
Implementation evaluation	Project initiation progress evaluation	5%	It reflects the progress of project approval and is a negative indicator.	ERP project construction time - feasibility study preliminary design review time
	Project scale evaluation	5%	It reflects the progress of project initiation, with appropriate indicators.	Investment scale and project initiation time
Economic performance	Increased supply load per unit investment	7%	It reflects the benefits brought by investment and is a positive indicator.	Ratio of the difference between the maximum power supply load in the assessment year and the maximum power supply load in the reference year to the grid investment in the planning period
	Net present value	6%	This indicator is used to indicate the profitability of the project.	Sum of net present value of net cash flow in each year
	Internal rate of return	7%	Reflect the profitability of indicators.	Internal rate of return=(financial internal rate of return on capital - industry benchmark rate of return)/industry benchmark rate of return * 100%

Fig. 2. Evaluation index system for investment benefit of line engineering distribution network project

to each index. According to relevant documents, the indicators are divided into positive, negative and moderate indicators, and the indicator threshold interval and scoring rules are determined to comprehensively and effectively support the comprehensive analysis of investment benefits of distribution network projects. The investment benefit evaluation index system of the line project and the substation project distribution network project are shown in Fig. 2 and Fig. 3 respectively.

2.2 Construction of Investment Benefit Evaluation Model for Differentiated Distribution Network Infrastructure Projects

Through the establishment of indicator system, the formulation of indicator scoring rules and weights, this study is divided into line project and substation project, and distinguishes [9] project attributes (meeting the requirements of new load, improving line N−1,

Level I indicators	Secondary indicators	Index weight	Index Meaning	Calculation formula
Operating efficiency	Average load rate	15%	Reflect the overall operation efficiency of the station area. Moderate indicators.	Index value=average load of substation area/distribution and transformation capacity of substation area
	Load achievement rate	15%	Index of operating efficiency of reaction equipment. Positive indicators.	Load achievement rate=current load/target load
Power supply capacity	Household distribution and transformation capacity	10%	It reflects the average power supply capacity of the substation area for each user. Moderate indicators.	Index value=distribution and transformation capacity of this year/number of low-voltage users of this year
	Maximum load rate	10%	It reflects the satisfaction of substation capacity to the overall load demand. Moderate indicators.	Index value=maximum load of the year/distribution and transformation capacity of the year
	Proportion of light load distribution transformer	10%	It reflects the degree to which the substation meets the load demand. Negative indicators.	10kV light load distribution transformer ratio=10kV light load distribution transformer number/10kV total distribution transformer number
Power supply quality	Utilization rate of unit distribution and transformation capacity	10%	Reflect the utilization of distribution transformer capacity. Positive indicators.	Utilization rate of distribution and transformation capacity=electricity sales/distribution and transformation capacity
Implementation evaluation	Project initiation progress evaluation	5%	It reflects the progress of project approval and is a negative indicator.	ERP project construction time - feasibility study preliminary design review time
	Project scale evaluation	5%	It reflects the progress of project approval and is a moderate indicator.	Investment scale and project initiation time
Economic performance	Increased supply load per unit investment	7%	It reflects the benefits brought by investment and is a positive indicator.	Ratio of the difference between the maximum power supply load in the assessment year and the maximum power supply load in the reference year to the grid investment in the planning period
	Net present value	6%	This indicator is used to indicate the profitability of the project.	Sum of net present value of net cash flow in each year
	Internal rate of return	7%	Response index profitability.	Internal rate of return=(financial internal rate of return on capital - industry benchmark rate of return)/industry benchmark rate of return * 100%

Fig. 3. Evaluation index system for investment benefit of substation project distribution network project

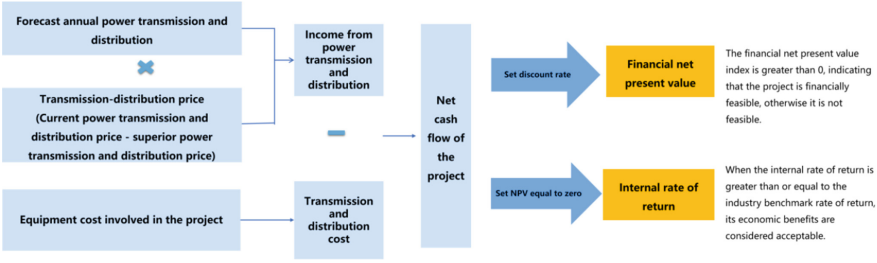

Fig. 4. Schematic Diagram of Financial Post evaluation Calculation

eliminating line heavy overload, eliminating line single radiation, eliminating low voltage in substation area and eliminating distribution transformer heavy overload), showing the operation status indicators of different projects and the overall investment benefits of the project. The overall logic of the [4] financial post-evaluation is shown in Fig. 4, in which the net present value and internal rate of return of the project are calculated by calculating the annual transmission and distribution income and annual transmission and distribution cost, providing a quantitative analysis tool for the evaluation of the economic benefit dimension of the project.

2.3 Empirical Analysis

Taking a substation project as an example, its project attribute is "eliminating low-voltage in substation area". In 2021, the average maximum load rate of the project will be 30%, the line loss rate will be 2.17%, the average load rate will be 4%, the project investment will be 3.5818 million yuan, and the annual power supply will be 1291.72 kWh.

Fig. 5. Comprehensive evaluation results of investment benefit of a project

2.3.1 Overall Situation of the Project

From the comprehensive evaluation results in Fig. 5, the total score of this project is 74 points, which is lower than the average level of the project with the attribute of "eliminating low-voltage in the substation area" and the overall level of the substation area. From the perspective of specific dimensions, the dimensions of operation efficiency, power supply quality and implementation evaluation indicators are basically consistent with the average level of this attribute, and the scores of power supply capacity and economic benefits are lower than the average level of this attribute, which is relatively low.

2.3.2 Analysis of Project Indicators

According to the operation efficiency dimension indicators of the project in Fig. 6, the average load rate of the project is 4.38%, which is low because the average load rate of equipment 5 is 2%. The load fulfilment rate of this project is 62%, because the actual load is 401.94 kVA, which is relatively low. According to the power supply quality dimension indicators of the project, the utilization rate of unit distribution and transformation capacity of the project is 63%, and the indicator value is relatively low.

According to the power supply capacity dimension index of the project in Fig. 7, the maximum load rate indicator of the project is 20.1%, which is relatively low, because the maximum load rate of equipment 5 is only 9%, and the indicator value of equipment 6 is

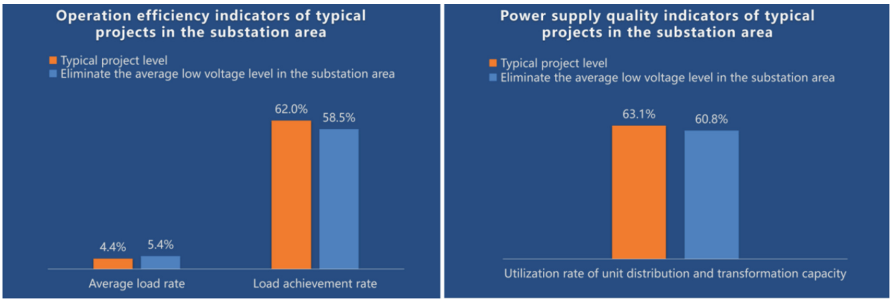

Fig. 6. Operation efficiency and power supply quality indicators of a project

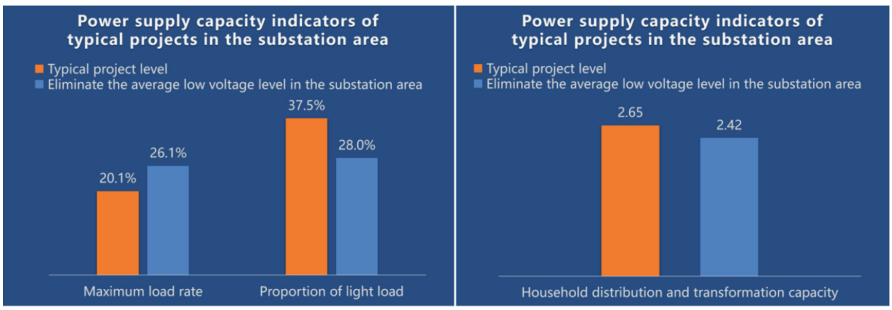

Fig. 7. Power supply capacity indicators of a project

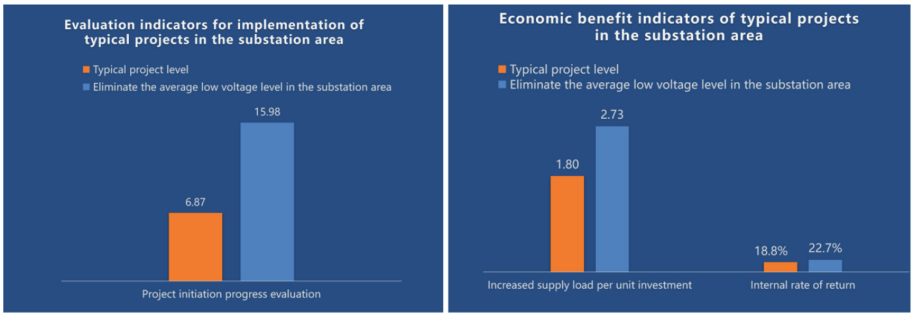

Fig. 8. Implementation evaluation and economic benefit indicators of a project

0. The average household distribution and transformation capacity index value is 2.65, which is within the reasonable threshold range of this index. Light load accounts for 38%, and the indicator value is relatively large, because there are 3 equipment operating under light load.

According to the implementation of Fig. 8, the project is better than the average level of the attribute, and both indicators are relatively good. According to the economic benefit dimension indicators, the NPV of the project is greater than zero. The internal rate of return is 19%, which is lower than the average level of the platform project (23%). The indicator value of unit investment increased supply load is 1800 kW/yuan, which is lower than the average level of this indicator. Penetrating into the equipment layer, the increased supply load of equipment 5 is low, less than 40kW, and that of equipment 6 is 0.

2.4 Problems and Suggestions

Specific problems and suggestions are as follows:

(1) Improve equipment data quality. [8] The current equipment data quality is relatively poor, so the function configuration of the industry and finance system can be further optimized, data labels can be added according to management requirements, and system control and verification can be strengthened. It can also continuously promote the link

connection between systems, improve the level of system integration, and improve the coordination efficiency between systems.
(2) Improve the operation efficiency level. The load fulfillment rate is relatively low. It is necessary to strengthen load management, reasonably forecast the target load, avoid failing to meet the expected load, accelerate the construction of a new load management system, and improve the capacity of load forecasting and accurate deployment.
(3) Improve power supply capacity. The average household distribution and transformation capacity is relatively low. The average household distribution and transformation capacity can be reasonably determined according to the per capita domestic electricity consumption level in the planning period, avoiding repeated construction and reform, and improving the development and operation level of the distribution network.
(4) Improve the level of economic benefits. The unit investment supply increasing load and internal rate of return are relatively low. It is suggested to continue the deep integration of industry and finance, take improving the efficiency and benefit of power grid investment as the goal, break professional barriers, and promote more reasonable calculation of equipment investment income. We should also pay attention to improving service quality and efficiency, increasing supply and sales, increasing power supply (sales), and increasing the return on grid asset investment.

3 Conclusion

Based on the research on the investment benefit evaluation model of the differential distribution network project, according to the comprehensive evaluation guidelines for the development level of the distribution network, and based on the data and system research, this study constructs the evaluation index system of the investment benefit of the differential distribution network project. In combination with the index evaluation rules and weights, it distinguishes the project attributes, constructs the differential distribution network project investment benefit evaluation model, carries out investment benefit analysis in different dimensions, summarizes the distribution network project business problems, puts forward investment related management suggestions, and realizes the refined management of investment decisions.

References

1. Haowen Lu, Yinyin Lin, Haisheng Hong. (2019) Establishment and application of urban distribution network asset performance evaluation system [J]. Electromechanical Information, 21:22-23.
2. Ronnie (2020) Research on evaluation of distribution network resource allocation benefits of power supply enterprises J. Modern economic information, 35: 180-181.
3. Hui Zhang. (2020) Analysis and research on comprehensive efficiency evaluation of input-output of power grid enterprise assets in the whole life cycle J. Managing the World, 15: 295-296.
4. Zheng Wu, Wenting Cui, Yu Long, etc (2016) Post evaluation of distribution network investment effect and investment rationality analysis J. Journal of Electric Power System and Automation, 28 (12): 96-102.

5. Shengli Liu, Yang Cao, Yueliang Feng (2018) Research and application of distribution network investment benefit evaluation and decision-making model J. Power System Protection and Control, 2: 119-125.
6. Bo Yang (2009) Research on the post-investment evaluation index system of 10 kV and below distribution network construction and transformation J. China Southern Power Grid Technology, 3:8-14
7. Qian Li, Wenting Xu (2010) Construction of post-evaluation index system for distribution network projects of 10kV and below J. China International Conference on Communication and Information Technology, 35: 19-22
8. Qianrong Ye (2009) Research on post-evaluation index system of distribution network investment projects of 10 kV and below in Guangzhou Power Supply Bureau J. Power and Energy, 31: 302-303
9. Qian Ma, Bo Wang, etc (2015) Research on evaluation and decision-making optimization of distribution network construction and transformation projects J. Power grid and clean energy, 31 (3): 11-17
10. Guoquan Wang, Kun Qiao, etc (2017) Distribution network investment benefit evaluation and investment project optimization J. Journal of Power System and Automation, 29 (12): 146-150