Research on Financial Benefit Evaluation of Distribution Network Transformation and Upgrading Projects

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Abstract. National policy documents such as the "14th Five Year Plan for National Urban Infrastructure Construction" and the "14th Five Year Plan for Modern Energy System" clearly support and encourage investment, construction, transformation and upgrading of power grids, distribution networks, smart grids, and new power systems. There is currently no calculation method that only considers the financial benefits brought by the transformation and upgrading of the distribution network for the evaluation of the financial benefits of the distribution network transformation and upgrading project. This article proposes a financial benefit evaluation method for distribution network renovation and upgrading projects, and analyzes it using a typical regional distribution network renovation and upgrading project as an example. Provide important reference for the investment and construction of regional distribution network renovation and upgrading projects in the future.

Keywords: Distribution network; Renovation and upgrading; Financial benefits

1 Introduction

The power supply bears the important mission of ensuring economic and social development. The demand for power supply in new towns is increasing, and there are more and more distribution network renovation and upgrading projects. Choosing scientific and reasonable methods to evaluate the financial benefits of distribution network renovation and upgrading projects is of great significance for the decision-making of distribution network renovation planning schemes.

Due to the multiple construction contents, complex implementation process, and unclear improvement in user experience of distribution network renovation and upgrading projects, it is difficult to scientifically and reasonably evaluate the financial benefits of distribution network renovation and upgrading projects. In existing research, most of them use Analytic Hierarchy Process (AHP), Fuzzy Comprehensive Evaluation (FCE), and other methods to construct a comprehensive evaluation index system for the overall comprehensive evaluation of distribution network projects from aspects such as project process, project effectiveness, and project benefits [1-5]; Some scholars also use

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traditional financial evaluation models to calculate the profitability and solvency of distribution network projects based on the newly added electricity sales and average electricity prices in the investment area [6-7], and attribute the electricity revenue brought about by regional economic development to the project itself. However, the majority of the newly added electricity sales are due to the increment brought about by regional economic development, which does not fully reflect the electricity increase brought about by the transformation and upgrading of the distribution network. This article proposes a financial benefit evaluation method for distribution network renovation and upgrading projects, and analyzes it using a typical regional distribution network renovation and upgrading project as an example.

2 Model building

The financial benefits of the distribution network renovation and upgrading project mainly include three parts: reducing power outage time and increasing electricity sales revenue; Quick fault location and isolation, reducing operation and maintenance costs; The economic operation of the distribution network reduces the cost of energy loss. Namely:

$$R = R_{sd} + R_{yw} + R_{sh} \tag{1}$$

Where R represents the total financial benefits of the project; R_{sd} represents the increased revenue from electricity sales; R_{yw} is the reduced operation and maintenance cost; R_{sh} is the cost of reducing electrical energy loss.

(1) Increased electricity sales revenue

The increased revenue from selling electricity is calculated by the product of the average outage time of the project area, the operating energy per unit time and the transmission and distribution price of the voltage level.

$$R_{sd} = T_{av} \times Q_{av} \times P_{av} \tag{2}$$

Where T_{av} is the average power outage time; Q_{av} is the operating power per unit time; P_{av} is the transmission and distribution electricity price for this voltage level.

(2) Reduced operational and maintenance costs

The reduced operation and maintenance costs are calculated based on the product of the average number of on-site fault detections in the project area, the average line length, and the approved maintenance cost.

$$R_{yw} = C_{av} \times L_{av} \times C_{av} \tag{3}$$

Where C_{av} is the average number of on-site fault detections; L_{av} is the average line length; C_{av} is the approved maintenance cost.

(3) Reduced cost of electrical energy loss

The reduced cost of electricity loss is calculated by multiplying the average loss of electricity in the project area by the transmission and distribution electricity price of that voltage level.

$$R_{sh} = Q_{av,sh} \times P_{av} \tag{4}$$

Where $Q_{av,sh}$ is the average loss of electricity; P_{av} is the transmission and distribution electricity price for this voltage level.

3 Example analysis

3.1 Project Introduction

The area where the project is located is the location of local government agencies, a Ghetto of large commercial centers, cultural centers, and residential communities. It is characterized by many important users, large load density, and high requirements for power supply reliability. It belongs to Class A power supply area. In order to better support the adjustment of the regional economic layout and industrial development, we will implement the distribution automation improvement and transformation project, comprehensively improve the level of distribution network operation management and system power supply reliability.

The project construction content is divided into three parts, and the grid structure mainly includes the construction of new ring network boxes and the laying of various types of cables; The newly installed and renovated parts mainly include ring network boxes, column mounted circuit breakers, etc. for newly installed or renovated lines; The communication part mainly includes laying optical cables, configuring optical line terminal OLT equipment, EPON network management system, ONU equipment, splitter equipment, etc.

3.2 Financial benefits

3.2.1 Increased electricity sales revenue.

Through the construction of distribution automation system engineering and the application of feeder automation functions, the fault handling time and power recovery time of non fault line segments can be significantly reduced. By increasing the sales of electricity, direct benefits can be brought to power supply enterprises.

(1) Annual average power outage time of users

According to DL/T 5729-2016 "Technical Guidelines for Distribution Network Planning and Design", the relationship between the average annual power outage time of users and power supply reliability is shown in Table 1.

Table 1. Relationship between Annual Power Outage Time of Users and Power Supply Reliability[8]

Outage time	Power supply reliability
Annual average power outage time of users ≤5min	≥99.999%
Annual average power outage time of users ≤52min	≥99.990%
Annual average power outage time of users ≤3h	≥99.965%
Annual average power outage time of users ≤12h	≥99.863%
Annual average power outage time of users ≤24h	≥99.726%

The regional power supply reliability rates before and after project implementation are 99.942% and 99.999%, respectively. Based on the relationship between the average annual power outage time of users and the power supply reliability rate in the table above, the average annual power outage time of users before and after project implementation is calculated to be 5 hours and 5 minutes, respectively.

(2) Line operating power

The project involves a total of 25 10kV lines. Based on the operating electricity of each line, the average operating electricity of the lines before and after the project implementation is calculated to be 16.33 million kWh and 15.74 million kWh.

(3) Transmission and distribution electricity price

Most of the electricity in this area is for general industrial, commercial, and other purposes. According to the relevant regulations of local transmission and distribution electricity prices, a general industrial, commercial, and other electricity price of less than 1 kV, which is 0.34406 yuan/kWh, is adopted. See Table 2 for details.

Table 2. Transmission and Distribution Tariff Table[9]

Unit: yuan/kWh

Electricity classification	Electricity price	
	Less than 1 kV	1-10 kV
General industrial, commercial and other electricity consumption	0.34406	0.29907
Large industrial electricity consumption	-	0.12055

(4) Increased electricity sales revenue

The increased electricity sales revenue of this transformation is calculated by the product of the average outage time, the operating energy per unit time and the transmission and distribution price of this voltage level. The power outage losses before and after project implementation were 0.0738 million yuan and 0.012 million yuan, respectively. The power outage losses after project implementation decreased by 0.0726 million yuan compared to before project implementation, equivalent to an increase of 0.0726 million yuan in electricity sales revenue.

3.2.2 Reduced operation and maintenance costs.

Distribution automation achieves the collection and monitoring of equipment information in the distribution network. It can quickly locate and isolate faults through feeder fault handling functions, effectively shortening fault detection time and reducing expenses for manual fault detection of vehicles, tools, and other equipment.

(1) Number of on-site fault detections

Based on the on-site fault detection frequency of each line in different years, the average on-site fault detection frequency of the line before and after project implementation is 2.38 and 1.94, respectively. The average number of on-site fault detections is shown in Table 3.

Table 3. Statistical Table of Onsite Fault Detection Times

Unit: Times

Line name	2018	2019
Line 1	2	2
Line 2	3	2
Line 3	1	0
Line 4	3	3
Line 5	3	2
Line 6	4	4
Line 7	1	1
Line 8	1	0
Line 9	0	0
Line 10	1	0
Line 11	0	0
Line 12	2	1
Line 13	6	5
Line 14	5	6
Line 15	3	3
Line 16	3	2
mean value	2.38	1.94

(2) Average line length

Based on the length of each line in different years, the average length of the line before and after project implementation is calculated to be 13.98km and 9.43km, respectively.

(3) Single maintenance cost

According to the "Cost Standards for Maintenance, Operation and Management of Power Grid and Power Generation", the maintenance cost of 10kV and below distribution network lines is determined to be 1053 yuan/km.

(4) Reduced operational and maintenance costs

The reduced operation and maintenance costs for this renovation are calculated based on the product of the average number of on-site fault detections, average line length, and approved maintenance costs. The operation and maintenance costs before and after project implementation were 0.8039 million yuan and 0.4426 million yuan, respectively. After project implementation, the operation and maintenance costs were reduced by 0.3612 million yuan compared to before project implementation.

3.2.3 Reduced Energy Loss Cost.

Through the construction of distribution automation engineering, the economic operation of the distribution network has been achieved, the efficiency of distribution network operation management has been improved, the level of line loss management has been improved, and the power loss has been controlled to a certain extent.

(1) Line operating power

Based on the operating electricity consumption of each line in different years, the average operating electricity consumption of the line before and after project implementation is 16.3386 million kWh and 15.7443 million kWh, respectively.

(2) Line loss of electricity

Based on the line loss rates of each line in different years, the average power consumption of the line before and after project implementation is calculated to be 1.3362 million kWh and 1.1037 million kWh, respectively.

(3) Transmission and distribution electricity price

Most of the electricity in this area is for general industrial, commercial, and other purposes. According to the relevant regulations of local transmission and distribution electricity prices, a general industrial, commercial, and other electricity price of less than 1 kV, which is 0.34406 yuan/kWh, is adopted.

(4) Reduced cost of electrical energy loss

The reduced electricity loss cost of this renovation is calculated by multiplying the average electricity loss by the transmission and distribution electricity price of this voltage level, and the electricity loss costs before and after the project implementation are 10.574 million yuan and 8.7339 million yuan, respectively. After the project implementation, the loss was reduced by 1.841 million yuan compared to before the project implementation.

3.2.4 Total financial benefits of the project.

The financial benefits of the project mainly include three parts: reducing power outage time and increasing electricity sales revenue; Quick fault location and isolation, reducing operation and maintenance costs; Economical operation of the distribution network to reduce energy loss. The annual financial benefit of this project is 0.0726 million yuan+0.3612 million yuan+2.7807 million yuan=3.2145 million yuan.

4 Conclusion

This article proposes a quantitative calculation method for the financial benefits of a distribution network renovation and upgrading project. The financial benefits of the project mainly include three parts: reducing power outage time and increasing electricity sales revenue; Quick fault location and isolation, reducing operation and maintenance costs; Economical operation of the distribution network to reduce energy loss. Taking a distribution network transformation and upgrading project in a Type locality as an example, the calculation and analysis of financial benefits are carried out. The results show that the method has important reference value for analyzing the financial benefits of distribution network transformation and upgrading projects.

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