Research on the Construction and Analysis Method of Investment Benefit Evaluation Model of Distribution Network Project Adapting to the Reform of Transmission and Distribution Electricity Price

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Abstract. Post-evaluation of power grid infrastructure projects plays an important role in front-end investment management decisions. As an important part of infrastructure project investment, distribution network investment is evaluated in terms of granularity in counties. The evaluation method is relatively extensive, which is difficult to support the accurate allocation of distribution network investment resources. However, looking at the current distribution network evaluation content, it is lack of economic benefit evaluation content, and it is difficult to adapt to the company's permitted income recovery requirements under the current transmission and distribution electricity price reform. Therefore, this paper takes a single distribution network project as the evaluation object, constructs the distribution network investment benefit evaluation system, studies the determination method of the distribution network project value index, and applies the entropy weight method to determine the weight of the distribution network project investment benefit index, and constructs the distribution network project investment benefit evaluation model. By collecting the data of distribution network projects, verify the applicability of the model, and analyze the economic benefits of different projects invested in the distribution network, so as to lay the foundation for the application of the distribution network investment benefit auxiliary investment resource allocation scenario.

Keywords: Electricity price reform of transmission and distribution · Distribution network project · Investment benefit evaluation · Investment benefit analysis

1 Research Background

As an important part of the back end of investment management, the post evaluation of power grid infrastructure projects plays a vital role in feeding back the front-end decision-making of investment management. At present, the post investment evaluation of the distribution network is relatively mature [1]. According to the characteristics of

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the distribution network investment and construction, the evaluation mode adopts the county packaging method. The evaluation method is relatively extensive, and it is unable to conduct lean evaluation on the investment benefit of a single project. However, the current investment plan resource allocation is made by the project as the main body, and the granularity of the back-end evaluation and front-end decision-making is inconsistent, resulting in the evaluation results can not meet the application needs of front-end investment decision-making [2]. Therefore, it is urgent to adapt to the current reform form of transmission and distribution electricity price, optimize the granularity of post investment evaluation of existing distribution network projects, study the evaluation method of investment benefits of individual distribution network projects, strengthen the application of evaluation results in investment decision-making, and give play to its greater value in lean investment management of the company.

2 Research Objectives

This paper takes a single distribution network project as the research object, aims to achieve a lean evaluation of the investment benefit of a single project, and strengthen its application in the investment decision-making link. It mainly carries out the following research: First, based on the current post evaluation index system, combined with the current transmission and distribution price reform requirements, determine the investment benefit index system of a single distribution network project; Second, according to the optimized investment benefit evaluation system, study the investment benefit evaluation method of single project; The third is to use analysis technology to analyze and apply project evaluation results, and propose investment decision-making strategies according to classification.

With the deepening of transmission and distribution electricity price reform, the actual operating electricity level of the company is the key factor for revenue recovery. Therefore, in order to measure the benefit level brought by the annual incremental investment, the electricity data generated by the equipment will be connected with the investment, and the multi-dimensional cost data will be allocated to the project according to the business motivation, forming the correlation relationship between the project from investment to electricity, to operation and maintenance costs, and starting from several key elements such as investment, assets, electricity, costs, etc. according to the above constructed distribution network project investment benefit evaluation index system.

3 Investment Benefit Evaluation Index System of Distribution Network Project

Based on the existing distribution network project investment benefit evaluation system, combined with the transmission and distribution electricity price verification principle, starting from the investment project asset equipment transmission chain, the distribution network project investment benefit evaluation index system is designed from the

three dimensions of asset formation rate, asset operation efficiency and investment efficiency, and the distribution network project investment benefit evaluation index system is determined.

(1) *Asset formation rate*

From the asset formation process, reflect the asset formation efficiency, and select the asset transfer rate indicator. This indicator is for incremental investment [3].

Calculation method: asset transfer rate = cumulative new assets/cumulative investment plan.

(2) *Investment benefit*

① 10000 yuan asset income

Meaning: 10000 yuan asset income reflects the gross profit brought by unit assets. The higher the index, the greater the investment output benefit of the evaluation object [4].

Calculation formula: 10000 yuan asset income = transmission and distribution income ÷ average asset scale, wherein, the average original value of fixed assets = (original value of grid fixed assets at the beginning of the year + original value of grid fixed assets at the end of the year)/2;

② 10000 yuan asset operation and maintenance cost

Capital investment forms assets, and the assets will cost operation and maintenance costs. Therefore, the operation and maintenance efficiency is considered as a part of the investment efficiency benefit evaluation, which is mainly reflected by the 10000 yuan asset operation and maintenance cost index.

Meaning: 10,000 yuan asset operation and maintenance cost reflects the level of operation and maintenance cost per 10,000 yuan asset cost. The lower the index is, the greater the benefit from the new operation and maintenance cost of the evaluation object will be [5].

Calculation formula: 10000 yuan fixed assets operation and maintenance cost = operation and maintenance cost/average original value of fixed assets × 10000, of which: operation and maintenance cost = material cost + repair cost + others (excluding labor cost), [this part is excluded due to the weak correlation between labor cost and electricity growth],

Average original value of fixed assets = (original value of fixed assets at the beginning of the period + original value of fixed assets at the end of the period)/2;

③ Increased electricity sales per unit investment

Meaning: The increase in electricity supply per unit investment reflects the increase in power supply benefits brought by the new investment. The higher the index, the higher the output benefit of the new investment of the evaluation object [6].

Calculation formula: increased electricity sales per unit power grid investment = [(electricity sales in the current period - electricity sales in the same period of last year)/average power grid investment in the previous three years] × 100%;

④ Increased income from unit investment

Meaning: The increase in income per unit investment reflects the increase in benefits brought by incremental investment. The higher the index is, the greater the benefit of the new investment of the evaluation object will be [7].

Calculation formula: increased transmission and distribution income per unit investment = (transmission and distribution income of the current year - transmission and distribution income of the previous year) ÷ average investment in the previous three years.

4 Investment Benefit Evaluation Method of Distribution Network Project

4.1 Key Element Determination Method

1) Determination method of electric quantity of distribution network project

According to the business logic of the distribution network project from investment, construction and operation, sort out the relevant systems and data involved, and collect data such as investment, transfer of assets, key asset cards of power transformation/transmission/distribution, standing books of power transformation/transmission/distribution equipment, and operation of power transformation/transmission/distribution equipment, so as to perform associated matching between the project and the electricity quantity. Through research, the correlation path between investment and operating power of distribution network project has been established. See the following for details (Fig. 1):

According to the project electricity matching data, combined with the project type (power distribution equipment, power distribution lines, etc.) and construction nature (new construction, expansion, etc.), determine the principles for determining the new electricity generated by the project investment. See the following for details (Fig. 2):

2) Electricity price determination method

According to the verification logic of transmission and distribution electricity price, adopt the method of "allocating the gross profit of the company to each voltage level" to determine the electricity price of each voltage level [8]. The specific algorithm is as follows:

First, calculate the gross profit of the company. Gross profit of the company = electricity sales revenue - electricity purchase cost,

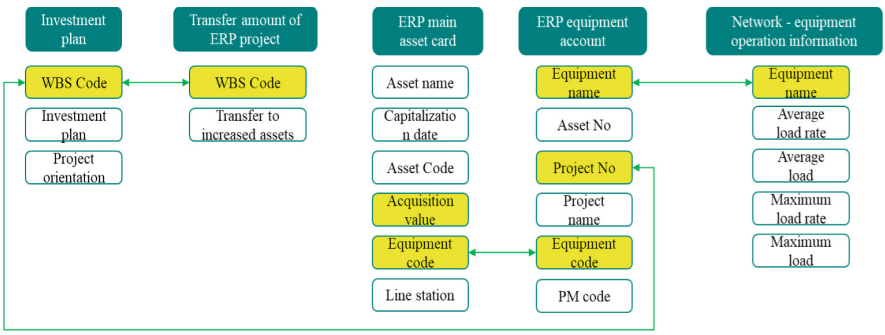

Fig. 1. Project electricity correlation path

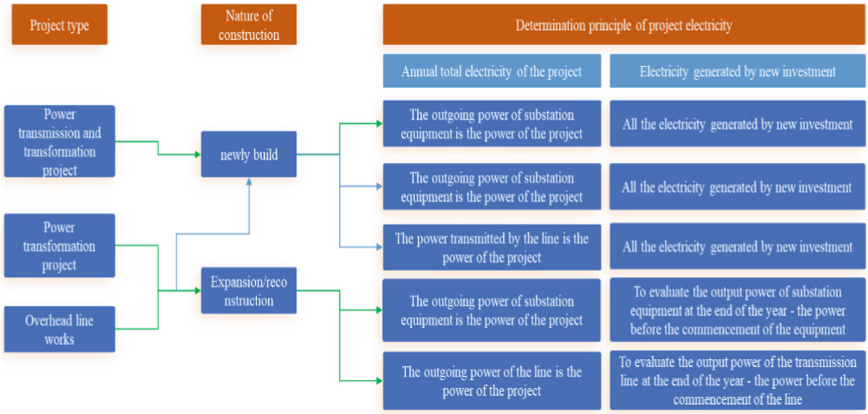

Fig. 2. Determination principle of newly added electricity in distribution network project

Second, calculate the allowable income of each voltage level = allowable cost + allowable income = depreciation cost + labor cost + material cost + repair cost,

Third, calculate the proportion of 10 kV allowable income = 10 kV allowable income/the company's overall allowable income,

Fourth, calculate the proportion of 10 kV shared gross profit = the company's gross profit * 10 kV allowed income,

Fifthly, calculate the gross profit/power transmission and distribution of 10 kV unit electricity yield = 10 kV sharing;

Unit electricity income of 10 kV distribution transformer = unit electricity income * original value of distribution assets/original value of assets of this voltage level;

Unit electricity yield of 10 kV transmission = unit electricity yield * original value of transmission assets/original value of assets of this voltage level.

3) Determination method of project operation and maintenance cost

In order to determine the maintenance operation and maintenance cost after the project is put into operation, combined with the company's multi-dimensional business activity operation and maintenance cost and considering its corresponding relationship with assets, the cost of different business activities of maintenance operation and maintenance is allocated to the corresponding assets, and then the cost is allocated to the project according to the proportion of the asset value formed by the new investment [9]. See the following for specific ideas (Fig. 3):

4.2 Construction of Evaluation Model for Investment Benefit of Distribution Network Project

According to the determination method of the key elements of the distribution network project, the project electricity operation and maintenance cost correlation path is set, and then according to the established distribution network project investment benefit evaluation index system, the asset formation efficiency and investment efficiency indicators are calculated, and the corresponding weights are set to form the distribution network project investment benefit evaluation model [10].

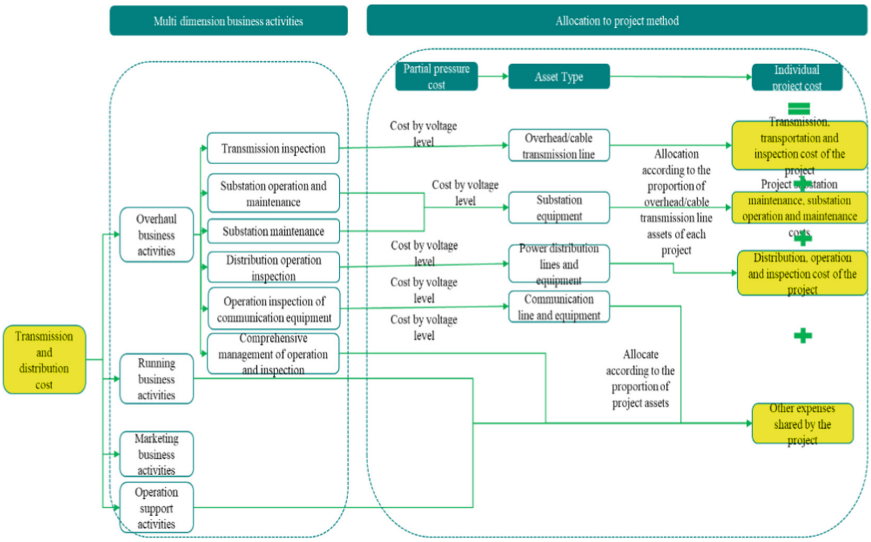

Fig. 3. Determination of project operation and maintenance cost allocation

First, determine the index weight. The index weight is determined by entropy method. According to the principle of entropy method, the weight of indicators is calculated using R language. The specific code is as follows (Fig. 4):

```
min.max.norm <- function(x){
  (x-min(x))/(max(x)-min(x))
}
max.min.norm <- function(x){
  (max(x)-x)/(max(x)-min(x))
}
sourui_1 <- apply(sourui[,-c(7,11)],2,min.max.norm)
sourui_2 <- apply(sourui[,c(7,11)],2,max.min.norm)
sourui_t <- cbind(sourui_1,sourui_2)
first1 <- function(data)
{
  x <- c(data)
  for(i in 1:length(data))
    x[i] = data[i]/sum(data[])
  return(x)
}
dataframe <- apply(sourui_t,2,first1)
first2 <- function(data)
{
  x <- c(data)
  for(i in 1:length(data)){
    if(data[i] == 0){
      x[i] = 0
    }else{
      x[i] = data[i] * log(data[i])
    }
  }
  return(x)
}
dataframe1 <- apply(dataframe,2,first2)

k <- 1/log(length(dataframe1[,1]))
d <- -k * colSums(dataframe1)
d <- 1-d
w <- d/sum(d)
```

Fig. 4. Example of indicator weight determination code

Table 1. Index weight table

Index	Entropy	Differentiation coefficient	Weight
Capital transfer rate	0.80	0.20	0.10
10000 yuan of asset income	0.80	0.20	0.10
10000 yuan of asset operation and maintenance cost	0.80	0.20	0.20
Increased sales of electricity per unit investment	0.71	0.29	0.25
Income from increased sales of unit investment	0.00	1.00	0.35

The entropy weight and entropy value of indicators are calculated according to the principle of entropy method, and the specific results are as follows (Table 1):

The second is to determine the evaluation rules. Total score = index 1 score * index 1 weight + index 2 score * index 2 weight++ Index n score * index n weight. Total score of project investment benefit = index 1 score * index 1 weight + index 2 score * index 2 weight +… The higher the total score, the better the project investment benefit.

Thirdly, according to the index and its evaluation rules, set the index parameters and weights, and build the distribution network investment benefit evaluation model.

4.3 Analysis of Investment Benefit Evaluation Results of Distribution Network Project

According to the estimated investment benefit of the distribution network project, analyze the level of investment benefit generated by projects with different investment directions (such as solving heavy overload of equipment, solving low voltage platform area, eliminating potential safety hazards, etc.), and provide reference for the formulation of future investment strategies.

5 Verification of Investment Benefit Evaluation of Distribution Network Infrastructure Projects and Application of Results

According to the above model, collect relevant project data and carry out investment benefit calculation and analysis.

5.1 Data Acquisition

Collect the following relevant data (Table 2) according to the requirements of indicator measurement.

5.2 Result Analysis

Through the calculation results (Table 3 and Table 4) of the investment benefit model, analyze the investment benefit results of projects with different investment orientations.

Table 2. Data requirements table

Order number	Data content	Scope description	Department	System
1	Detailed data of annual capital transfer from 2019 to 2021	2019–2021	Finance Department	ERP
2	Table of Suggestions for the Historical Annual Investment Plan of the Project to be Put into Production in 2019–2021	From the beginning of the project to release the investment plan	Development Department	online grid
3	Asset Card	Distribution transformer, distribution equipment and distribution line	Finance Department	ERP
4	Equipment account	Power distribution equipment, lines and other equipment	Equipment Department	PMS
5	Device power information	Distribution transformer, wiring, etc.	Development Department	online grid
6	2020–2021 Multi dimensional Data of Transmission and Distribution Costs	2020–2021	Finance Department	Financial control
7	Detailed statement of cost and expense management, fixed assets and accumulated depreciation, electricity sales revenue and electricity purchase cost	2019–2021	Finance Department	Financial control

Table 3. Results of project investment benefits

Project	Item Properties	Asset formation rate	10000 yuan asset income	10000 yuan asset operation and maintenance cost	Increased electricity sales per unit investment	Increased income from unit investment	Total score
1	Meet the new load	22.58	4.79	10.00	9.16	6.28	52.82
2	Meet the new load	26.23	25.50	10.00	9.27	20.00	90.99
3	Meet the new load	27.00	30.00	10.00	10.00	7.24	84.24
4	Lifting line N-1	25.74	18.96	10.00	9.69	17.13	81.52
5	Lifting line N-1	25.96	9.70	10.00	9.84	11.62	67.13
6	Lifting line N-1	25.00	26.32	10.00	9.32	19.08	89.73
7	Eliminate line heavy overload	25.74	30.00	10.00	9.74	13.60	89.08
8	Eliminate line heavy overload	20.36	4.79	10.00	9.69	8.98	53.81
9	Eliminate single line radiation	22.34	18.96	5.00	9.63	17.27	73.20
10	Eliminate single line radiation	22.24	16.68	10.00	9.63	14.21	72.75
11	Eliminate single line radiation	22.47	9.70	10.00	9.90	15.03	67.09
12	Meet the new load	24.00	24.14	10.00	9.73	13.69	81.55
13	Meet the new load	18.00	22.00	10.00	9.72	8.77	68.50
14	Meet the new load	24.00	28.57	10.00	9.78	20.00	92.35

(*continued*)

Table 3. (*continued*)

Project	Item Properties	Asset formation rate	10000 yuan asset income	10000 yuan asset operation and maintenance cost	Increased electricity sales per unit investment	Increased income from unit investment	Total score
15	Eliminate low voltage in substation area	15.00	25.15	10.00	9.02	19.03	78.20
16	Eliminate low voltage in substation area	15.00	23.25	10.00	10.00	15.94	74.19
17	Eliminate heavy overload of distribution transformer	12.00	15.56	10.00	9.51	17.43	64.49
18	Eliminate heavy overload of distribution transformer	15.00	27.00	10.00	9.94	12.22	74.17

5.3 Application of Investment Benefit Evaluation Results

On the basis of the above investment benefit evaluation methods, the accurate distribution network investment allocation is assisted. According to the evaluation results, the historical input-output efficiency, economic benefits, etc., the current situation coefficient and comprehensive performance coefficient of the synthetic power grid are compared and analyzed horizontally, which provides a reference basis for the accurate allocation of investment resources of the municipal company in combination with the reported investment needs (Fig. 5).

Table 4. Results of investment benefits from different investment directions

Number	Item Properties	Asset formation rate	10000 yuan asset income	10000 yuan asset operation and maintenance cost	Increased electricity sales per unit investment	Increased income from unit investment
1	Lifting line N-1	25.57	18.33	10.00	9.62	15.95
2	Eliminate line heavy overload	23.05	17.40	10.00	9.71	11.29
3	Meet the new load	22.00	24.90	10.00	9.74	14.15
4	Eliminate low voltage in substation area	15.00	24.20	10.00	9.51	17.49
5	Eliminate heavy overload of distribution transformer	13.50	21.28	10.00	9.73	14.83

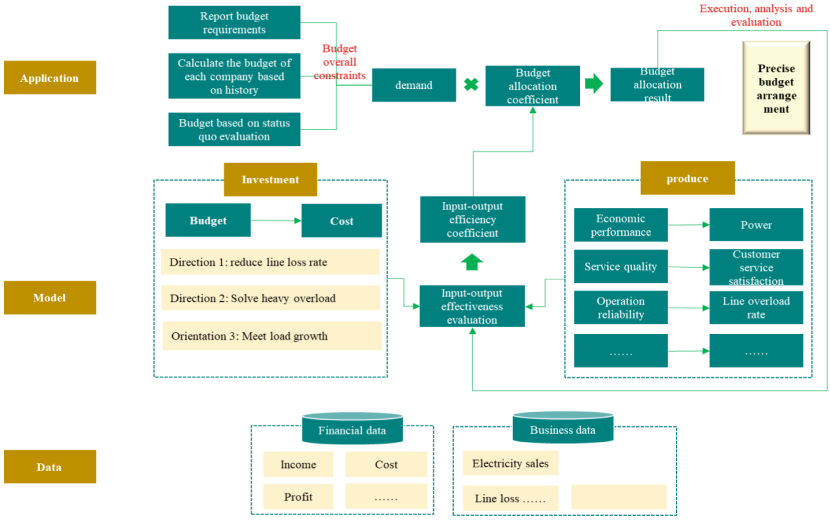

Fig. 5. Application ideas of investment benefit evaluation results

6 Conclusion

On the basis of the existing distribution network investment benefit evaluation, combined with the requirements of the current transmission and distribution electricity price reform, this topic constructs the investment benefit evaluation index system, and proposes the distribution network project investment benefit evaluation method, which provides a basis for the calculation of investment benefit. After verification, the model has strong practicability, which provides a quantitative analysis method for the investment benefit evaluation of distribution network projects, and also provides support for better adapting to the requirements of transmission and distribution electricity price reform, striving for favorable electricity price parameters, and better assisting the company in formulating investment strategies.

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