Analysis and Application of Investment Cost of 10 kV and Below Power Grid Infrastructure Projects

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Abstract. Under the influence of foreign economic slowdown, internal transmission and distribution price reform, the company's main business profit is under pressure, and its operation and management are facing new challenges. In order to reduce the uncertainty caused by decision-making, lean management of State Grid investment needs to be implemented quickly. In recent years, the investment scale of distribution network is increasing year by year, but the allocation and use efficiency of its investment resources lack a means of pre-control to post-evaluation. Starting from the analysis and application of investment balance level, this project takes power grid infrastructure projects of 10 kV and below as the research object, carries out analysis on the proportion of investment structure, investment balance and investment cost level, and forms the parameter standard of pre-control and post-evaluation of investment. Through the construction of investment multi-business application scenarios, Support distribution network project investment plan preparation, feasibility study/initial design review, investment process control, support the realization of the company's efficiency and benefit goals under the constraints of limited investment resources.

Keywords: 10 kV and below power grid infrastructure project · Investment balance · Pre control and post evaluation

1 Research Background and Objectives

Under the influence of the external economic environment, and the growth of electricity slowed down. At the same time, the introduction of external policies such as the transmission and distribution price reform and the market-based reform of the on-grid price for coal-fired power generation has compressed the company's profit margin. Under the severe internal and external environment, the company's investment efficiency pressure highlights. In addition, in recent years, the investment scale of the distribution network has been increasing year by year, but the allocation and use efficiency of investment resources lack a check means from pre-control to post-evaluation. In order to strengthen

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the precise management and control of investment execution process, allocate investment resources scientifically, and improve investment efficiency, it is urgent to explore the dynamic monitoring method of 10 kV investment check, and support the precise management and control level of distribution network project investment process. This paper takes the power grid infrastructure project of Zhejiang Lishui Company of 10 kV and below as the research object. By collecting sample data, it analyzes the proportion of investment structure, investment balance and investment cost level, forms the parameter standard of investment control before and evaluation after, and constructs the investment check and dynamic prediction and early warning model. Support distribution network project investment plan preparation, feasibility study/initial design review, investment process control, investment post evaluation and other work, improve investment precision and resource use efficiency.

2 Research Ideas and Methods

According to the above objectives, the research ideas of this topic are determined as shown in Fig. 1.

According to the research objectives and ideas, the definitions and algorithms of multidimensional attributes, investment balance rate, investment control coefficient and unit cost level involved in the analysis and research process are described:

First, the definition of multidimensional attributes of the project. Multidimensional attributes refer to different construction properties (new construction, reconstruction), different project types (cable lines, overhead lines, overhead cable mixing, distribution and transformation cable mixing, distribution and transformation overhead cable mixing, distribution and transformation overhead mixing, distribution and transformation projects), different terrain (flat land, hilly land), and different regions (urban areas, rural areas). Among them, there is no standard classification method for determining the project type. In combination with the practical experience of experts, it is necessary to determine the category according to the proportion of budget estimates of three types of

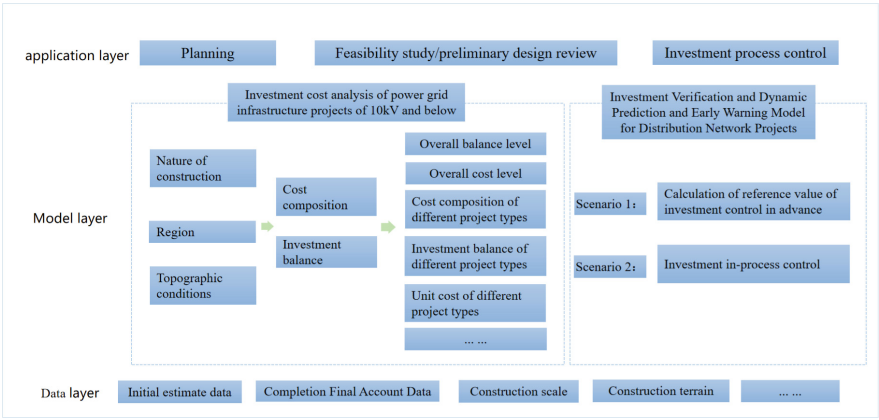

Fig. 1. Investment Execution Analysis and Evaluation System

Table 1. Example of project classification. Unit: Ten thousand yuan, %

entry name	Project estimate				Cost proportion			Project classification
	Power distribution station	Overhead line	Cable	Total	Power distribution station	Overhead line	Cable	
Power line landing project	188.39	11.96	187.82	388.17	48.53%	3.08%	48.39%	Distribution transformer cable mixing
Public transformer and low-voltage line construction project	55.10	4.82	140.13	200.05	27.54%	2.41%	70.05%	Distribution transformer cable mixing
Newly built 10 kV transformer for inspection	19.08	2.47	0.33	21.88	87.20%	11.29%	1.51%	Distribution transformer project
**110 kV Yanquan substation 10 kV outgoing line transformation project	5.08	364.98	2.90	372.96	1.36%	97.86%	0.78%	Overhead line works

monomer projects, namely, distribution substation, overhead line and cable line, in the budget estimate document of distribution network projects. The criterion is whether the proportion of monomer reaches or exceeds 85%. When the proportion of the cost of a certain type of monomer exceeds 85%, the project is classified as this type of monomer, and the proportion of budget estimates of two types of monomer accounts for more than 85%, The project is classified as a mixture of two types of monomers (Table 1).

Second, the definition and algorithm of investment balance rate. The investment balance rate refers to the saving ratio of the project final accounts compared with the budget estimates.

Balance rate of a county company = $(\sum_1^n$ Budgetaryestimate $-\sum_1^n$ Finalsettlementincludingtax$)/\sum_1^n$ Budgetaryestimate.

(Where, n is the number of sample items included in the county company.)

Third, tInvestment control coefficient algorithm.

Investment control coefficient = 1 - investment balance rate.

Fourth, Unit cost level algorithm.

Unit distribution transformer cost level = final settlement of distribution transformer project completion/actual construction distribution transformer scale;

Unit overhead line cost level = final settlement of distribution and transformation project completion/actual construction distribution and transformation scale;

Cost level of unit cable line = final settlement of distribution transformer project completion/actual construction distribution transformer scale.

3 Analysis on the Investment Cost of Power Grid Infrastructure Projects of 10 kV and Below

Select the distribution network projects that have been completed and put into operation in a certain year, extract the final account statements of sample projects in the ERP system, the preliminary design budget estimate and other relevant data in the power supply service system, and analyze the distribution network investment parameters from the aspects of overall sample analysis, cost composition, investment cost balance of different types of projects, and unit cost level. The specific research ideas are as follows:

3.1 Sample Description

The total static investment of the sample project budget is 131.77 million yuan, the dynamic investment is 132.4 million yuan, and the dynamic investment of the final account is 121.96 million yuan (8% less than the total estimate). The details are shown in Table 2.

The sample projects are divided into 7 categories: cable route, overhead line, overhead cable mixing, distribution transformer cable mixing, Mixed overhead cables of distribution transformer, Distribution transformer overhead hybrid and transformer distribution engineering. The sample situation is shown in Table 3.

Table 2. Statistical table of the overall situation of the sample. Unit: Ten thousand yuan, %

Process	Budgetary estimate	Final accounts	Increase/decrease	Remarks
Static total investment	13177			
Dynamic investment	13240	12196	-8%	(Final accounts-Dynamic investment)/Dynamic investment
Length of new overhead lines	228.5	264.1	16%	From the final statement of completion
New cable line length	31.6	27.9	-12%	From the final statement of completion
Number of additional/replacement transformers	73.0	74.0	1%	From the final statement of completion
Increase/change the capacity of distribution transformer	30.1	30.1	0%	From the final statement of completion

Table 3. Proportion of Different Project Types. Unit: Numbers, %, Ten thousand yuan

Single project	Number	Proportion	Dynamic investment	Final accounts
Cable route	40	41%	2624	2423
Overhead line	17	17%	4165	3724
Overhead cable mixing	16	16%	1248	1106
Distribution transformer cable mixing	10	10%	655	576
Mixed overhead cables of distribution transformer	9	9%	4344	4180
Distribution transformer overhead hybrid	6	6%	205	187

Note: the classified method of distribution network project type top, need according to the actual name of the project, the construction scale and item to determine the level of cost, the judgment standard of cost accounting for more than more than 85%

3.2 Analysis of Cost Composition

According to the structure of the budget estimate, it can be divided into four expenses: construction cost, installation cost, equipment purchase cost and other costs. The proportion of expenses is as follows: installation cost accounts for 42%, equipment purchase cost accounts for 32%, construction cost accounts for 16%, and other costs account for 10%.

Among them, other expenses mainly include construction site requisition and clean-up fees, project supervision fees, preliminary project fees, survey and design fees, production preparation fees, loan interest during the construction period and others. It is found that the production preparation cost basically does not occur; The interest on loans during construction is only about 1%; About 2% of the pre-project cost; Construction site requisition and cleaning expenses accounted for about 16%; Engineering supervision expenses accounted for about 18%; Survey and design expenses accounted for 46%. From the point of view of different construction properties, there are differences in the cost composition of various types of projects. Other new construction projects are mainly based on equipment purchase and installation costs, while reconstruction projects are mainly based on installation costs, and other expenses account for about 10% regardless of construction or reconstruction (Table 4).

3.3 Analysis of Investment Balance

The dynamic investment of sample projects was 132.4 million yuan, and the final investment was 121.96 million yuan, which was 10.44 million yuan less than the estimated budget. The overall balance rate of sample projects was 8%.

Table 4. Four fee structure with different construction properties

Nature of construction	Final accounts (Tax included)				Final accounts (Tax excluded)			
	Architecture	Install	Purchase	Other	Architecture	Install	Purchase	Other
Newly project	18%	26%	48%	8%	18%	27%	46%	9%
rebuild project	14%	57%	18%	11%	14%	58%	18%	11%

From the perspective of project types, above the average balance rate level (8%), there are transformer overhead cable mix (12%), transformer cable mix (11%), transformer overhead cable mix (11%) and transformer overhead mix (9%).

From the perspective of construction nature, 35 new projects were built, with dynamic investment of 64.59 million yuan in the budget estimate and final investment of 60.42 million yuan, 4.17 million yuan less than the budget estimate, and the balance rate was 6%. There were 63 reconstruction projects with dynamic investment of 67.81 million yuan in the budget estimate and final investment of 61.53 million yuan, which was 6.28 million yuan less than the budget estimate, and the balance rate was 9%. Overall, the balance of reconstruction projects is greater than that of new projects.

From the perspective of the nature and type of construction items, the balance of new construction category of cable line, overhead line, overhead cable mixture, distribution and overhead mixture is lower than that of reconstruction category, and the balance level is lower, within 12%. However, the balance of newly built projects of mixed power distribution and transformer cable and mixed power distribution and transformer overhead cable is about 20%, much higher than the balance of reconstruction projects (5%).

3.4 Unit Cost Level Analysis

According to the summary of sample data, the overhead line project of 10 kV and below is 148 km, with the investment of 19.83 million yuan, and the average cost per unit length of the line project is 290,000 yuan/km. The cable line project of 10 kV and below is 25 km, with investment of 26.23 million yuan, and the average cost per unit length of the line project is 900,000 yuan/km.

① overhead lines:

Different construction properties: the cost level per unit length of new and reconstruction projects is 270,000 yuan/km and 290,000 yuan/km respectively, with an average of 280,000 yuan/km.

Different regions: the average unit length cost level of urban and rural projects is 240,000 yuan/km and 290,000 yuan/km respectively, and the unit cost level of urban areas is lower than that of rural areas.

Different terrain conditions: the average unit length of the flat and hilly projects is 150,000 yuan/km and 330,000 yuan/km respectively, with an average of 240,000 yuan/km.

② cable lines:

Different construction properties: there are only newly built projects in the samples, and the average cost level per unit length is 896,000 yuan/km.

Different regions: Since the samples are only urban projects, the average cost level per unit length of the ontology is 900,000 yuan/km.

Different terrain conditions: The average unit length of the 10 kV and below cable line project is 900,000 yuan/km.

3.5 Summary of Investment Cost Analysis

Based on the above analysis, with the project type as the main analysis dimension, three parameters of cost composition, investment balance and unit cost level are obtained:

overall balance/cost level;

① overall investment balance of the company. This parameter standard will be used in the company's allocation investment plan, which can reduce the investment demand according to the balance level of the historical sample projects. Second, the company's overall unit cost level. The parameter standard can calculate the total investment of the project according to the company's investment construction scale.

② Project type parameter 1 is cost composition parameter. The expense composition of different constructive project types can be applied to evaluate the proportion of the overall four expenses of the company to determine the rationality of the overall expense composition (Tables 5 and 6).

4 Model Construction and Design

4.1 Business Scenario Design

Based on the measurement results of sample projects, the application scenario design was carried out.

First, advance control of auxiliary investment. Prior management and control of distribution network projects, mainly including feasibility study scale review, application

Table 5. Cost composition of different project types and different construction nature

Project Type	Newly project				Rebuild project			
	Architecture	Install	Purchase	Other	Architecture	Install	Purchase	Other
Cable route	20%	12%	63%	6%	19%	53%	19%	9%
Overhead line	21%	58%	7%	13%	12%	64%	11%	12%
Overhead cable mixing	14%	44%	32%	10%	18%	55%	15%	13%
Distribution transformer cable mixing	15%	34%	42%	9%	1%	57%	34%	7%
Mixed overhead cables of distribution transformer	20%	44%	24%	12%	6%	34%	53%	7%
Distribution transformer overhead hybrid	9%	47%	35%	9%	5%	63%	17%	15%

of unit cost investment to estimate the total investment, and judgment of the rationality of the total investment; The investment balance is used to set the investment control coefficient and determine the total investment of the project.

Second, auxiliary investment is controlled in the process. Compare the implementation of distribution network investment with the progress of entry, and give early warning for projects exceeding the reasonable deviation threshold.

4.2 Business Model Construction

Construction of distribution network project investment check and dynamic prediction and early warning model based on investment cost analysis (Fig. 2).

Reference value of total investment = length of overhead line * average cost per unit length of line project + length of cable line * average cost per unit length of cable project + capacity of distribution transformer * average cost per unit length of distribution transformer project.

Model function 2: ②–③: use the reference value of total investment estimated by unit cost to evaluate the rationality of the feasibility study estimate. According to the management requirements, a 10% interval between the total investment in the feasibility study and the estimated total investment is set. If the deviation between the total investment in the feasibility study/budget estimate and the estimated total investment exceeds ±10%, the total investment in the feasibility study is considered unreasonable. Since the investment plan is issued based on the feasibility study estimate, the total investment needs to be corrected.

Model function 3: ③–④: according to the investment balance rate of each detailed cost (construction engineering, installation engineering, equipment purchase cost and

Table 6. Balance of four new projects of different project types

Project Type	Balance rate							
	Newly project				Rebuild project			
	Architecture	Install	Purchase	Other	Architecture	Install	Purchase	Other
Cable route	-14%	-29%	4%	42%	23%	7%	-1%	31%
Overhead line	18%	4%	-13%	3%	19%	3%	3%	23%
Overhead cable mixing	-65%	-19%	23%	55%	6%	9%	21%	19%
Distribution transformer cable mixing	51%	14%	5%	30%	70%	-23%	20%	17%
Mixed overhead cables of distribution transformer	38%	10%	19%	20%	-3463%	-9%	14%	46%
Distribution transformer overhead hybrid	-25%	11%	4%	18%	20%	9%	1%	17%
Subtotal	-4%	-10%	8%	42%	13%	3%	14%	23%

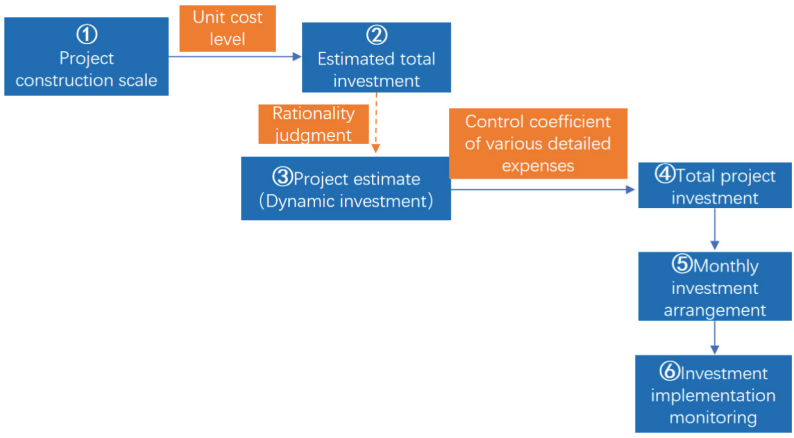

Fig. 2. Distribution network investment check and dynamic prediction and early warning model Model function1:①–②: Estimated total investment. According to the project attribute characteristics, match the cost level of unit capacity and unit line length, and estimate the reference value of the total investment of the project according to its construction scale. The calculation formula is as follows:

other costs), set the investment control coefficient of each detailed cost, and determine the total investment of the project, which is the basis for issuing the investment plan.

Total investment of the project = construction cost * (1-investment balance rate of construction cost) + installation cost * (1-investment balance rate of installation cost) + equipment purchase cost * (1-investment balance rate of equipment purchase cost) + other costs * (1-investment balance rate of other costs).

Model function 4: ④–⑤: forecast the monthly investment plan of the whole life cycle of the project. Take the determined total investment of the project as the basis for the prediction of the monthly investment plan for the whole life cycle of the project. According to the completion law of the monthly investment plan, predict the completion of each month's investment for the whole life cycle of the project as the recommended value of the annual investment plan.

Model function 5: ⑤–⑥: investment execution monitoring. According to the key index data in the process of investment implementation of each project - reported investment completion value, material cost entry, service cost entry and other key process data, the corresponding tax rate of cost data is restored as the true investment completion number, and the deviation analysis is conducted with the reported investment completion number and monthly predicted investment completion number. According to the deviation threshold standard (tentative 10%), whether the project has investment implementation risk is determined, for projects with investment execution risks, the alert results are displayed.

4.3 Model Validation

The first batch of supporting projects of a city's "photovoltaic well-off" 10 kV power grid are selected. The construction nature is reconstruction, the construction scale is

Table 7. Full life cycle monthly investment plan. Unit: % Ten thousand yuan

Month	Forecast investment progress	Estimated completed investment
2021.05	5%	14.57
2021.06	11%	32.05
2021.07	15%	43.71
2021.08	16%	46.62
2021.09	17%	49.54
2021.10	18%	52.45
2021.11	18%	52.45
total	100%	291.40

33.22 km of overhead lines, the project area is rural, and the terrain characteristics are comprehensive terrain. The feasibility study estimate is 2.9463 million yuan, and the commencement date is May 2021.

Model function 1: ①–②: Estimate the total investment. According to the unit cost level (the unit line cost length of overhead line project under comprehensive terrain is 88100 yuan/km), the total investment is estimated to be 3083600 yuan (the unit cost is 92800 yuan/km * the line length is 33.22 km).

Model function 2: ②–③: judge the rationality of project feasibility study/budget estimate. Comparing the estimated investment scale with the estimated amount, the deviation rate is 4.66%, lower than 10%, and the feasibility study estimate is reasonable.

Model function 3: ③–④: Determine the total investment of the project. According to the feasibility study estimate of various detailed costs of the project (16000 yuan for construction projects, 1695800 yuan for installation projects, 998900 yuan for equipment purchase and 372300 yuan for other costs) and the investment balance rate (19% for construction projects, 3% for installation projects, 3% for equipment purchase and 23% for other costs), the specific calculation shows that the total investment is 1.67 * (1–19%) + 169.58 * (1–3%) + 99.89 * (1–3%) + 37.23 * (1–23%), and the total investment is determined to be 2.914 million yuan.

Model function 4:④–⑤: forecast the investment in the whole life cycle of the project. According to the monthly construction law of the distribution network project, the monthly investment completion in the whole life cycle is predicted. See Table 7 for details.

Unit:Ten thousand yuan

Basic information of the project												Entry cost	Investment completion			Deviation		Deviation Alert Results	Alert Description
Num.	Project	Region	Terrain	Reconstruction	Project type	Commencement date	Current time	Release investment	Budgetary estimate	Report investment	Investment forecast value		Total	Service	Material	Deviation between reported investment and returned investment	Deviation between entry progress and predicted value		
1	"Photovoltaic well-off" 10kV power grid supporting project in 2021	rural	comprehensive	reconstruction	Overhead line	2021.05	2021.08	308.36	308.36	105.00	90.33	74.40	89.12	55.10	34.02	-17.82%	17.63%		The deviation between the reported investment and the returned investment and the deviation between the recorded progress and the predicted value exceed 10%

Fig. 3. Example of early warning model during investment

Model function 5: ⑤–⑥: investment execution monitoring. An alert is displayed when the progress deviation exceeds the set threshold range. The actual investment progress of the project deviates too much from the investment completion after the return, and from the predicted investment progress, so an early warning is displayed. See the Fig. 3 for specific data.

5 Conclusion

This paper collects the annual investment, cost entry and other data of 10 kV and below power grid infrastructure projects of Lishui Power Supply Company, and carries out the analysis of the proportion of four costs of different types of projects, the analysis of investment balance, and the analysis of unit cost level. On the one hand, it grasps the management status of 10 kV and below power grid infrastructure projects, and on the other hand, it lays a foundation for the construction of the distribution network investment verification scenario. On the basis of fully applying the analysis data, we will build an "in advance" and "in the process" application model to assist investment decision-making and improve the level of lean management.

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