Research and Demonstration on Automatic Generating Algorithm of Distribution Network Investment Statistics

Peng An¹, Jian Zhang², Jiaguo Liu³, Guoming Liu⁴, Peng Rong⁵, Laizhi Shan⁶, Qing Wang⁷, Caiyang Yue⁸, Baijian Yu⁹, Wei Zhang¹⁰

Jian Zhang², State Grid Corporation of China, Beijing, 100000, China
Peng An¹, Caiyang Yue⁸, Baijian Yu⁹, State Grid Shandong Electric Power Company, Jinan, Shandong Province, 250000, China
Jiaguo Liu³, Guoming Liu⁴, Peng Rong⁵, Laizhi Shan⁶, Qing Wang⁷, Wei Zhang¹⁰, State Grid Shandong Electric Power Company Taian Power Supply Company, Taian, Shandong Province, 271000, China
Peng An’s e-mail: 12536060@qq.com

Abstract. The statistics and guarantees of the investment completion data of the current distribution network infrastructure projects still use the traditional offline manual calculation method which lacks objective and unified calculation standards. Meanwhile, the number of distribution network infrastructure projects is large, the single investment amount is small, the completion of investment is a large workload, and the accuracy, objectivity and timeliness are poor. It is difficult to adapt to the external investment supervision, the authenticity of statistical data and the objective needs of the development of big data technology. Taian Power Supply Company actively explores the application of information technology to automatically calculate the algorithm of distribution network investment statistics, unifies the calculation standard of investment completion of distribution network projects, improves the quality of statistical data of distribution network investment, and improves the lean management level of distribution network investment.

1. The problems of distribution network investment statistics

Grid enterprises recently face the reform of transmission and distribution prices, and grid investment is subject to strict external supervision. Due to the increasing quality requirements of investment statistics, the distribution network investment statistics work put forward higher requirements. In recent years, the investment in distribution network projects has been increasing year by year, and the amount of distribution network projects is small and the number is large. Therefore, there are still many difficulties in the statistics of distribution network investment, which can be reflected in the following aspects:

(1) The investment statistics of distribution network projects still use the traditional offline manual submission method, and the traditional reporting method has a large workload;

(2) Due to the large number of cities and counties involved in the distribution network project, there is a lack of scientific and unified calculation standards for the investment statistics of distribution network which is subjected to subjective interference and the quality of statistical data;
Some local and municipal companies have submitted the distribution investment amount of the distribution network according to batch packaging, and the management granularity is relatively coarse, which is difficult to adapt to the current lean management requirements of distribution network investment. Therefore, it is necessary to make full use of the current mature technical means to explore a scientific and effective method to solve the problems of large workload, low efficiency, slow update speed and low accuracy in the completion of manual statistics and submission of distribution network investment. By standardizing the calculation method of unified investment project engineering investment statistics to avoid the interference of subjective factors, realize the "complete basis" for investment completion, improve the statistical data quality of distribution network investment, assist the accurate decision-making of power grid investment and promote the high-quality development of the company's power grid.

2. The calculation method of fixed assets investment amount of distribution network infrastructure projects

The distribution network is divided into high-voltage distribution network (35kV, 110kV) and medium-low voltage distribution network (10kV and below). According to the difference of high-voltage and medium-low voltage distribution network management, the medium and low-voltage distribution network is the research object, that is, the power supply infrastructure of 10kV and below project.

By analyzing and studying the total number of construction network projects, investment scale and construction period of the Shandong Power Supply Company in 2017, we find that the overall investment project of Shandong Company Distribution Network has the characteristics of single project, small investment and short construction period. It is different from the calculation method of fixed assets investment amount of the main network, which does not subdivide the four expense of construction engineering, installation engineering fees, equipment purchase fees and other expenses. Considering that in the engineering cost accounting process of the finance department, the material and service cost data is easy to obtain and the accuracy is high, the fixed asset investment amount of distribution network infrastructure projects can be calculated by distinguishing goods and services according to the integration of the distribution network investment statistics management requirements and the financial department ERP system engineering cost data.

Distribution network infrastructure projects can be divided into four phases: Pre-starting $T_0$, Start-up Month $T_1$, After-starting $T_{n-1}$, and Production Month $T_n$ (n is the number of months from project start-up to commissioning). To calculate the investment of fixed-line infrastructure projects, the specific algorithm diagram of each stage is as follows:

![Diagram of calculation method about fixed assets investment completion of 10kV and below power grid infrastructure projects](image)

Figure 1. Diagram of calculation method about fixed assets investment completion of 10kV and below power grid infrastructure projects

A. Pre-strating $T_0$
Since the investment statistics period of the distribution network infrastructure project starts from the start of the project, the fixed assets investment of the distribution network should not be calculated before the start of construction, the formula is as follows:

T_0 phase: FAI_0 = 0

Among them, FAI_0 indicates the completion of fixed assets investment before the start of construction.

B. Start-up month T_1

In the start-up month, using the calculation method that the accumulated cost of goods and services after tax reduction has been recorded into the investment amount in a lump sum to calculate the amount of fixed assets invested, the formula is as follows:

T_1 time: FAI_1 = MC * (1 + T_m) + SC * (1 + T_s)

Among them, FAI_1 indicates the amount of fixed assets investment in the start-up month;
MC indicates the material category cumulative cost since the beginning of the construction, the same below;
T_m indicates the comprehensive value-added tax rate of the material category, the same below;
SC indicates the service category cumulative cost since the beginning of the construction, the same below;
T_s indicates the comprehensive value-added tax rate of the service category, the same below;

The material category and service category cumulative cost since the beginning of the construction are taken from ERP system.

C. From the start of construction to the production month T_{2-n-1}

During the period from the start of construction to the production, the monthly fixed assets investment amount is calculated according to the accumulated cost of materials and services after the reduction of taxes, the formula is as follows:

T_{2-n-1} phase: FAI_{2-n-1} = MC * (1 + T_m) + SC * (1 + T_s)

D. In the month of production T_n

In the month when the distribution network project is put into operation, the fixed asset investment amount should be calculated according to the difference between the approved budget estimate and the accumulated completed investment amount, the formula is as follows:

T_n time: FAI_n = Approved Budget Estimate - ∑FAI_{1-n-1}

3. The implementation of automatic calculation system for fixed assets investment in distribution network

The automatic generation of distribution network investment data mainly comes from the planning system, PMS2.0 system and ERP system. By optimizing the management function of the investment report of the full-caliber full-process system distribution network infrastructure project. Automatically integrate the data engineering cost of the source system and the image progress data of the distribution network project, and automatically calculate the monthly investment completion value of the distribution network infrastructure project according to the above algorithm standard, and realize the automation, lean and intelligent of the investment statistics management of the distribution network infrastructure project. The specific system functional architecture is shown in Figure 2.

Automation——Optimizing the management function of the investment statistics report of the full-caliber full-process system distribution network infrastructure project according to the design research results of the amount of the fixed assets algorithm design in distribution network, to realize the automatically generating and regularly reporting of the monthly data of the distribution network investment statistics.

Lean——The distribution network investment statistics management work is managed by from project package to individual project management and the city company investment statistics special coverages to the district and county company full - time management to realize the lean management of distribution network investment management.
Intelligent——Based on the investment network statistical report management platform of the distribution network infrastructure project to add the function of automatic intelligent verification, warning prompts and multi-dimensional display about data results to realize intelligent and wisdom management of the distribution network investment statistics.

Figure 2. Function structure diagram of the automatic generation system for distribution network infrastructure project investment statistics

4. Empirical analysis
The monthly report of investment completed in Shandong is sent by the local market package, so the first batch of small towns (central villages) power grid transformation and upgrading project package in Taian County, Shandong Province is selected as an example for empirical analysis, the specific conditions of the project package are as follows:

The first batch of small towns (central villages) power grid reconstruction and upgrading project package in Taian County in 2017, which total planned investment is 74.451 million yuan includes 40 projects and 334 individual engineering. The project started to construct on March 28, 2017, and produced on November 30, 2017. As of December 31, 2017, there are 40 completed settlement projects which accounting for 100% of the total planned investment.

Calculating the mount of fixed asset investment in accordance with the single unit according to the new calculation methods, and comparing them with the actual investment completed by the project package. The specific calculation results are as follows:

Table 1. Fixed asset investment calculation results of the first batch of small towns (central villages) power grid transformation and upgrading projects in Taian county in 2017(unit: Ten thousand yuan)

| Month   | Actual reported investment completion | Automatic calculation investment completion | Difference amount | Difference rate |
|---------|---------------------------------------|---------------------------------------------|-------------------|----------------|
| March   | 1497                                  | 1200                                        | 297               | 20%            |
| April   | 3743                                  | 3034                                        | 709               | 19%            |
| May     | 4490                                  | 3732                                        | 758               | 17%            |
| June    | 5240                                  | 4416                                        | 824               | 16%            |
| July    | 5988                                  | 5369                                        | 619               | 10%            |
| August  | 5988                                  | 5581                                        | 407               | 7%             |
| September | 7485                               | 7027                                        | 458               | 6%             |
| October | 7485                                  | 7377                                        | 109               | 1%             |
As we can see from the table, the average difference rate between actual reported investment completion and automatic calculation of investment completion is 8%, as the month increases, the difference rate becomes smaller and smaller. The calculation results show that it is basically consistent with the actual situation, so the constructed automatic calculation algorithm of distribution network investment statistics has practical feasibility.

5. Conclusion
This paper takes the Taian Power Supply Company's distribution network infrastructure project as the research object, and focuses on the automatic generation algorithm and system realization path of the investment statistics of 10kV and below power grid infrastructure projects, realizing the automatic generation and reporting of fixed assets investment in distribution network, improving the accuracy, objectivity and timeliness of distribution network, and having significantly improved the efficiency and efficiency of distribution network investment statistics management.

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