Construction and Application Practice of Early Warning Model for Investment Progress of Electricity Grid Construction Projects

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Abstract. As the reform of transmission and distribution prices moves from the “construction mechanism” to the “strong supervision” stage, the authenticity and effectiveness of the grid investment plan implementation during the supervision cycle will definitely be the focus of external supervision. This will also directly affect the approval of the permitted revenue of grid companies in the next regulatory period. This paper takes the 110kV and above electricity grid construction projects as the research object, and constructs an early warning model for the progress of investment in electricity grid construction projects to identify and quantify the management and data problems existing in the project construction process, promote collaborative management of electricity grid construction projects and improve the authenticity and reliability of investment completion statistics.

1. Problems in the management of investment execution process of electricity grid construction projects
The current investment completion data reflecting the implementation of the annual investment plan of
the power grid has the phenomenon of “rising in the middle of the year and rising in the end of the year”. During the construction of the power grid project, there are also problems such as start-up and stoppage, continuous shutdown for 3 months and above, and actual construction period exceeding the reasonable construction period. The investment amount does not match the progress of infrastructure construction or financial accounting. However, due to the inability to obtain the full process data of the grid in time, the whole process management and control of electricity grid construction project lacks a strong grasp, and can not grasp the current situation of the project in a comprehensive and timely manner. And it is not conducive to the implementation analysis of the grid investment plan and the scientific adjustment of the mid-year plan. Therefore, it is urgent to change the management mode of investment execution process of electricity grid construction projects to improve the lean management level of power grid companies.

2. Thoughts on the construction of the risk early warning model for the electricity grid construction project investment completion

The 110kV and above electricity grid construction projects are the research objects. Matching rate of project construction progress, investment completion progress and cost accounting progress is the control handle. Based on the big data of the whole process development, construction, finance and other departments of the electricity grid construction project, identify the key risk factors that may exist in the whole process of the electricity grid construction project, clarify the risk factor identification and quantitative rules, and construct the early warning model of the investment completion progress risk of the electricity grid construction project. Quantify the risk management level of electricity grid construction project investment management, identify the risk status of the electricity grid project in batches, quickly and accurately, and adjust the "basis" in the mid-year investment plan to improve the efficiency and efficiency of investment management of electricity grid construction projects. The specific model construction ideas are as follows:

(1) Data collection. Collect data on the whole process of power grid engineering with voltage levels of 110kV and above, including project attributes, project construction progress, cost accounting, investment completion, actual and planned start-up time, actual and planned production time, etc.

(2) Risk factor identification. Analyze and screen comprehensive indicators and factors that can comprehensively reflect the coordinated management of electricity grid construction projects, as a key risk factor for identifying investment schedule management of electricity grid construction projects.

(3) Risk quantification. Comprehensively judge each risk factor and develop a discriminating rule for identifying each risk element. Risk scoring of grid infrastructure projects based on quantitative score tables. According to the risk score, the risk of the project is divided into three levels: high, medium and low, and the red, yellow and green signals are output respectively.

(4) Empirical Analysis and Application. Apply the above-mentioned model risk quantification rules to the project of 110 kV and above power grid construction in a certain city, measure the risk of the power grid project, and verify and analyze the rationality of the rules.
3. Constructing an early warning model for investment schedule risk of electricity grid construction projects

3.1 Identify risk factors
Through the investigation of the power grid infrastructure project management professional departments, understand the key problems in the project management process of the whole process of power grid infrastructure construction, infrastructure construction, finance and other departments, and use these issues as key risk factors for identifying the progress management of power grid project investment.

Firstly, it analyzes and screens comprehensive indicators that can comprehensively reflect the development of grid infrastructure projects, infrastructure and finance departments—that is, report the matching of "investment completion progress" of development department with "project construction progress" of infrastructure construction department and "cost entry progress" of financial department.

Secondly, comprehensive consideration of typical problems existing in the project construction process, including continuous shutdown for more than 3 months, overdue projects, etc. Projects with such problems are also focused on projects that are adjusted during the mid-year investment plan.

Thirdly, considering that some city power supply companies have completed the annual comprehensive plan indicators, there is a steep increase in investment completion at the end of the year. Therefore, the Development Department’s Statistics Department is more concerned about the completion of the fourth quarter investment completion project.

Finally, considering the current situation of external regulatory tightening, the project is mainly focused on external auditing, and it is also one of the key risk factors for identifying the progress management of grid project investment.

In summary, the investment completion schedule is matched with the construction and financial accounting progress, the continuous shutdown for more than 3 months, the overdue project, the completion of the investment in the fourth quarter, and whether the external audit focuses on the project, etc. Using the above as a key risk factor for identifying the progress management of grid project investment.

3.2 Identify risk factor rules
According to the above identified key risk factors, based on the whole process data of the electricity grid construction projects of the development, construction, finance and other departments, the risk factor identification rules are formulated. The specific identification rules are as follows:
3.2.1 Matching of Investment Reporting with Construction and Financial Progress

Based on the overall progress of the electricity grid construction project, construction progress, investment completion progress, and cost accounting progress data to identify the progress of the submitted investment and the mismatch between the construction and financial progress. Differentiate between the two cases that have been put into production and not put into production, and determine the identification rules of the elements separately.

(1) Projects already in production

For projects already put into operation, when the cumulative investment progress, cumulative accounting progress, and cumulative construction progress satisfy the following judgment conditions at the same time, the investment progress matches the construction and financial progress, otherwise, the investment progress does not match the construction and financial progress. The specific rules are as follows:

a. The cumulative investment progress since the start of construction is between [95%, 110%].

b. Since the cumulative accrual progress is greater than or equal to 60%.

c. The cumulative construction progress since the start of construction is greater than or equal to 80%.

(2) Uninvested project

For unfinished projects, only when the following investment progress and construction progress verification rules, investment progress and financial entry progress verification rules are met at the same time, can the investment progress be mismatched with the construction and financial progress. The specific identification rules are as follows:

a. Investment schedule and construction progress do not match identification rules.

i. The actual construction progress ≤30%, and | (Actual investment completion progress - Actual construction progress) | = Construction deviation rate > [10%]. If this rule is met, this project is a project that does not match the investment progress and construction progress.

ii. The actual construction progress >30%, and | (Actual investment completion progress - Actual construction progress) | = Construction deviation rate > [50%]. If this rule is met, this project is a project that does not match the investment progress and financial progress.

b. Investment progress and financial accounting progress do not match identification rules.

i. The actual construction progress ≤30%, and | (Actual investment completion progress - Actual accounting progress) | = Financial deviation rate > [10%]. If this rule is met, this project is a project that does not match the investment progress and financial progress.

ii. The actual construction progress >30%, and | (Actual investment completion progress - Actual accounting progress) | = Financial deviation rate > [50%]. If this rule is met, this project is a project that does not match the construction progress and financial progress.

3.2.2 Overdue project

If the actual construction period (month) of the electricity grid construction project exceeds the reasonable construction period of the conventional new power transmission and transformation project specified by the State Grid Corporation's power transmission and transformation project schedule management method for more than 6 months, it is judged to be the overdue project. The specific overdue engineering judgment rules for power transmission and transformation projects of different voltage levels are:

i. 110(66)kV: (Current month - Actual project start date) > [19 months];

ii. 220(330)kV: (Current month - Actual project start date) > [22 months];

iii. 500kV: (Current month - Actual project start date) > [24 months];

iv. 750kV: (Current month - Actual project start date) > [25 months].
3.2.3 Continuous shutdown for more than 3 months
Based on the monthly data of the actual construction progress of the electricity grid construction project, the impact of winter construction will be removed, and check whether there are continuous shutdowns for 3 months and above during the period from April to December.

3.2.4 The completion of project investment may suddenly increase in the fourth quarter
To determine whether the completion of project investment has suddenly increased in the fourth quarter, the specific identification rules are as follows:

- The actual construction progress ≤30%, and if (The investment plan is issued at the beginning of the year - The cumulative investment is completed this year - The project budget estimate × The theoretical investment completion monthly growth rate (5%) × The remaining forecast month) > 0. If this rule is met, the completion of project investment may suddenly increase in the fourth quarter.
- The actual construction progress >30%, and if (The investment plan is issued at the beginning of the year - The cumulative investment is completed this year - The project budget estimate × The theoretical investment completion monthly growth rate (25%) × The remaining forecast month) > 0. If this rule is met, the completion of project investment may suddenly increase in the fourth quarter.

The above-mentioned theoretical investment completes monthly growth rate is initially determined according to typical projects. The specific calculation rules are as follows:

- If the project equipment cost has been accounted for, the monthly growth rate of the theoretical investment in the above identification rules is calculated according to [5%].
- If the project equipment cost is not recorded, the monthly growth rate of the theoretical investment in the above identification rules is calculated according to [25%].

3.2.5 Projects focused on external audit
For the nature of the project, “three districts and two states” deep poverty, national poverty counties, coal-to-electricity, winter Olympics and other types of projects, which are the focus of external audit projects.

3.3 Risk quantification score and rating
For the degree of mismatch between the submitted investment progress and the infrastructure and financial progress, the risk amount is divided into five grades according to the amount of deviation of the reported investment amount and the investment collection value (automatically generated value of investment completion). After identifying the above risk factors, formulate investment progress risk early warning scoring rules. The specific risk scoring rules are shown in Table 1:

| Serial number | Risk factors                                                                 | Risk score |
|---------------|-----------------------------------------------------------------------------|------------|
| 1             | The degree of mismatch between investment completion progress and construction progress and financial progress |            |
|               | 0 to 1 million yuan (including 1 million yuan)                              | 0 marks    |
|               | 1 to 5 million yuan (including 5 million yuan)                              | 1 marks    |
|               | 5 to 30 million yuan (including 30 million yuan)                            | 2 marks    |
|               | 30 to 50 million yuan (including 50 million yuan)                           | 3 marks    |
|               | More than 50 million yuan                                                  | 4 marks    |
| 2             | Overdue project                                                             | 2 marks    |
| 3             | Continuous shutdown for more than 3 months                                  | 2 marks    |
| 4             | May become a tail-raising project in the fourth quarter                     | 2 marks    |
| 5             | Projects focused on external audit                                         | 3 marks    |
Calculate the risk factor scores for each project. The project risk score is divided into three levels: low, medium and high, of which 3 points and below are low risks, 4 to 7 are classified as medium risks and 8 points and above are high risks. The risk rating rules are shown in Table 2.

| Risk level | Lower limit | Upper limit |
|------------|-------------|-------------|
| Low        | 0           | 3           |
| Medium     | 4           | 7           |
| High       | 8           | 14          |

4. Empirical analysis

Select Suzhou Power Supply Company in Jiangsu Province to conduct empirical analysis. The total number of 110kV and above electricity grid construction projects included in the 2018 investment plan of the local power supply company is 147, excluding 33 projects already put into operation, and the number of electricity grid construction projects involved in the calculation is 114. According to the above rules, the model automatically generates a list of investment progress risk of the electricity grid construction project (see Figure 2 for an example), and feeds the measurement results back to the relevant departments of development, construction, finance, etc. All departments are requested to verify the accuracy of relevant basic data, and analyze the rationality of the model calculation results according to the actual construction of the project to verify the applicability of the set rules.

Figure 2. Electricity grid construction project investment schedule risk warning example

According to the investment schedule risk of the above-mentioned electricity grid construction projects, 81 projects with a construction cost of 110kV and above are not matched with the construction and financial progress, accounting for 55% of the total number of electricity grid construction projects of 110kV and above. The statistics on the number of overdue, continuous shutdowns over 3 months and tail-raising projects in the fourth quarter are shown in Table 3 below.

Table 3. Statistical table of various problems of 110kV and above electricity grid construction projects

| Question type | Number of projects | Proportion of total electricity grid construction projects of 110kV and above |
|---------------|--------------------|--------------------------------------------------------------------------------|
|               |                    |                                                                                |
| Investment progress does not match construction progress and financial progress | 81 | 55% |
|---|---|---|
| Overdue project | 3 | 2% |
| Continuous shutdown for more than 3 months | 72 | 49% |
| May become a tail-raising project in the fourth quarter | 2 | 1% |
| External key audit project | 0 | 0% |

It has been verified that the results measured by the model can basically reflect the current status of the current electricity grid construction projects. The distribution of project problems is in line with the actual situation of the Suzhou Power Supply Company. The model is usable, and its early warning results can provide investment decision support for development, construction, finance and other departments, and support investment plan execution analysis and mid-year plan adjustment.

5. Conclusion
This paper takes the electricity grid construction project of 110kV and above as the research object, and focuses on the early warning solution for investment schedule risk of 110kV and above electricity grid construction projects. This paper studies the construction, finance and investment progress of the project, constructs the early warning model of the progress risk of the power grid infrastructure project, improves the coordination level of the development, finance, construction, materials and other departments, innovates the statistical monitoring means of the power grid infrastructure project investment, standardizes the submission of the investment completion, improves the quality of the statistical data of the power grid infrastructure project investment, and significantly improves the efficiency and efficiency of the investment management.

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