Research on Dynamic Monitoring and Control of Power Grid Infrastructure Project Based on Investment Progress Model

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Abstract. China's economy has entered a period of new normal, the medium-to-high growth of economy still promotes the increase of power load, so that the investment scale of power grid infrastructure projects is continuously expanding. Improving the level of project investment management is the key point to control the total project investment. This paper investigated the current situation of power grid project investment management. Built a reasonable investment progress model through big data mining and k-means clustering algorithm. Designed an early warning control system to realize the dynamic monitoring and control of the whole process of power grid infrastructure project based on the investment progress model.

Keywords: power grid infrastructure project, investment progress model, investment management.

1 Introduction

In recent years, China has made a series of major strategic arrangements and requirements to deepen the reform of state-owned enterprises, deepen the reform of the power system and strengthen the supervision of state-owned assets. It has fundamentally changed the original operation mode of power grid enterprises. Power grid enterprises will improve the efficiency and benefits of investment management through efficient control of power grid investment. There is an urgent need to study and build a dynamic investment monitoring and control system, so that the requirements of the contemporary era by rationally optimizing the progress of project investment and controlling the overall investment scale of companies. In addition, an early warning system should be established in conjunction with the key nodes of the project so as to facilitate the construction project to form effective assets as soon as possible and improve the overall input-output benefits of the grid projects.

Power grid infrastructure projects typically have the characteristics of large investment, lengthy construction time and high risk, so it is highly necessary to manage the investment plan, which can effectively control the investment risk and guarantee the investment income [1]-[3]. Traditional management and control of investment plans for power grid projects usually employ a broad, single-threaded management model. For example, investment plan preparation relies on manual experience which only focuses on the final completion. It does not pay attention to the whole process of the investment and cannot be applied to the investment plan management aiming at improving quality and efficiency [4]. Existing research mainly aim at the study of

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infrastructure project investment management analysis [5][6] and management digital information system [7][8]. Research and analysis about the model of investment plan are confined to assist annual investment plans [4][9][10]. The research about adjusting the investment during construction, monitoring and early warning the risk of complete the investment during the whole process are less.

To this end, this study constructs a dynamic monitoring and control system for power grid projects based on an investment progress model. It uses the historical project investment progress data, establish a reasonable investment progress model and formulate a reasonable project investment plan. Combined with early warning indexes, the system can comprehensively manage the investment plan of power grid projects, and further improve the 'refined, precise, lean' management level of power grid enterprises.

2 Construction of reasonable investment progress model for power grid infrastructure projects

In order to build a scientific, reasonable and practical investment progress model for power grid infrastructure projects, a typical construction period model is built by analyzing the historical construction and investment data. Through the typical construction period model of power grid infrastructure project, the reasonable investment progress, the start construction time and operation time of different types of power grid projects are determined.

2.1 Assumptions of model establishment

The establishment of the model is based on the following assumptions: (1) The investment of a project shall be arranged annually, and the investment plan for the next year shall be arranged at the end of each year. (2) The investment data is collected once a month. (3) The amount of work is proportional to the investment. (4) The new infrastructure project must have the estimated start construction time or the estimated operation time. (5) The project under execution must have an actual start time.

2.2 Data pre-processing

The sample database was established by selecting 110 (66) kV~750kV power grid infrastructure projects put into operation in recent 15 years (2008-2022). In order to ensure the representatives of the projects in the sample database, the initial sample database was processed: (1) The projects with incomplete information were excluded, including the projects with missing start construction time and operation time. (2) Excluding some projects with same start construction time and operation time, which are mainly repurchase projects. (3) Excluding projects with too long construction period: 110 (66) kV project is over 19 months, 220 (330) kV project is over 22 months, 500 kV project is over 24 months, 750 kV project is over 25 months.

2.3 Project investment progress model

Data-mining the typical project database, such as the start construction time and operation time, construction location, project category (main grid, urban network, rural network), property of construction (new construction, expansion, renovation, etc.), project type (power transmission and transformation project, substation project, transmission line project, etc.), progress of

investment (referring to the percentage of the construction project workload expressed in monetary form in the total project investment), etc.

Using K-means clustering algorithm to calculate the theoretical curve of investment for each type of project [11]. The steps of K-means algorithm to achieve curve clustering of power grid infrastructure projects are as follows:

Step1: Select k kinds of initial centers.

Step2: Start the iterative process, find the distance between any sample to k centers, and classify the sample into the center with the shortest distance.

Step3: Calculate the mean value to update the central value using formula (1).

$$c = \sum_n \sqrt{\|X_n - X_c\|_2} \tag{1}$$

Where c is the central value, n is the number of samples belonging to this kind. Xc is the mean value of the center sample to this kind; Xn is the nth sample.

Step 4: For all the clustering centers, after updating by the iterative method of step 2 and step 3, the central value converges and the iteration ends. Otherwise, the iteration continues.

2.4 Project investment progress curve

The project investment progress curve can be generated using this reasonable investment progress model as shown in Figure 1.

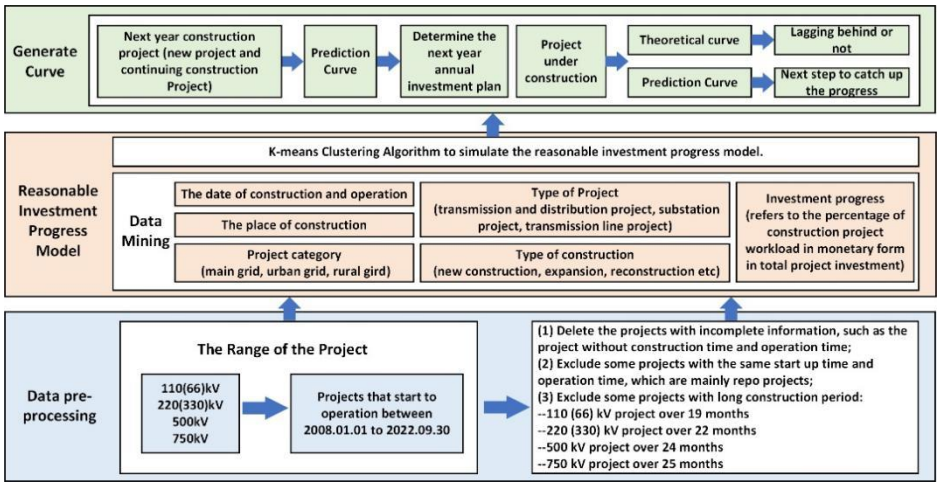

Fig. 1. The reasonable investment progress model

The reasonable investment progress model can generate prediction curve based on the fitted curve of the historical production project to assist in determining the investment plan of the next year. The model can also generate a theoretical curve to judge whether the investment schedule of the ongoing project is lagging and generate the prediction curve to tell the project what to do next in order to complete the construction in time.

3 Dynamic monitoring and control system

3.1 Dynamic monitoring mechanism

The system is using digital means to realize the dynamic monitoring and control of power grid infrastructure projects. The dynamic monitoring was conducted at monthly frequency. The monitoring and control system will track the progress data and calculate the indicators to make a notification.

3.2 Monitoring and control system

The management and control system mainly consists of three parts: the data layer, platform layer and application layer. These three layers have the functions of data access and preprocessing, the model of index analysis and display of analysis results.

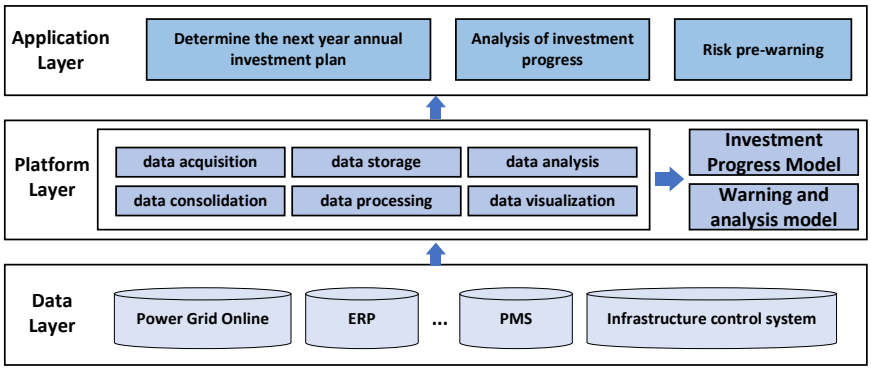

Fig. 2. Overall architecture of the system

1. Data access and preprocessing: Access the internal data of 'online power grid', ERP, PMS and other systems in the electric power enterprises. The project execution data, provides data basis for the calculation and analysis of monitoring and control indicators.
2. The model of index analysis: Based on the application of the reasonable investment progress model and the project execution data, the early warning index analysis model is constructed to realize the whole-process management of the project.
3. Display of analysis results. Using ECharts, Flex, Javacsript, Jsp technology, the project early warning and analysis evaluation can be displayed in multi-dimensional visualization. The interaction functions can provide users with multiple perspectives.

4 Case Study

The case study analysis of a 220kV transmission and transformation project in eastern China. It has a project budget of 266 million yuan, which has a total line length of 6km and a transformation capacity of 24kVA.

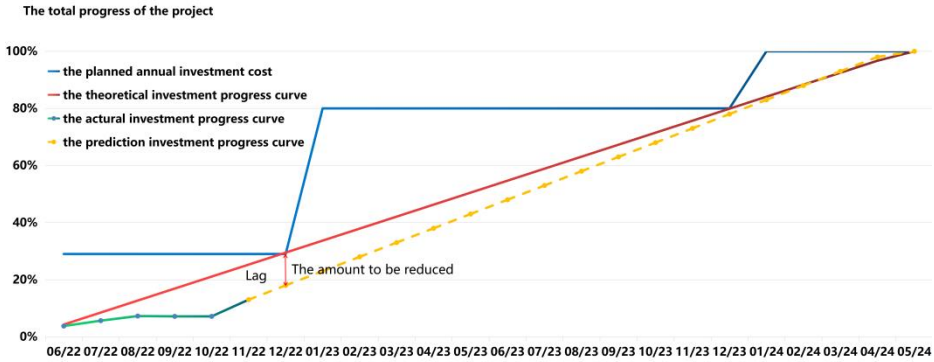

Fig. 3. Case Study

The project is planned to start construction in June 2022. Using k-means cluster analysis, the theoretical curve can be generated (red line). It is predicted that the project should be completed in May 2024. According to the theoretical line, the investment should be completed 29% in December 2022 and 80% in December 2023 (blue line). Thus, the annual investment for the three years is 65.54 million, 115.26 million and 45.20 million respectively.

The project actually starts construction in June 2022. According to the monthly monitoring, the actual execution progress of the project only reached 13% at the end of November this year (green line). The predication investment progress curve (yellow line) showed that the project can only complete 18% of the investment by the end of 2022.

The result of monitoring and control system shows that: The project started construction as planned. The prediction curve shows that it can only complete 47.88 million by the end of this year. The annual investment plan in 2022 can not be completed. Departments need to pay attention to problems arising from the actual progress of the project. Furthermore, the system suggests reducing the annual investment of 17.66 million or accelerating the actual execution progress of the project.

5 Conclusion

Nowadays, the power grid infrastructure projects have the characteristics of large quantities, wide construction area and heavy construction tasks. It is necessary to strengthen the control of the whole investment process, discover the possible problems in the project investment process from the perspectives of timeliness, accuracy, comprehensiveness and compliance. Fulfill the positive role of management, improve the internal management and control ability, operation and execution ability of enterprises. To make sure that the power grid infrastructure projects can be constructed smoothly and realize the unity of economic benefits and social benefits.

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