A Method of Power Grid Investment Control Based on Lifetime Cost

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Abstract. With the development of industrialization, the power grid has a huge investment every year. Grid is the basis of economic and social development, investment in power grids need to trade-off between safety and economy. In this paper, a horizontal and vertical bidirectional index system is proposed to quantify and guide the investment in the power grid. The vertical index system establishes the evaluation index from the perspective of management, and the horizontal index system establishes the evaluation index from the perspective of the executive layer. Based on the horizontal and vertical bidirectional index system, this paper puts forward the design framework of grid investment management and control system.

Introduction

In recent years, the size of China's power grids and equipment are more and more large, assets of power grid is huge, the power grid construction is accelerating, and the power grid assets are rejuvenated. The traditional extensive power asset management mode has some deficiencies in some aspects.

Since 2004, SGCC has explored asset life cycle management, introduced LCC approach and LCC management[1], and has gone from project management to key business management to asset life cycle management system, and from point to line to surface. It began to build an asset management system with reference to PAS55 standards in 2013. With the help of the concept and method of life cycle management of assets, the Company fully optimized and perfected the asset management of power grids and systematically solved the problems existing in the life cycle management of enterprise assets limitations and deficiencies[2,3].

When China's power grid is in its development phase, it needs to increase its capital investment appropriately, which will inevitably affect the short-term economic benefits of the assets. However, in the long run, it will be beneficial to economic benefits. If only the current short-term economic indicators are used for assessment, Grid development leads to the wrong direction, restricting the overall long-term development of enterprises. In addition, based on the available data, there has not been any research on the construction of evaluation index system and the comprehensive evaluation method for the effectiveness of asset management both at home and abroad. It has not carried out the international benchmarking work specifically for the effectiveness of asset management, besides, the typical methods of international advanced asset management case is less[4].

The proposed horizontal and vertical bidirectional index control system for the life-cycle management of power grid assets draws lessons from the Anthony structure proposed by the United States Keelung School of Management and divides the power grid asset management into three levels of structure: strategic level, management level and executive level. At the strategic management level, the index system of results is set up based on the three strategic objectives of safety, efficiency and cycle cost; the whole process control index system is established around the asset management process at the executive level. The vertical result index system and the horizontal process control index system are inter-related, and the vertical result index is decomposed into the process index related to the business process in detail, so that the overall management goal can be transformed into the control of the specific business process.
Horizontal and Vertical Bidirectional Index System

A scientific and reasonable index system is an important guarantee for the scientific guidance of the asset life cycle management in an orderly manner and in practical effect. The horizontal and vertical bidirectional index management and control system for life cycle management of power grid assets provided in the present invention is constructed according to the principles of stratified evaluation and comprehensive assessment as shown in Figure 1. The indicators are decomposed layer-by-layer from the strategic level to the management level to the execution level, from the overall goal to management goals, and finally decomposed to each employee's task indicators, constitute a tree-like indicator system. Through the evaluation of indicators can find the gap with the overall goal, through the analysis can be found in the asset management weaknesses, enabling the implementation layer in accordance with strategic objectives and requirements put in place. Executive layer through the management of the strategic level can be clear at a glance.

The bidirectional and bidirectional index system for asset life-cycle management is used to comprehensively measure the life-cycle management level of the company's assets and evaluate the overall effectiveness of the asset management and the operation of major processes. Through the application and analysis of the indicator system, it is possible to promote the overall balance and organic unity of the security, benefit and cycle costs of all the companies in each province.

Vertical Index System

Vertical control index system for top-down, horizontal through the tree system. From three aspects of safety, performance and cycle cost, it is constructed and strategically located at the management level to measure the realization of the life-cycle management objectives of the assets and focus on the life-cycle management of the assets to measure whether or not the goals of company's life-cycle management strategy are achieved and what level. Outcome indicators mainly include the following three categories:

Safety indicators are indicators that reflect the stability and reliability of the company's asset system. They measure the management level and effectiveness of assets in terms of safety, including the number of grid accidents, the number of equipment accidents and the number of personal accidents.
Performance indicators reflect the utilization of assets, availability and quality of service indicators to measure the effectiveness of assets in the management level and effectiveness.

The cyclical cost index is a measure of the capital and cost expenditures of an asset over its life cycle and measures the management and effectiveness of the asset in terms of investment and cost.

\[
SEC = \sum_j (k_j \times SEC_j) \times f_S \times f_E \times f_{NET}
\]

Among them:

\[
\sum_j (k_j \times SEC_j)
\]

is the weighted sum of the \(SEC_j\) values for each classification asset.

\(j\) represents the different categories of indicators of assessment of assets, mainly include substation assets and transmission line assets.

\(k_j\) represents the weight proportion of the \(j\)-th asset scale in the whole grid scale, and the formula is:

\[
k_j = \frac{S_j}{S_{NET}}, \text{ } S_j \text{ is the } j\text{-th asset capacity scale and } S_{NET} \text{ is the total system scale.}
\]

\(f_S\) is the safety index factor.

\(f_E\) is the performance quality index factor.

**Horizontal Index System**

The construction of horizontal control index system mainly focuses on the business processes related to the planning of asset management, purchasing bidding, construction, operation and maintenance, and retirement decommissioning phase. The specific construction ideas are shown in Figure 3:

1) Split the result indicator into several sub-indicators based on different drivers (such as at different stages of the life cycle).

2) Identify key success factors that may have an impact on sub-metrics.

3) Implement the key success factors to the corresponding management processes in the asset life cycle.
4) According to the management process of the key measurement point finishing corresponding process indicators.

Take C1 "Equivalent Annual Equivalent Cost" of the indicator as an example, according to the LCM, the annual cost equivalent of the asset is decomposed and finally decomposed into five sub-indicators. After a detailed review, key success factors that may have an impact on the "capital investment" sub-index are investment decisions, investment management and control, and optimization of construction costs. Among them, the management process corresponding to the elements of optimizing investment decisions includes the asset planning process and the project preparation process. Subsequently, according to the key measurement points of the management process, the process indicators are split to form the indicators of "planning dynamic adjustment" and the "LCC method for economic evaluation of planning plans". Figure 3 shows the process of splitting.

For the process of multiple departments involved in the process of indicators (that is jointly determined by the multi-sectoral work of the process of indicators), according to departmental business management (or process) split, so that each department clearly corresponds to a single indicator, clear responsibilities.

Framework of Grid Investment Management and Control System

Power Grid Development Business management and control is a systematic project that runs through the entire project from the formation of the equipment to the operation of the equipment and has different characteristics and objectives at different stages. The management loops are linked at each stage, which is both phased and integrated. Management and control of the main involved in more involved, the main inter-contact, mutual restraint. In order to make full use of the data advantages of the Ministry of Development as the centralized management department for statistical management, joint planning, design, planning, procurement, construction, production, material and finance departments will be implemented to achieve the asset life cycle control.

The basic idea of life-cycle control of assets is based on the principles of full-caliber, entire process and full expense, taking the statistical process as the object, the refined model as the method and the management information as the means.

(1) The whole process, the full cost principle. The whole process mainly refers to taking into account the entire project cycle from planning, project establishment, design to scrapping to avoid the decision-making limited to a certain period of time or node at a certain time, and to realize overall optimization throughout the whole process from the mechanism. The principle of full cost mainly considers the entire all costs incurred during the life cycle, including procurement and construction investment, and equipment operation and maintenance costs, maintenance costs and failure, scrap costs.

(2) For the statistical process as the object, establish statistical processes that run through all phases of investment control, effectively link up and flow smoothly, and make full use of the value of control and investment statistics in the entire process of investment.

(3) With the lean model as the method, we use the quantitative equipment operation evaluation index and input-output lean mathematical model to evaluate.

(4) Management information as a means. Information visualization is one of the important means of modern enterprise management. It realizes the information life-cycle management of investment,
eliminates the information silos, strengthens the communication and coordination among management layers, stages and between departments, and improves the operation efficiency of enterprises.

Based on the actual needs of the company's statistical work and based on the system construction of the full-caliber full-time system, two key construction functions of the asset life-cycle management and control system are put forward.

The first is to carry out the global life cycle control of assets, fully realize the monitoring of key business processes, and find the alarm items from top to bottom and position them to solve problems and provide feedbacks from the bottom up.

Figure 4. Framework of grid investment management and control system.

Second, based on the full-caliber, full-process and full-cost statistics of completed projects, according to Anthony Structure put forward by the United States Keelung management trainees, a progressive management level of business layer, management layer and strategic layer is built to improve business process management efficiency, and give full play to the management efficiency of investment statistics to provide strong support for the strategic decision-making of the Company's investment projects.

The overall framework of asset life cycle management consists of management mechanism, management methods and management tools. The management mechanism is mainly to realize the basic guarantee of the entire life cycle of investment. The management method is the concrete measure to achieve the overall goal of investment life-cycle management. The management method is Achieve management and control mechanisms and management methods of the important platform.

(1) Management mechanism

Asset Life Cycle Management According to the division of management stages, management stages are closely linked. Meanwhile, the management elements are fully integrated to form a standardized and standardized management mode. Therefore, the life-cycle control mechanism of assets changes from the current fragmented functional management to process management, focusing on process convergence, coordinating the management among specific business processes through perfect process management, and conducting cross-departmental and cross-business collaboration and exchange. Form a close cooperation and a good link between the process, establish and improve a closed-loop management mechanism to achieve the entire process of investment management and overall optimization of life cycle.
(2) Management methods

The management method mainly refers to the investment life-cycle management method system, including quantitative evaluation index system, solidified business statistics flow and lean input-output mathematical model. The quantitative evaluation index system runs through all stages of the investment life cycle and reflects the characteristics of all the investment statistics. Curing the business statistics process includes the management of various stages of the process of statistics, indicators collection, analysis and evaluation, based on the assessment results put forward corrective measures, business processes, including each business process node self-assessment, as well as information between different management processes feedback and sharing, forming a continuous cycle of statistical evaluation and closed-loop management. The lean mathematical model of input-output is an effective tool to quantify and evaluate the project's investment returns. It can scientifically evaluate the investment life-cycle management and all stages of work and correctly guide the planning of the company's investment projects.

(3) Management tools

Investment life cycle management tools rely on a sound information system and the establishment of the appropriate decision support system to break the original different departments and different business processes between the information barriers to achieve the planning, project, the initial set, the tender, construction, operation, etc. Stage of integrated statistical management, the full integration of independent management information system will improve communication and coordination between departments, and achieve information sharing and comprehensive decision-making.

Summary

The power grid investment needs to balance between safety, performance and cost. The proposed horizontal and vertical bidirectional index system proposed in this paper establishes a vertical management index system covering three levels: executive, management and decision-making levels, through result indicators to measure whether the company's entire process of management and control strategy has achieved and its level; the establishment of the whole process of horizontal management and control indicators system including planning, construction, operations and so on, through process indicators to measure whether the relevant management processes and implementation of quality can efficiently support investment. The horizontal and vertical index system can be used to evaluate and guide power grid investment management and effectively support the power grid investment decisions.

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