# Research on Evaluation Method of Maturity of Power Grid Project Cost Management Based on Fuzzy Theory

Shibo Dong[1], Tong Liu[2], Yuanyuan Rong[2], Ye Li[3], and Cuiliu Liu[3](✉)

[1] China Electric Power Project Cost Administration, Beijing 100053, China
[2] CEC Technical & Economic Consulting Center of Electric Power Construction, Beijing 100053, China
[3] CEC Electric Power Development Research Institute, Beijing 100053, China
1182306191@ncepu.edu.cn

**Abstract.** Strengthening the cost management of power grid projects is an important way to improve the efficiency of project management and the level of business efficiency of enterprises. Based on the maturity related theories, this paper constructs a fuzzy theory-based power grid engineering cost management maturity evaluation model, and validates the effectiveness of the model with actual engineering cases. This method of evaluating the maturity of power grid engineering cost management can further improve the efficiency of power grid enterprise cost management and control.

**Keywords:** Fuzzy theory · grid engineering cost · management maturity · evaluation techniques

## 1 Introduction

With the rapid development of China's social economy, social production, life demand, in the power grid project construction scale, the new situation, power enterprise cost lean control degree is low, the lack of management problem, how to get good enterprise profits is a major challenge facing power enterprises [1]. Under this premise, strengthening the efficiency level of power grid project cost management has become one of the important starting points to improve the sustainable operation and development of power grid enterprises.

Document [2] combines the impact of power system reform on power grid enterprises, uses the fish bone map method and the fuzzy threshold method to identify the sensitive factors with a great impact on the difference of investment in power transmission and transformation projects, and builds a library of differential sensitive factors to provide support for improving the cost management level of power grid projects. Document [3] first analyzes the main factors affecting the cost of power transmission and transformation projects. On this basis, the cost prediction model of power transmission and transformation project based on the artificial neural network is constructed to


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provide reference for enterprises to improve the cost management level of power grid. Document [4] puts forward a risk management evaluation model for power transmission and transformation projects based on FCE and DEA, which provides a reference for strengthening cost risk management for power grid projects.

In summary, related scholars pay more attention to the analysis of factors affecting the cost of power grid projects, the construction of cost forecasting models, and cost risk management. However, the research on the maturity of cost management of power grid enterprises is relatively weak. Based on this, this article starts from the perspective of power grid engineering cost management in the whole process, combined with the characteristics of power grid engineering cost management, constructs a fuzzy theory-based power grid engineering cost management maturity evaluation method, and provides guidance for grid companies to further improve the efficiency of cost management.

## 2 Construction of the Maturity Evaluation Index System of Power Grid Engineering Cost Management

### 2.1 Maturation Correlation Theory

The maturity model was first proposed by the Institute of Software Engineering at Carnegie Mellon University in the United States and studied by [5]. In the process of software development, in order to avoid the passive solving problems after the event, managers decided to improve this situation, through scientific methods to find problems and avoid problems in advance, and improve the level of software development management, thus starting the study of maturity model.

By the 1990s, more and more institutions and scholars began to study the project management maturity model, expect to optimize the project management, establish a standardized standard process, to scientifically evaluate the level of project management, and give the operational management level continue to improve the path and suggestions.

The maturity model can be understood as a process of continuous optimization and improvement of the research subjects, a tool for evaluation, improvement, re-evaluation and reimprovement, and a reproduction of the PDCA management process. The maturity model consists of improved evaluation indicators, evaluation methods, and evaluation results, as shown in Fig. 1.

### 2.2 Construction of the Maturity Evaluation Index System

This paper starts to improve the efficiency level of cost management of power grid enterprises, combined with the construction process of power grid engineering, to build the power grid project cost management maturity evaluation index system. The index system In accordance with the principle of the index system construction, combined with the characteristics of the cost management of the whole process of the power grid project and the factors with important influence on the cost management, the evaluation index system for the maturity of the power grid project cost management has been constructed. The evaluation index system is divided into target layer, element layer, standard layer and index layer. Target layer, which is the maturity of hydropower project cost management;

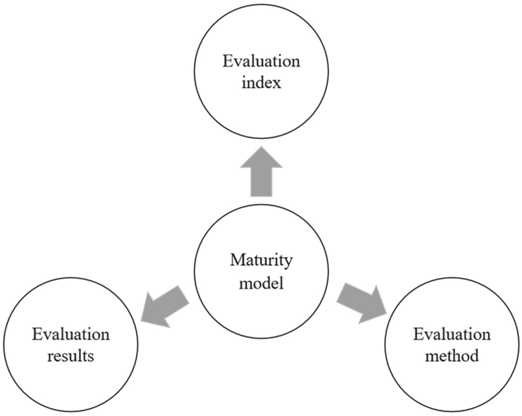


**Fig. 1.** Composition of the maturity evaluation model

factor layer mainly includes five stages of grid engineering cost management, namely investment decision stage, design stage, bidding stage, construction stage and completion acceptance stage. The standard layer is the factor identification and refinement of the cost management of grid engineering cost management, the actual layer and the direct indicator of the maturity of grid engineering cost management. The evaluation index system is shown in Table 1.

# 3 Construction of the Maturity of Cost Management Based on Fuzzy Element Method

## 3.1 Index Weight Determination Based on the Hierarchical Analysis Method

Hierarchical analysis (Analytic Hierarchy Process, abbreviated AHP) is one way to express and process human subjective judgment in quantitative form is an effective multi-standard decision-making method, is also the most common method of subjective empowerment method, and is also an effective method for people to make an objective description of subjective judgment. The basic principles of hierarchical analysis are as follows:

(1) According to the importance scale theory, construct a pairwise comparison judgment matrix A for the evaluation index system:

$$A = \left(a_{ij}\right)_{n \times n}(i, j = 1, 2, \cdots, n) \quad (1)$$

(2) Then normalize the judgment matrix A, the calculation formula is:

$$\overline{a}_{ij} = a_{ij} / \sum_{k=1}^{n} a_{kj}(i, j = 1, 2, \cdots, n) \quad (2)$$

**Table 1.** Evaluation index system of power grid project cost management maturity.

| Decision-making layer | Elements layer | Code layer | Index layer |
|---|---|---|---|
| Evaluation of the maturity of power grid engineering cost management | decision phase | decision-making management | Decision-making demonstration is scientific |
| | | | Decision-making depth and quality |
| | | risk management | Risk identification sensitivity |
| | | | Risk prevention and control measures are reasonable |
| | | Estimate management | Estimate preparation compliance |
| | | | Estimate the preparation depth |
| | | Resource input | Cost management personnel qualification |
| | | | Complete of cost management procedures |
| | design phase | Design document preparation | rationality of design scheme |
| | | | Professional level of designers |
| | | Budget estimate and budget management | Estimates and budgeting are comprehensive |
| | | | Compliance of budget estimate and budget preparation |
| | | | Deviation rate of budget estimates |
| | | | Budgeting deviation rate |
| | Bidding stage | Bidding process management | Compliance of the bidding documents |

(*continued*)

**Table 1.** (*continued*)

| Decision-making layer | Elements layer | Code layer | Index layer |
|---|---|---|---|
| | | | Bidding process compliance |
| | | | Reasonable rationality of bidding control price |
| | | | Procurement method compliance |
| | | Management of Bill of Quantities | Quality of Bill of Quantity preparation |
| | | | The bill of quantities preparation is comprehensive |
| | Construction stage | contract management | Contract content is rigorous |
| | | | Timely timeliness of contract signing |
| | | | Contract filing integrity |
| | | Design change and visa management | Change and visa basis adequacy |
| | | | Change and visa ratio |
| | | Project settlement management | Reasonable of settlement documents |
| | | | Settlement and handling compliance |
| | Final accounts stage | Project final account management | Reasonable compilation of final accounts |
| | | | Final account documents are comprehensive |
| | | Investment control level | Investment deviation rate at each stage |
| | | | Summary of deviation analysis |

(3) Calculation index weights:

$$w_i = \overline{w}_i / \sum_{i=1}^{n} \overline{w}_i (i = 1, 2, \cdots, n) \tag{3}$$

(4) Finally determines consistency. If the consistency test, the results are valid and not adjust the results.

## 3.2 Construction of the Evaluation Model Based on the Fuzzy Element Method

(1) Build a fuzzy membership function

The power grid engineering cost management maturity model determined in this paper is divided into five levels. On this basis, the maturity level comment set $U = \{U_1, U_2, U_3, U_4, U_5\}$ and the rating range are determined, where $U_1$ represents the confusion level (0–60 points) and $U_2$ simple level (60–70 points), $U_3$ means specification level (70–80 points), $U_4$ means excellent level (80–90 points), $U_5$ means lean level (90–100 points). Invite members of the power grid project cost management maturity evaluation team to score each index level, and use the average score of each index as the final score, and calculate the membership degree of the evaluation index based on the membership function and the score. The five-level membership functions are as follows Show.

$$\mu_1(x) = \begin{cases} 1 & x \le \beta_1 \\ \frac{\beta_2 - x}{\beta_2 - \beta_1} & \beta_1 < x \le \beta_2 \\ 0.1 & \beta_2 < x \le \beta_3 \\ 0 & \beta_3 < x \le \beta_4 \\ 0 & \beta_4 < x \le \beta_5 \\ 0 & x > \beta_5 \end{cases} \tag{4}$$

$$\mu_2(x) = \begin{cases} 0 & x \le \beta_1 \\ 0.8 - \mu_1(x) & \beta_1 < x \le \beta_2 \\ \frac{\beta_3 - x}{\beta_3 - \beta_2} & \beta_2 < x \le \beta_3 \\ 0.1 & \beta_3 < x \le \beta_4 \\ 0.1 & \beta_4 < x \le \beta_5 \\ 0 & x > \beta_5 \end{cases} \tag{5}$$

$$\mu_3(x) = \begin{cases} 0 & x \le \beta_1 \\ 0.1 & \beta_1 < x \le \beta_2 \\ 0.8 - \mu_2(x) & \beta_2 < x \le \beta_3 \\ \frac{\beta_4 - x}{\beta_4 - \beta_3} & \beta_3 < x \le \beta_4 \\ 0.1 & \beta_4 < x \le \beta_5 \\ 0 & x > \beta_5 \end{cases} \tag{6}$$

$$\mu_4(x) = \begin{cases} 0 & x \le \beta_1 \\ 0.1 & \beta_1 < x \le \beta_2 \\ 0.1 & \beta_2 < x \le \beta_3 \\ 0.8 - \mu_3(x) & \beta_3 < x \le \beta_4 \\ \frac{\beta_5 - x}{\beta_5 - \beta_4} & \beta_4 < x \le \beta_5 \\ 0 & x > \beta_5 \end{cases} \tag{7}$$

$$\mu_5(x) = \begin{cases} 0 & x \le \beta_1 \\ 0.1 & \beta_1 < x \le \beta_2 \\ 0.1 & \beta_2 < x \le \beta_3 \\ 0.1 & \beta_3 < x \le \beta_4 \\ 0.8 - \mu_4(x) & \beta_4 < x \le \beta_5 \\ 0 & x > \beta_5 \end{cases} \tag{8}$$

(2) Build the maturity fuzzy element evaluation model

Membership shall be calculated from the low to the high level, the membership function, the previous layer according to the index weight vector and membership matrix, and the upper membership function in the evaluation index system. The membership matrix is:

$$R = \begin{bmatrix} & M_1 & M_2 & \ldots & M_5 \\ C_1 & b_{11} & b_{12} & \ldots & b_{15} \\ C_2 & b_{21} & b_{22} & \ldots & b_{25} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ C_n & b_{n1} & b_{n2} & \ldots & b_{n5} \end{bmatrix} \tag{9}$$

In the formula, $b_{ij}$ represents the degree to which index $i$ belongs to level $j$. According to the membership matrix of the uppermost index and the corresponding index weight, the final fuzzy comprehensive evaluation vector can be obtained:

$$P = \begin{bmatrix} M_1 & M_2 & M_3 & M_4 & M_5 \\ n_1 & n_2 & n_3 & n_4 & n_5 \end{bmatrix} \tag{10}$$

According to the principle of the maximum degree of index membership, the maximum degree of membership $\mu_{\max}$ can be obtained, so that the level of maturity of the power grid engineering cost management can be determined.

## 4 Empirical Analysis

This paper selects the actual cost management of a power grid project as an example to carry out empirical analysis. First of all, experts in the power grid project cost management are invited to score the actual cost management of the project, and the weight of each index is determined according to the hierarchical analysis method, as shown in Table 2.

**Table 2.** Weight calculation results of the evaluation index system

| Decision-making layer | Elements layer | weight | Code layer | weight | Index layer | weight |
|---|---|---|---|---|---|---|
| Evaluation of the maturity of power grid engineering cost management | decision phase | 0.2599 | decision-making management | 0.2866 | Decision-making demonstration is scientific | 0.6667 |
| | | | | | Decision-making depth and quality | 0.3333 |
| | | | risk management | 0.3057 | Risk identification sensitivity | 0.2500 |
| | | | | | Risk prevention and control measures are reasonable | 0.7500 |
| | | | Estimate management | 0.3439 | Estimate preparation compliance | 0.2000 |
| | | | | | Estimate the preparation depth | 0.8000 |
| | | | Resource input | 0.0637 | Cost management personnel qualification | 0.8000 |
| | | | | | Complete of cost management procedures | 0.2000 |
| | design phase | 0.2227 | Design document preparation | 0.1667 | rationality of design scheme | 0.7500 |
| | | | | | Professional level of designers | 0.2500 |
| | | | Budget estimate and budget management | 0.8333 | Estimates and budgeting are comprehensive | 0.1416 |

(*continued*)

**Table 2.** (*continued*)

| Decision-making layer | Elements layer | weight | Code layer | weight | Index layer | weight |
|---|---|---|---|---|---|---|
| | | | | | Compliance of budget estimate and budget preparation | 0.0835 |
| | | | | | Deviation rate of budget estimates | 0.4409 |
| | | | | | Budgeting deviation rate | 0.3340 |
| | Bidding stage | 0.116 | Bidding process management | 0.3333 | Compliance of the bidding documents | 0.1467 |
| | | | | | Bidding process compliance | 0.0800 |
| | | | | | Reasonable rationality of bidding control price | 0.4400 |
| | | | | | Procurement method compliance | 0.3333 |
| | | | Management of Bill of Quantities | 0.6667 | Quality of Bill of Quantity preparation | 0.7500 |
| | | | | | The bill of quantities preparation is comprehensive | 0.2500 |
| | Construction stage | 0.3341 | contract management | 0.5753 | Contract content is rigorous | 0.2484 |
| | | | | | Timely timeliness of contract signing | 0.6115 |
| | | | | | Contract filing integrity | 0.1401 |
| | | | Design change and visa management | 0.1507 | Change and visa basis adequacy | 0.1667 |

(*continued*)

**Table 2.** (*continued*)

| Decision-making layer | Elements layer | weight | Code layer | weight | Index layer | weight |
|---|---|---|---|---|---|---|
| | | | | | Change and visa ratio | 0.8333 |
| | | | Project settlement management | 0.2740 | Reasonable of settlement documents | 0.6667 |
| | | | | | Settlement and handling compliance | 0.3333 |
| | Final accounts stage | 0.0673 | Project final account management | 0.1667 | Reasonable compilation of final accounts | 0.2500 |
| | | | | | Final account documents are comprehensive | 0.7500 |
| | | | Investment control level | 0.8333 | Investment deviation rate at each stage | 0.8333 |
| | | | | | Summary of deviation analysis | 0.1667 |

Combined with the evaluation model, the evaluation results of the power grid engineering cost management maturity are calculated as follows:

$$Y = (0.2599, 0.2227, 0.1160, 0.3341, 0.0673) * \begin{bmatrix} 0\ 0.1000\ 0.0946\ 0.6854\ 0.1199 \\ 0\ 0.1000\ 0.1000\ 0.4294\ 0.3706 \\ 0\ 0.1000\ 0.1000\ 0.5647\ 0.2353 \\ 0\ 0.1000\ 0.1628\ 0.5774\ 0.1599 \\ 0\ 0.1000\ 0.5469\ 0.2656\ 0.0875 \end{bmatrix}$$

$$= (0, 0.1000, 0.1497, 0.5500, 0.2003)$$

It can be obtained from the calculation results that the evaluation results belong to the disorder level, simple level, standard level, excellent level and lean level respectively. The highest degree, it can be judged that the maturity of the power grid project cost management is at an excellent level.

## 5 Conclusion

Under the new situation, with the continuous advancement of the reform of the power system, strengthening the management level of power grid engineering costs has become one of the important starting points for power grid companies to adapt to policy development and enhance their competitiveness. This paper first builds a power grid engineering cost maturity evaluation index system based on the whole process, and combines the analytic hierarchy process to determine the index weight; then builds a power grid engineering cost management maturity evaluation model based on fuzzy theory; Under the new situation, with the continuous advancement of the reform of the power system, strengthening the management level of power grid engineering costs has become one of the important starting points for power grid companies to adapt to policy development and enhance their competitiveness. This paper first builds a power grid engineering cost maturity evaluation index system based on the whole process, and combines the analytic hierarchy process to determine the index weight; then builds a power grid engineering cost management maturity evaluation model based on fuzzy theory; finally, combined with actual cases, it is verified The validity of the model. This method for evaluating the maturity of power grid project cost management can further improve the efficiency of power grid project cost management and project construction. This method for evaluating the maturity of power grid project cost management can further improve the efficiency of power grid project cost management and project construction.

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