Power grid technology economic evaluation system based on life cycle theory

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Abstract. The whole-life-cycle theory and Analytic Hierarchy Process (AHP) was used to establish a technical and economic fuzzy evaluation system for Electric Power Engineering. The combination weighting of game theory was used to obtain the optimal weight by fusing the weights by entropy method and Cholesky decomposition method. It could make the evaluation results more objective and scientific, and reduce the one-sidedness of evaluation, which could greatly improve the accuracy of the evaluation results.

1. Introduction
Conducting technical and economic evaluation of the project and analyzing the problems may provide a scientific basis for the project manager to judge whether the project is feasible and determine the best implementation plan. It will help to improve the investment efficiency of the project, thereby improving construction efficiency and management level [1]. This avoids the problem of the lack of horizontal comparison between the indicators when calculating the weights by the entropy method, and reduces the influence of the square root method on the rationality of the judgment matrix, so that the evaluation results are more accurate[2].

2. Evaluation index and weight of power transmission and transformation engineering

2.1 Determination of indicator weight
The initial weights are calculated based on the product square root method and the entropy method, and the combined weights based on game theory are used to determine the combined weights, which reduces the one-sidedness caused by the single evaluation method. In the product square root method, first calculate the product of each row element of the judgment matrix, and open the root of the product by n times to obtain the weight:

\[ w_j = \sqrt[n]{\prod_{i=1}^{n} a_{ij}}, i, j = 1, 2, \cdots, n \]  

Normalize \( w_j \) to get the initial weight of all indicators:
Thus the initial weight is obtained by the product square root method:

\[ w_i' = \left( \frac{w_i}{\sum_{j=1}^{n} w_j} \right)^{1/2}, i = 1, 2, \ldots, n \]  

(2)

Assuming that each indicator has \( m \) kinds of comment items, and the probability of each comment appearing is \( p_j (j = 1, 2, \ldots, m) \), the entropy of the system can be defined as

\[ h = -\sum_{j=1}^{m} p_j \ln p_j \]  

(3)

Where \( p_j \) satisfies \( 0 \leq p_j \leq 1 \), \( \sum_{j=1}^{m} p_j = 1 \). When various reviews appear to have equal probability, that is, \( p_j = \frac{1}{m} (j = 1, 2, \ldots, m) \), the entropy takes the maximum value \( H_{\text{max}} = \ln m \).

The original evaluation matrix \( X = (x_{ij})_{n \times m} \) is formed by \( m \) kinds of comment items and \( n \) evaluation indexes, and the information entropy of the \( i \)th item index is calculated as

\[ h_i = -\frac{1}{\ln m} \sum_{j=1}^{m} P_{ji} \ln P_{ji} \]  

(5)

From this, the weight of the \( i \)th indicator is determined:

\[ w_i' = \frac{1 - h_i}{\sum_{i=1}^{n} (1 - h_i)} \]  

(6)

Thus, the entropy method obtains the hierarchical structure index weight

\[ w'_i = \left[ w'_1, w'_2, \ldots, w'_n \right]^T \]

2.2 Comprehensive evaluation model for power transmission and transformation engineering

On the basis of the determination of the weight of the indicator, the fuzzy comprehensive evaluation of the target to be evaluated is carried out. First, determine the comment set of the indicator, \( V = \{v_1, v_2, \ldots, v_m\} \), the comment set given by the article \( V = \{\text{excellent, good, medium, poor}\} \). Then, a fuzzy evaluation of each indicator is made, that is, the degree of membership of each index in the comment set is determined \([11] \):
Where \( i = 1, 2, \ldots, m \), \( j = 1, 2, \ldots, m \). Calculate the degree of membership of each indicator to each comment in the comment set, then you can get the fuzzy matrix:

\[
R = \begin{bmatrix}
R_1 \\
R_2 \\
\vdots \\
R_m
\end{bmatrix} = \begin{bmatrix}
r_{i1} & r_{i1} & \cdots & r_{i1} \\
r_{i1} & r_{i1} & \cdots & r_{i1} \\
\vdots & \vdots & \ddots & \vdots \\
r_{i1} & r_{i1} & \cdots & r_{i1}
\end{bmatrix}
\] (8)

The single layer fuzzy evaluation model is

\[
B = w \circ R = \begin{bmatrix} b_1, b_2, \ldots, b_n \end{bmatrix}
\] (9)

Where \( \circ \) is a fuzzy operator; \( B \) is the result of each layer evaluation;

\[
b_j = \max_{1 \leq i \leq m} \left\{ \min(w_i, r_{ij}) \right\}, j = 1, 2, \ldots, n. \text{ If } \sum_{i=1}^{n} b_i \neq 1 \text{ occurs in the calculation result, normalization is required.}
\]

In the multi-level fuzzy evaluation, the underlying indicators are evaluated first, and the upper-level indicators are evaluated layer by layer until the highest-level comprehensive evaluation results are obtained, and the final evaluation results are determined according to the principle of maximum membership degree [12]

### 3. Instance application

After the competent authorities [12] at the higher level and the experts of the construction enterprise judged the importance of the indicators and gave comments on the completion of the indicators, according to the evaluation system constructed in the paper, and finally the evaluation results of the power transmission and transformation projects were calculated. Due to space limitations, only the indicators of the first layer and the second, third layers are selected as examples. The weights after calculation are shown in Tables 1 and 2.

#### Table 1 First layer indexes and weights

| First layer indexes | weights |
|---------------------|---------|
| Preliminary preparation | 0.32817 |
| Medium term construction | 0.39884 |
| Late run | 0.27299 |

#### Table 2 Second and third layer indexes and weights

| First layer indexes | Second layer indexes | weights |
|---------------------|---------------------|---------|
| Post evaluation | Effectiveness and benefit evaluation | 0.34206 |
| Process evaluation | | 0.31825 |

| Third layer indexes | weights |
|---------------------|---------|
| Scientific and effective evaluation of management at all stages | 0.31150 |
| Financial evaluation benefit | 0.33365 |
| Social evaluation benefit | 0.35485 |
| Decision evaluation process | 0.33333 |
According to the same method, the fuzzy evaluation of the third layer, the second layer and the first layer index is carried out layer by layer. In the formula (20), $w_{41}$ corresponds to the first index of the fourth layer. Finally, the first layer of evaluation results is $B_1 = w_1 \odot R_{11} = \begin{bmatrix} 0.34711 & 0.50889 & 0.14125 & 0.00275 \end{bmatrix}$. The maximum value is 0.50889. According to the principle of maximum membership degree, the evaluation result of the power transmission and transformation project is a good grade.

4. Conclusion

In this paper, a fuzzy evaluation system for power engineering based on the life cycle theory is established. The game theory combination weighting method is used to combine the entropy method and the product square root method to obtain the optimal weight. The evaluation system is used to evaluate and analyze the actual power transmission and transformation project in the area. The results not only reflect the objective mathematical theory and method, but also combine the subjective information of experts on the evaluation system.

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