Research on Comprehensive Evaluation of Power Network Planning Project Based on Fuzzy Synthesis

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Abstract: At present, the research on the comprehensive evaluation of power grid planning projects cannot comprehensively consider the economics and reliability of the planning projects, the adaptability and the degree of impact on the environment, etc., and the guidance for the construction of modern power grids in the low-carbon economy mode is not strong. This paper firstly determines the index system of comprehensive evaluation of power grid projects, then constructs a comprehensive evaluation model of power grid planning projects based on fuzzy comprehensive theory. It can conduct comprehensive evaluation research on a 110kV power transmission and transformation project, so as to study and to analyze the comprehensive evaluation results, which provides a reference to a similar power grid planning project in the future.

Keywords: Power grid planning project; comprehensive evaluation; fuzzy comprehensive theory.

1. Introduction
Most of the traditional grid evaluation work pays more attention to the single evaluation evaluation indicators, such as power supply quality, safety and reliability of power grid planning. Among them, the literature [1] uses the neural network theory to study the reliability index of the power grid in depth. The literature [2] conducts in-depth research on the safety index of the power grid planning project, and the literature [3] adopts the subjective and objective phase. The combined fuzzy comprehensive evaluation method discusses the power quality of power grid planning projects. The literature [4] improves the evaluation effect, and fully considers the uncertainty of the original data when evaluating the reliability of the distribution network. At different degrees and from different sides, these documents evaluate the technical level of power grid planning, but lack of consideration for the economic, risk
and environmental impacts of power grid planning, thus affecting the comprehensiveness of evaluation. The rationality of a power grid planning plan should be assessed from all aspects involved in the program. The power grid planning project will generally be related to the project's risk, economy and environmental impact. Therefore, a complete power grid planning comprehensive evaluation system should also include the above three aspects [5-7].

2. Construction of comprehensive evaluation system for power grid planning projects

2.1 Comprehensive evaluation indicators for power grid planning project

According to the principles of fairness and independence constructed by the grid planning evaluation index system, the combination of qualitative indicators and quantitative indicators, objectivity and operability, combined with the characteristics of power grid planning projects, expert opinions, text data, etc. Comprehensive evaluation index system for power grid planning projects. The current comprehensive evaluation index system for power grid planning is shown in Table 1.

Table 1. Comprehensive evaluation index system for power grid planning projects

<table>
<thead>
<tr>
<th>Comprehensive evaluation index system for power grid planning projects</th>
<th>criteria layer</th>
<th>solution layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>economic indicator</td>
<td>Power supply capability of unit assets</td>
<td>Equipment utilization</td>
</tr>
<tr>
<td></td>
<td>Line loss reduces revenue</td>
<td>Increase power supply revenue</td>
</tr>
<tr>
<td></td>
<td>Internal Rate of Return</td>
<td>Economic net present value</td>
</tr>
<tr>
<td>technical indicators</td>
<td>&quot;N-1&quot; meets the situation</td>
<td>Transient stability</td>
</tr>
<tr>
<td></td>
<td>Short circuit current level</td>
<td>Load ratio</td>
</tr>
<tr>
<td></td>
<td>Line loss rate</td>
<td></td>
</tr>
<tr>
<td>environmental indicators</td>
<td>Noise effect</td>
<td>Emissions</td>
</tr>
<tr>
<td></td>
<td>Electromagnetic interference</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soil and vegetation damage</td>
<td>environmental compliance rate</td>
</tr>
</tbody>
</table>
2.2 Construction of comprehensive evaluation model for power grid planning based on fuzzy synthesis

Fuzzy comprehensive evaluation is a quantitative analysis method that transforms the uncertainty problem into a determinable distinction. Through the assignment and non-dimensionalization of the index weights of each level, the relative importance degree of the index is determined, and the membership degree matrix \( R \) is constructed. In this paper, the factor weight of the group decision \( G_1 \) and the factor fuzzy importance matrix can be used to determine the importance degree of the relative level of the plan layer, and finally the effect evaluation of the target is obtained.

Establish factor set \( U \) and evaluation set \( V \). \( U = \{U_1, U_2, U_3, \ldots, U_m\} \), where \( U_i (i=1,2,\ldots,m) \) is the evaluation factor, which is the specificity of the criterion layer and the scheme layer in the hierarchical structure evaluation system. Different evaluation factors form an evaluation factor \( U \) under the upper evaluation target or criterion, where \( m \) is the number of evaluation factors. A comment set \( V \) is established, \( V = \{V_1, V_2, V_3, \ldots, V_m\} \), where \( V_j (i = 1, 2, \ldots, n) \) is the evaluation level of the element [70]. \( V \) determines the standard selection range of the evaluation factor set \( U \). The domain element of the comment set \( V \) is the region of the segmented fuzzy boundary, for example: \( V = \{\text{very good, better, average, poor, very poor}\} \), thus forming a Complete closed domain, and determine the corresponding value for each boundary area. The numerical value determination method is expert assignment.

Determine the evaluation level of factors and establish a fuzzy judgment matrix

For the \( i \)-th evaluation factor \( U_i \) of the factor set \( U \), the single factor evaluation of the \( j \)-th comment level \( V_j \) in the comment set \( V \) is performed, and a fuzzy map is obtained.

\[
R = \begin{bmatrix}
    r_{11} & r_{12} & \cdots & r_{1n} \\
    r_{21} & r_{22} & \cdots & r_{2n} \\
    \cdots & \cdots & \cdots & \cdots \\
    r_{m1} & \cdots & \cdots & r_{mn}
\end{bmatrix}
\]

\( R \) is the membership degree matrix, which is the possible degree of evaluation scale of \( U \) to \( V \), and is denoted as \( r_{ij} \), where \( 0 \leq r_{ij} \leq 1 \), and \( m \) rank elements are judged by \( n \) ranks, and the result is a matrix of \( m \) rows and \( n \) columns.

(3) Determine the weight vector, \( W \) is the weight of the evaluation factor \( W = (w_1, w_2, \ldots, w_n) \) is the factor index weight after the dimensionless processing, where \( W_i (i = 1, 2, \ldots, n) \) represents the factor \( U_i (i = 1, 2, \ldots, n) \). The degree of importance in the comment set \( V \), that is, the weight assigned to \( U_i (i = 1, 2, \ldots, n) \). If the fuzzy boundary theory field of the comment set \( V \) is digitized, the double weight method can be used to calculate the specific evaluation value of the evaluation target or criterion.

(4) Calculate the comprehensive assessment vector \( S \) and the comprehensive rating \( \mu \). The combination of the weight vector \( W \) and the judgment matrix \( R \) is the final
A fuzzy vector represents the result of a fuzzy comprehensive evaluation of an evaluated object, and it contains a wealth of information. In addition, the vector needs to be defuzzified to determine the specific level of the evaluation object. In the comprehensive evaluation, the conclusions of the fuzzy evaluation are judged. The fuzzy distribution method and the maximum membership degree method are usually used to perform fuzzy vector defuzzification.

The basic principle of the maximum membership degree method is as follows. Set the domain, there are m fuzzy sets A1, A2, .., Am. If for any one, i=(1,2,...,m), yes, then xi Relatively affiliated with Ai., determine the corresponding construction quality evaluation level. The principle of maximum membership degree can directly reflect the distribution of membership degrees of each level. It is a commonly used fuzzy matrix anti-fuzzification method. The principle of maximum membership degree can help decision makers to make correct treatment measures.

3. Example Analysis

The analytic hierarchy process is used to calculate the weight and the comprehensive evaluation model of power grid planning based on the attribute interval identification theory. This chapter combines the actual situation of a 110kv power transmission and transformation project to conduct comprehensive evaluation research on the power grid planning project.

3.1 Weight Determination Process

The index system constructed in this paper is divided into three levels. From high to low, it is the target level indicator, the criterion level indicator and the program level indicator. Firstly, according to the weight calculation method, the weights of the index of each scheme layer are calculated, and the matrix of the scheme layer obtained by the expert scoring is obtained, and the weights of each index of the scheme layer are obtained, and the weights of the index of each criterion layer are further obtained according to the judgment matrix of the criterion layer. Get the weight of the entire indicator system, and lay the foundation for the next comprehensive evaluation. From the above analysis, the weights of the indicators of the evaluation index system of this project can be obtained, as shown in Table 2.
Table 2. Power grid planning project evaluation index system weight

<table>
<thead>
<tr>
<th>Criteria layer</th>
<th>Weights</th>
<th>Solution layer</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>economic indicator</td>
<td>0.3989</td>
<td>Power supply capability of unit assets</td>
<td>0.2508</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment utilization</td>
<td>0.2598</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Line loss reduces revenue</td>
<td>0.2677</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase power supply revenue</td>
<td>0.0439</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal Rate of Return</td>
<td>0.1778</td>
</tr>
<tr>
<td>technical indicators</td>
<td>0.3597</td>
<td>Economic net present value</td>
<td>0.2722</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;N-1&quot; meets the situation</td>
<td>0.2266</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transient stability</td>
<td>0.3183</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Short circuit current level</td>
<td>0.0508</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Load ratio</td>
<td>0.1321</td>
</tr>
<tr>
<td>environmental indicators</td>
<td>0.2414</td>
<td>Line loss rate</td>
<td>0.2216</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Noise effect</td>
<td>0.1553</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Emissions</td>
<td>0.5421</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electromagnetic interference</td>
<td>0.0810</td>
</tr>
</tbody>
</table>

3.2 Implementation of Comprehensive Evaluation of Power Grid Planning Projects

According to the comprehensive evaluation system constructed in the previous section, a comprehensive evaluation of a power grid planning project is carried out.

(1) Determine the comment set

The power transmission and transformation project is taken as the research object, and the evaluation index system \( R = \{ R_1, R_2, R_3 \} \) is determined. The expert's evaluation of each evaluation factor constitutes a comment set \( V = \{ v_1, v_2, v_3, v_4 \} \); \( v_1, v_2, v_3, v_4 \) respectively indicate that the indicators of the indicators indicate that the comprehensive evaluation results of the power grid planning project are best, good, general, and poor, and thus the single-factor fuzzy evaluation matrix of the evaluation object can be obtained.

(2) Score and weight calculation of secondary indicators

According to the expert experience and related literature, 10 experts are asked to score the scores in the comprehensive evaluation of the grid planning project under the specified comment set, each scored 1 point, and finally aggregated for averaging. The results are shown in Table 3.

Table 3. Power grid planning project evaluation index evaluation result

<table>
<thead>
<tr>
<th>R1</th>
<th>best</th>
<th>good</th>
<th>general</th>
<th>poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply capability of unit assets</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Equipment utilization</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Line loss reduces revenue</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Increase power supply revenue</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
Calculate the weights of the influencing factors of each power grid planning project according to the analytic hierarchy process:

- \( W_1 = \{0.2508, 0.2598, 0.2677, 0.0439, 0.1778\} \)
- \( W_2 = \{0.2722, 0.2266, 0.3183, 0.0508, 0.1321\} \)
- \( W_3 = \{0.2216, 0.1553, 0.3421, 0.2810\} \)

Fuzzy comprehensive evaluation of secondary indicators under the primary indicators:

1) One-factor evaluation of economics

\[
S_1 = w_1 \times R_1 = \begin{bmatrix}
0.2 & 0.6 & 0.2 & 0 \\
0.4 & 0.3 & 0.3 & 0
\end{bmatrix} \times \begin{bmatrix}
0.2508 \\
0.2598 \\
0.2677 \\
0.0439 \\
0.1778
\end{bmatrix} = (0.29, 0.30, 0.29, 0.02)
\]

2) For technical one-factor evaluation

\[
S_2 = (0.2722, 0.2266, 0.3183, 0.0508, 0.1321)
\]

3) One-factor evaluation of environmental factors

\[
S_3 = w_3 \times R_3 = \begin{bmatrix}
0.2 & 0.2 & 0.6 & 0 \\
0.1 & 0.6 & 0.3 & 0 \\
0.2 & 0.7 & 0.1 & 0 \\
0.3 & 0.5 & 0.1 & 0.1
\end{bmatrix} \times \begin{bmatrix}
0.2216 \\
0.1553 \\
0.3421 \\
0.2812
\end{bmatrix} = (0.21, 0.52, 0.24, 0.28)
\]

(4) Fuzzy comprehensive evaluation of power grid planning projects
The membership matrix of the secondary indicators is integrated with the weight values to obtain the membership matrix of the primary indicators as follows:

\[
R = \begin{bmatrix}
0.29 & 0.40 & 0.29 & 0.02 \\
0.13 & 0.38 & 0.37 & 0.12 \\
0.21 & 0.52 & 0.24 & 0.28 \\
\end{bmatrix},
\]

According to the analytic hierarchy process, the weight vector of the first-level indicator is calculated as \( W = (0.2855, 0.1414, 0.1294, 0.1737, 0.1566, 0.1134) \)

\[
S = W \times R = (0.3898, 0.3597, 0.2414)
\]

3.3 Analysis of Evaluation Results

According to the principle of maximum membership degree, it can be judged that the comprehensive evaluation grade of the power grid planning project is at the second level, and the evaluation result is good. The single factor evaluation result of technical indicators is better, and the single factor evaluation result of environmental indicators is better, which makes the comprehensive evaluation of the power grid planning project develop better, but the economic index evaluation is close to the general and should be paid close attention. In summary, the power grid planning project has achieved the expected results and can be effectively applied to the production and operation of the power grid. The results of this project will be of reference to other power grid planning projects.

4. Conclusion

In this paper, the research status quo of the comprehensive evaluation theory of power grid projects at home and abroad is discussed in detail. The theory combines the actual and quantitative matching qualitative principles to construct a comprehensive evaluation model of power grid project based on attribute mathematics, and comprehensively evaluates the power grid planning project. Empirical analysis. In turn, provide corresponding guidance for the planning and construction of power grid projects.

Acknowledgements

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References


