Power System Risk Research Based on Entropy Weight Matter Element Extension Model

Yan Song¹, Hongwei Yang¹, Nan Xu¹, Dongchao Wang¹, Yongli Wang² and Shanshan Song²

¹ Economic Technology Research Institute, State Grid Hebei Electric Power Supply Co. LTD, shijiazhuang, 050021, China;
² North China Electric Power University, Changping Beijing, 102206, China

Abstract. With the rapid development of the national economy and the gradual improvement of people's living standards, the demand for electric energy in various fields is constantly increasing. In order to meet the growing demand for electricity, it is necessary to increase the level of power security. Based on the characteristics of power grid projects, this paper analyzes the shortcomings of previous power grid project risk assessment methods, proposes a matter-element extension analysis model based on entropy weight method, evaluates grid project risks and introduces related functions and correlations and scalability. Finally, the empirical analysis is carried out in conjunction with a Chinese urban power grid plan. The results show that the method has strong feasibility and practicability.

1. Introduction

The planning and design project of the power grid not only requires a lot of capital, but also has a fixed and one-time. After the completion of the project, it is difficult to modify the power grid again. Therefore, an unreasonable decision on the power grid planning project will not only result in waste of funds, but also a series of negative social and environmental impacts. In the process of project decision-making, if only considering an economic evaluation indicator or the expected result of the proposed basic plan is to meet the requirements, regardless of the existing risks, it may lead to huge losses.

Through the analysis of the research status, it shows that although the research on the risk management of power grid planning has developed in recent years, the theory and technology of the urban grid planning risk avoidance method and analysis evaluation model under the new electricity market situation. There are not many studies, and it is urgent to study the evasive methods and analytical evaluation models suitable for China's urban power grid planning risks. These actions have great application value and far-reaching impact on the formulation of urban power grid planning in China. The literature [1-3] proposes how to construct a risk assessment index system for power grid construction projects. At the same time, after determining each indicator, the AHP is used to empower the index system, and finally a comprehensive assessment, in which the overall project risk score is the sum of the risk-based score of each risk point. At present, there are three common types of risk assessment methods, namely quantitative analysis, qualitative analysis, qualitative analysis and qualitative analysis. The specific methods include analytic hierarchy process, fuzzy analytic net process, expert grade method and risk matrix analysis method [4-5].
In view of the fact that China's power grid construction projects are in the new power reform period, there will be a new risk situation for the entire power grid construction, and the theoretical system for this system has not yet formed a system. Therefore, based on the risk assessment of power grid construction engineering at home and abroad, this paper takes the power enterprise distribution network project as the research object to construct the risk of distribution network project. Analyze the model and the characteristics of China's power enterprise distribution network project, and identify its risk indicators. At the same time, use the combination of qualitative and quantitative analysis methods, use the matter element extension model based on entropy weight, introduce the correlation function and correlation degree in the extension set, establish the indicator system of urban power grid planning risk and the matter element evaluation model for a certain city power grid risk assessment[6].

2. Evaluation model based on entropy weight matter element extension

2.1 Matter matrix setting

(1) Grid project risk rating evaluation M, comprehensive evaluation feature c and eigenvalue x, grid project risk rating evaluation object R, recorded as R = (N, c, x), if N has more than n features, each The corresponding magnitude of the feature is x, which is expressed as:

\[
R = \begin{bmatrix}
M_1 \\
M_2 \\
\vdots \\
M_n
\end{bmatrix} = \begin{bmatrix}
U & c_1 & x_1 \\
c_2 & x_2 \\
\vdots \\
c_n & x_n
\end{bmatrix}
\] (1)

(2) The grid function risk rating evaluation index correlation function is defined as:

\[
K_j(V_i) = \begin{cases}
\frac{-\rho(x, X)}{b - a} & x \in X \\
\frac{\rho(x, X)}{\rho(x, Y) - \rho(x, X)} & x \not\in X, x \in Y
\end{cases}
\] (2)

Where: \(K_j(V_i)\) indicates correlation degree of the i-th indicator corresponding to the j-level comprehensive evaluation level.

\[
\rho(V_i, V_{ij}) = \left| V_{dn} - \frac{1}{2} (b_{in} + a_{in}) \right| - \frac{1}{2} (b_{in} - a_{in}) (i = 1, 2, \ldots n; j = 1, 2, \ldots n)
\] (3)

\[
\rho(V_i, V_{pn}) = \left| V_{dn} - \frac{1}{2} (b_{pn} + a_{pn}) \right| - \frac{1}{2} (b_{pn} - a_{pn}) (i = 1, 2, \ldots n)
\] (4)

Where: \(V_i, V_{ij}\) respectively represents the range of magnitudes of the classical field and the joint domain of the matter element power network projects to be evaluated; \(\rho(V_i, V_{ij})\) represents the distance between point \(V_i\) and the corresponding feature vector finite interval \(V_{ij}\); \(\rho(V_i, V_{pn})\) represents the distance between the point \(V_i\) and the corresponding feature vector finite interval \(V_{pn}\).

2.2. Setting of entropy weight assignment method

(1) Establishment of indicator matrix system

There are n schemes, that is, n evaluation targets, and m production and operation indicators, that is, m evaluation indicators, the initial indicator matrix is as follows:
\[
\begin{bmatrix}
X_{11} & X_{12} & X_{13} & \cdots & X_{1m} \\
X_{21} & X_{22} & X_{23} & \cdots & X_{2m} \\
X_{31} & X_{32} & X_{33} & \cdots & X_{3m} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
X_{n1} & X_{n2} & X_{n3} & \cdots & X_{nm}
\end{bmatrix}
\]  

(6)

Where: \(X_{ij}\) indicates the jth production and operation index of the i-th scheme.

(2) Non-dimensionalization of indicators

Let the matrix after the dimensionlessness be: \(Y = \{y_{ij}\}\). The formula for the dimensionless matrix is:

\[
y'_{ij} = \frac{x_{ij}}{\max \{x_i\}}
\]  

(7)

(3) Weight distribution

Generally speaking, the greater the difference between the index value of an indicator in the comprehensive evaluation and the optimal value of the index, the smaller the information entropy, the greater the weight of the indicator, indicating that the indicator provides a larger amount of information. At the same time, each evaluation object has obvious differences in the entropy of the index, and should be considered mainly. Otherwise, the smaller the weight of the indicator, the smaller the amount of information provided. The specific calculation process is as follows:

1) Calculate the proportion of the jth indicator of the a-th object to the indicator:

\[
p_{ij} = \frac{y_{ij}}{\sum_{i=1}^{n} y_{ij}}
\]  

(8)

Where: \(y_{ij}\) is the element of the normalized decision matrix.

2) Calculate the entropy of the jth indicator:

\[
e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} p_{ij} \ln p_{ij}
\]  

(9)

In the formula, \(p_{ij}\) is the proportion of the jth indicator of the i-th object to the index.

3) Calculate the difference coefficient of the jth indicator:

\[
g_j = 1 - e_j, 0 < g_j < 1
\]  

(10)

Where: \(e_j\) is the depreciation of the jth indicator. For the j-th index, the larger the coefficient of variation of the indicator value, the greater the effect on the evaluation of the scheme, and the smaller the depreciation.

4) Calculate the weight of the jth indicator:

\[
w_i = \frac{g_j}{m - E_e}, \quad E_e = \sum_{i=1}^{n} e_j
\]  

(11)

Where \(0 < w_j < 1, \sum_{i=1}^{n} w_j = 1, g_j\) is the coefficient of variation of the jth indicator, and \(e_j\) is the depreciation of the jth indicator.

3. Case analysis

First, establish a grid project risk rating indicator system, which determines the feasibility and scientificity of the evaluation model. Based on the characteristics and evaluation objectives of grid project risk management, this paper starts with the four dimensions of external factors, project management,
technical level and market factors, and establishes an overall response level evaluation index system. Table 1 shows the indicator system for the risk rating of grid projects.

### Table 1. Grid project risk rating evaluation index system

| Target layer | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 |
|--------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| Three-level indicator layer (Indicator layer) | Summer air conditioning electricity risk | Natural disaster risk | Risk of terrorist attacks | Organizational risk | Risk of quality hazard | Man-made damage | Load forecasting deviation | Design reliability | Distributed power access risk | Land acquisition and house demolition risk | Equipment price risk | Load fluctuation risk |
| | 0% | 84% | 95% | 84% | 95% | 84% | 95% | 84% | 95% | 84% | 95% | 84% |

This section describes a case study of a 220KV power transmission and transformation project in an autonomous region of China. The data used in this paper is derived from the feasibility study report of the autonomous region's power grid construction project. Table 2 shows the indicators for the items to be evaluated.

### Table 2. Collection of indicators to be evaluated

| Index | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 |
|-------|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| Value | 3.3 | 3.21 | 1.05 | 84% | 2.38 | 2.65 | 4% | 2.5 | 2.6 | 2.05 | 2.82 | 2.5 |

3.1. Index weight calculation

A project risk impact factor can be divided into several levels, and how to determine the weight between the same level after qualitative identification of each risk event factor is the basis for our quantitative analysis of risk. In this section, the weights of the evaluation indicators are calculated according to Section 2.2, and the results of calculating the weights of each indicator are shown in the table below.

### Table 3. Grid project risk grade evaluation index weight table

| Evaluation factor | Weights | Indicator system | Weights |
|------------------|---------|------------------|---------|
| External force factor B1 | 0.138093 | A1 | 0.074791 |
| | | A2 | 0.062471 |
| | | A3 | 0.000831 |
| | | A4 | 0.417673 |
| Project Management B2 | 0.449934 | A5 | 0.011878 |
| | | A6 | 0.020383 |
| | | A7 | 0.328553 |
| Technical level B3 | 0.362097 | A8 | 0.015100 |
| | | A9 | 0.018443 |
| | | A10 | 0.006139 |
| Market factor B4 | 0.049876 | A11 | 0.028637 |
| | | A12 | 0.015100 |

3.2. Relevance evaluation
According to the evaluation index of the risk level of the grid project, the indicators are divided into five indicators, namely, risk-free (Level I), low risk (Level II), general risk (Level III), high risk (Level IV) and high risk. 5 assessments (Level V). The relevance of this level is shown in the following table:

| Index | Level I | Level II | Level III | Level IV | Level V |
|-------|---------|----------|-----------|----------|---------|
| A1    | -0.030718 | -0.006233 | 0.011219 | -0.025429 | -0.039532 |
| A2    | -0.025472 | -0.003836 | 0.006559 | -0.022365 | -0.033823 |
| A3    | -0.000038 | 0.000021 | -0.000540 | -0.000656 | -0.000706 |
| A4    | -0.334139 | -0.306294 | -0.250604 | -0.083535 | 0.083535 |
| A5    | -0.004360 | 0.003682 | -0.002455 | -0.006224 | -0.007840 |
| A6    | -0.007821 | 0.003567 | -0.002378 | -0.009580 | -0.012667 |
| A7    | -0.005663 | 0.003775 | -0.002517 | -0.007550 | -0.009707 |
| A8    | -0.007026 | 0.003689 | -0.002459 | -0.008853 | -0.011593 |
| A9    | -0.002079 | 0.002916 | -0.001944 | -0.003622 | -0.004341 |
| A10   | -0.011233 | 0.002577 | -0.001718 | -0.012486 | -0.017100 |
| A11   | -0.005663 | 0.003775 | -0.002517 | -0.007550 | -0.009707 |

As can be seen from the above table, each evaluation index has a corresponding value, and each has a certain evaluation level, and the size of the correlation degree indicates the degree of the indicator.

### 3.3. Project risk assessment level

According to the model in Chapter 2, the membership of each evaluation index relative to the risk level is calculated as shown in Table 5.

| Category | Evaluation project |
|----------|--------------------|
| B1       | -0.081700          |
| B2       | -0.346319          |
| B3       | -0.122206          |
| B4       | -0.018975          |

Table 6 lists the degree of membership of each object to be evaluated with respect to the risk level.

| Evaluation level | Comprehensive relevance | Extension index | Risk level |
|------------------|-------------------------|-----------------|------------|
| Level I          | -0.5437282541           |                 |            |
| Level II         | -0.1828422305           | 3.317264734     | Level II   |
| Level III        | -0.3150641133           |                 |            |
According to the calculation results in Table 6, the comprehensive correlation degree of the risk grades of I, II, III, IV and V of this grid project is -0.54, -0.18, -0.31, 0.38, -0.28, respectively. It can be seen that the comprehensive correlation degree of risk assessment level II is the largest. According to the principle of maximum membership, the risk level of the project to be evaluated is two, and the project risk is small.

4. Conclusion
This paper establishes an object-based extension evaluation model based on entropy weight, evaluates the risk level of the grid project, and analyzes the feasibility of the model through case verification, and provides a new method for solving similar problems for the safe operation of the grid. Raising the structure of the power grid has made new ideas safer, more reliable, and more economical.

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