Evaluation of bidding risk for wind farm construction projects

Liu Shanshan¹

¹North China Electric Power University, Beijing 102206, China

*Corresponding author’s e-mail: liushanahan@foxmail.com

Abstract: With the rapid development and expansion of wind power generation capacity in China, the risk of wind farm construction projects has been paid more and more attention. Based on the method of can-expandable element and multi-level fuzzy comprehensive evaluation method, this paper makes an empirical analysis of the bidding risk of the wind farm construction project of Xintiandi Energy Company in Hebei Province. The research shows that the can-expander element method is more accurate in risk evaluation because there are no different evaluation principles, which can provide effective support for decision makers.

1. Introduction
Since 2000, China’s installed wind power capacity has been rising steadily. In 2018, China added 21,183MW of wind power, with a total installed capacity of 2,098,533MW (figure 1), ranking first in the world for many years. By the end of September 2019, the cumulative grid-connected capacity of wind power in China had reached 209,546MW, accounting for about 4.79% of the country’s electricity generation. From January to September 2019, the country’s wind power infrastructure will add 6,550MW of power generation capacity. Wind power completed an investment of 59.8 billion yuan, up 73% year on year.

Figure 1. China's total installed capacity of wind power and its growth rate from 2005 to 2018
With the expansion of wind power installed capacity, the risks faced by wind farm construction projects in China are also getting more and more attention. All along, domestic and foreign scholars mainly pay attention to bidding and bidding, evaluation of bids and bids analysis, project bidding risk identification and strategic research, but less research on wind farm construction projects bidding and risk evaluation. Based on the study of the risk identification, risk evaluation and risk management measures of domestic and foreign construction projects, this paper mainly discusses the risk factors of bidding for wind farm construction projects in China, and establishes a comprehensive evaluation index system of bidding risk for wind farm construction projects. Taking the bidding work of the wind farm construction project of Hebei Xintiandi Energy Company as a case, the bidding risk is evaluated by the method of can be expanded.

2. Calculation model

![Diagram](2. Wind farm bidding risk evaluation index system)

2.1. Construction of the index system of bidding risk evaluation for wind farm construction projects

Through the analysis of the relevant references for the evaluation of bidding risk steam in wind farms at home and abroad, combined with the actual experience of engineering managers, we can construct a system of bidding risk evaluation for junior wind farms, and set the index system as a questionnaire and send it to relevant experts. Using Delphi method to screen and supplement the bidding risk evaluation index system of primary wind farm, we obtain the bidding risk evaluation index system for wind farm.
construction projects (see Figure 2). The system consists of three secondary indicators, such as the risk index (U1) in the bidding preparation stage, the risk index (U2) in the stage of bidding implementation and the risk index of the phase of the calibration phase (U3), the technical risk, the social environment risk, the management ability risk, the assessment risk and the contract risk, and the 13 four-level indicators.

2.2 The idea and model of the analysis and calculation of the can-explore element method
At present, the methods of risk evaluation for wind farm construction projects have their own characteristics and shortcomings. The scale, location and process of wind farm construction projects are different, and the problems encountered are also different. The factors influencing the bidding process may come from multiple aspects. In the evaluation process, we often ignore the mutual exclusion between indicators in the risk evaluation system. Therefore, when selecting the risk evaluation model of wind farm construction project bidding, it is necessary to take into account the correlation of each index, so that the model can be more comprehensive and accurate. In this paper, the extension matter-element method is used to establish a multilevel matter-element model by taking the risk level, evaluation index and characteristic value of bidding for wind farm construction projects as matter-element.

The basic principle of the graphable element method is: First, based on the existing data, the evaluation object is divided into several levels, and based on the expert opinion or combination of data in the database, to determine the range of data values at each level. Secondly, the evaluation object’s index value is composed to the data set of each level specified above. Based on this step, the evaluation index and evaluation are analyzed. Finally, compared with each grade group, the correlation value of each indicator is calculated to determine the range of data values at each level. Second, the correlation degree is larger, the consistency of the indexes and their hierarchical set is better. Specific steps are shown in figure 3:

![Figure 3. Concrete steps for comprehensive evaluation of can-explore elements](image)

In this paper, when using the potential element method to evaluate the bidding risk status of wind farm construction projects, the bidding risk is divided into 5 levels: large, large, general, small, very small. Represented by \( N_i (i = 1, 2, 3, 4, 5) \).

1) Build a classic domain, mainly for four levels of metrics.

\[
R_j = (N_j, c_i, v_{ji}) = \begin{bmatrix} N_j & c_1 & v_{j1} \\ c_2 & v_{j2} \\ \vdots & \vdots \\ c_n & v_{jn} \end{bmatrix} = \begin{bmatrix} N_j & c_1 & < a_{j1} \cdot b_{j1} > \\ c_2 & < a_{j2} \cdot b_{j2} > \\ \vdots & \vdots \\ c_n & < a_{jn} \cdot b_{jn} > \end{bmatrix} (1)
\]

in the formula, the \( R_j \) represents the ith element of \( R \), \( N_j \) represents the jth level of the division of things, \( c_i \) represents the ith characteristic of the thing, \( v_{ji} \) represents the value range of the \( N_j \) on the \( c_i \), that is, the classical domain is determined.

2) Build section domain

Section domain, i.e. the level of bidding risk all about the value range of all features.

\[
R_j = (N_j, c_i, v_{ji}) = \begin{bmatrix} N_j & c_1 & v_{j1} \\ c_2 & v_{j2} \\ \vdots & \vdots \\ c_n & v_{jn} \end{bmatrix} = \begin{bmatrix} N_j & c_1 & < a_{j1} \cdot b_{j1} > \\ c_2 & < a_{j2} \cdot b_{j2} > \\ \vdots & \vdots \\ c_n & < a_{jn} \cdot b_{jn} > \end{bmatrix} (2)
\]
in the formula, prepresents the full level of bidding risk, that is, the whole level of the object to be evaluated, $v_{pi}$ indicates p about the range of value stakes for $c_i$, that is, the section domain is determined.

3) Establishing the object of bidding risk

The object to be evaluated in this paper is the bidding risk of wind farm construction project, therefore, the object of bidding risk is shown as shown in (3).

$$R_0 = \begin{bmatrix} P_0 & c_1 & v_1 \\ c_2 & v_2 \\ \vdots & \vdots \\ c_n & v_n \end{bmatrix}$$ (3)

in the formula, $R_0$ represents the object of the bidding risk, $c_i$ represents the ith characteristic of the bidding risk, $v_i$ indicates the specific data obtained $p_0$ the $c_i$.

4) Determining the weight of the bidding risk evaluation indicators at all levels

In this paper, the sequential relationship method empowers the three secondary indicators included in the bidding risk evaluation index system of wind farm construction projects, and the characteristic value method empowers the three-level index of bidding risk evaluation index system of wind farm construction projects. Using the value-based iterative method to calculate the weight coefficient of the four-level index of bidding risk evaluation index system of wind farm construction projects, the calculation is simple and intuitive, the calculation amount is reduced exponentially, and the AHP method is complicated to calculate, limited by the number of indicators.

5) Establish an association function to calculate the value of the association function

An association function is established between the various indicators of bidding risk and the level of the association, and the value of the association function is represented as shown in (4).

$$K_j(v_i) = \begin{cases} \frac{-\rho(v_i, v_{ji})}{|v_{ji}|}, & v_i \in V_{ji} \\ \rho(v_i, v_{ji}) - \rho(v_i, v_{pj}), & v_i \notin V_{ji} \end{cases}$$ (4)

in the formula, $K_j(v_i)$ indicates the correlation function value of the ith risk evaluation indicator in the bidding risk evaluation index system for the j risk level. $\rho(v_i, v_{ji})$ represents the distance between the i-th bidding risk evaluation and the classical domain, $|v_{ji}|$ represents the distance of the ith bid risk evaluation indicator on the classic domain of the j risk level, $\rho(v_i, v_{pj})$ represents the distance between the value of the subject matter element and the node domain of the i-th bidding risk evaluation.

Therefore, the correlation between the levels of bidding risk to be evaluated is indicated as shown in (5).

$$K_j(p_0) = \sum_1^n \omega_i K_j(v_i)$$ (5)

6) Make a risk level determination

When the $K_j(p_0)$ meets (6) relationship, the bid risk element $p_0$ is the No. j risk level.

$$K_j(p_0) = \max\{K_j(p_0)\} \quad j = 1, 2, \ldots, m$$ (6)

3. Case analysis

Taking the Xintiandi wind farm project in Hebei province as an example, this paper applies the bidding risk evaluation system of wind farm construction project constructed in this paper to practical work, and evaluates the bidding risk of this project.

Based on the experience and research results of the relevant staff and researchers on the historical bidding work of wind farm construction projects, the experts are invited to rate the importance of the different stages of the bidding process, and finally determine the ratio of the risk of the phase of the fixed label (U3) to the risk of the bidding stage (U1) is 1.2. The ratio of the phase risk (U2) to the phase risk (U3) of the bid implementation phase is 1.1. According to the sequential relationship method, the weight of the secondary indicator can be calculated, the specific value is shown in (7).
The three-level indicator syllable results and the weighting of each indicator are shown in Table 1, based on the opinions of each expert.

Table 1. Three-level index weight of bidding risk evaluation based on listed and countering wind farm construction projects

| Expert | $U_{111}$ | $U_{112}$ | $U_{113}$ | $U_{121}$ | $U_{122}$ | $U_{123}$ | $U_{211}$ | $U_{212}$ | $U_{213}$ | $U_{311}$ | $U_{312}$ | $U_{313}$ | $U_{321}$ | $U_{322}$ |
|--------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 1      | 1         | 1         | 1         | 0         | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 1         | 0         | 1         |
| 2      | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 0         | 1         |
| 3      | 0         | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 0         | 1         |
| 4      | 1         | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 0         | 1         |
| 5      | 1         | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 0         | 1         |
| 6      | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 0         | 1         |
| 7      | 1         | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 0         | 1         |
| 8      | 1         | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 0         | 1         |
| 9      | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 0         | 1         |
| 10     | 1         | 0         | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 1         | 0         | 1         |

The 10 invited experts are invited to select the 10 most important risk factors from the risk indicator system constructed in this paper. The specific screening results are shown in Table 4.

Table 2. Four-level index weight of bidding risk evaluation of wind farm construction projects based on value iteration method

| Index | Characteristic | Large | Average | Small | Very small |
|-------|----------------|-------|----------|--------|------------|
| $U_{11}$ | $c_1$ | -0.40 | 0.00 | 0.00 | -0.40 | -0.57 |
| $U_{11}$ | $c_2$ | -0.33 | 0.50 | -0.33 | -0.60 | -0.71 |
| $U_{11}$ | $c_3$ | -0.50 | -0.50 | -0.75 | -0.83 | -0.88 |
| $U_{12}$ | $c_4$ | -0.25 | 0.50 | -0.25 | -0.50 | -0.63 |

Based on the weight coefficient of the indicators at all levels obtained from the above calculation, we can combine the weight coefficient of the four-level indicator relative to the overall evaluation of the bidding risk, as shown in the equation (8).

$$A_4 = (0.055, 0.062, 0.055, 0.032, 0.028, 0.047, 0.179, 0.201, 0.037, 0.122, 0.071, 0.039, 0.070)$$

Since the evaluation index value of bidding risk of the wind farm construction project is within the classical domain of 5 risk levels, the correlation degree is calculated directly according to formula (4), as shown in Table 3.

Table 3. Correlation degree of bidding risk level of wind farm construction projects based on the method of expansionable element
Calculating the correlation degree of bidding risk levels for wind farm construction projects based on formula (5), as shown in formula (9) - (13).

\[
K_1(p) = \sum_{i=1}^{13} \omega_i K_1(v_i) = -0.338 \\
K_2(p) = \sum_{i=1}^{13} \omega_i K_2(v_i) = 0.091 \\
K_3(p) = \sum_{i=1}^{13} \omega_i K_3(v_i) = -0.121 \\
K_4(p) = \sum_{i=1}^{13} \omega_i K_4(v_i) = -0.480 \\
K_5(p) = \sum_{i=1}^{13} \omega_i K_5(v_i) = -0.624
\] (9) (10) (11) (12) (13)

The correlation between the various risk levels of the bidding work obtained from the above calculation shows that, \( K_2(p) = \max\{K_j(p)\} \) \((j = 1, 2, 3, 4, 5)\). Therefore, the risk level of bidding risk work of the wind farm construction project is large, which indicates that there is a greater bidding risk in the construction process of this wind farm project. The risk level for each risk factor is calculated separately as shown in Table 4.

| \(U_{11}\) | \(c_5\) | -0.25 | 0.50 | -0.25 | -0.50 | -0.63 |
| \(U_{12}\) | \(c_6\) | -0.33 | 0.00 | 0.00 | -0.33 | -0.50 |
| \(U_{21}\) | \(c_7\) | -0.33 | 0.50 | -0.33 | -0.60 | -0.71 |
| \(U_{21}\) | \(c_8\) | -0.40 | 0.00 | 0.00 | -0.40 | -0.57 |
| \(U_{31}\) | \(c_9\) | 0.00 | 0.00 | -0.50 | -0.67 | -0.75 |
| \(U_{31}\) | \(c_{10}\) | -0.43 | -0.20 | 0.50 | -0.20 | -0.43 |
| \(U_{31}\) | \(c_{11}\) | -0.40 | 0.00 | 0.00 | -0.40 | -0.57 |
| \(U_{32}\) | \(c_{12}\) | -0.43 | -0.20 | 0.50 | -0.20 | -0.43 |
| \(U_{32}\) | \(c_{13}\) | 0.00 | 0.00 | -0.67 | -0.80 | -0.86 |

**Table 4. Risk levels for each risk factor**

| Risk in tender preparation stage | Risk in the implementation stage of bidding | Risk of contract signing stage |
|----------------------------------|-----------------------------------------|--------------------------------|
| Technical risk                  | Social environmental risk               | Management ability risk | Evaluation | Contract risk |
| \(K_1(p)\)                     | -0.070                                  | -0.031                                    | -0.139      | -0.081       | -0.017       |
| \(K_2(p)\)                     | 0.004                                   | 0.03                                      | 0.090       | -0.024       | -0.008       |
| \(K_3(p)\)                     | -0.062                                  | -0.015                                    | -0.059      | 0.043        | -0.027       |
| \(K_4(p)\)                     | -0.105                                  | -0.046                                    | -0.188      | -0.078       | -0.064       |
| \(K_5(p)\)                     | -0.124                                  | -0.061                                    | -0.242      | -0.121       | -0.077       |
| Level 3 risk index             | \(K_2\)                                 | \(K_2\)                                   | \(K_2\)     | \(K_3\)      | \(K_2\)      |
| Level 2 risk index             | \(K_2\)                                 | \(K_2\)                                   | \(K_2\)     | \(K_2\)      | \(K_2\)      |

In summary, the three stages of the bidding process of the wind farm construction project are level two, among which, the bidding implementation stage risk is the highest, the label is about the minimum risk of the stage, the bidding preparation stage risk is in the first two. In the bidding process of the construction of the wind farm, the preparation of the stage of the labeling and the preparation stage of the bidding is slightly inadequate, and the corresponding risk prevention measures should be taken in time.

**4. Conclusion**

Based on matter-element theory, this paper constructs the risk evaluation system of bidding for wind farm construction projects and applies it to wind power projects under construction. The research shows
that the bidding risk of Xintiandi wind farm construction project is relatively high, among which the risk of the bidding implementation stage is the greatest, and the risk of the bid selection and signing stage is the least, so enough attention should be paid to the bidding implementation stage. Due to the existence of different evaluation criteria, the extension matter-element method is more accurate in the evaluation of bidding risks, which facilitates managers to formulate response strategies for specific risk situations and helps to improve the effectiveness of decision-making.

References
[1] Qin H.Y. (2017) The future of wind power in China is limitless. Energy information research, 10:25-30.
[2] Meng Z.S. (2019) Risk analysis and management in the bidding stage of power engineering construction. Development Guide to Building Materials, 17:321.
[3] Ding H. (2019) Analysis of the problems existing in the bidding management of construction projects and countermeasures. Mechanical and Electrical Information, 24:152-153
[4] Chorn L.G., Shokhor S. (2006) Real options for risk management in petroleum development investments. Energy Economics, 28:489-505.