Application of hybrid MCGDM model combined with VIKOR method in power grid equipment optimization

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Abstract. The evaluation index of national grid equipment procurement source value system has multi-dimensional, multilateral and multi-attribute characteristics which can cause problems, in order to solve these problems and find out optimize grid equipment suppliers, this paper put forward a hybrid multi-criteria group decision-making (HMCMDM) model combined with VIKOR algorithm. Firstly, constructing the index stereo network and introducing the intuitionistic fuzzy number (IFN) into the model in order to avoid the hard division of the decision judgment matrix. Secondly, using the ANP algorithm to calculate the joint-edge relationship value of each index at individual layers, and constructing the weighted super matrix to calculate the subjective weight value of the bottom indexes. Then, calculating the objective weight value of the bottom evaluation index by using Entropy method, and combining it with the subjective weight value to modify the overall weight value. Finally, using the VIKOR algorithm to rank the alternative programmes, and making comparison with the model formed through the TOPSIS method. The results show that the VIKOR algorithm can calculate the weight values of the bottom indexes in the complex relational network objectively and effectively, and having a good applicability for the equipment optimization.

1. Introduction

With the rapid growth of the economy, the demand for social electricity consumption is increasingly growing. The power grid has become the lifeline of the national economy and the pillar industry of energy security. Therefore, its construction and development are vital important, and the purchasing demand for the power materials also needs to be improved [1-2]. According to these, searching for an optimal power grid equipment is not only a vital thing for keeping the enterprise’s supply chain system stable, but also meaningful for guaranteeing the reliability of this enterprise.

In terms of the particularity of power grid construction, it is necessary to take various factors into account during the process of constructing the index system of procurement source value. Eventually, these index elements can form a multilateral, multi-element, multi-attribute and multi-dimensional network structure. Scholars have made a series studies on the calculation methods of evaluation index weight value. Based on the AHP [3], Saaty proposes the Analytic Network Process (ANP), which consists of the independent units and specific feedback [4]. And Dr. Tang supposes to construct a fuzzy super-matrix by using triangular fuzzy numbers. In this way, the problems of fuzzy and hard partition in ANP judgment matrix can be solved [5]. The essence of equipment selection process is the ranking of alternative evaluation information, commonly used preferential decision models are divided
into VIKOR (Vlsekriterijumska Optimizacija I Kompromisno Resenje) and TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) [6-7].

These researches can solve the problem of mutual independence among the element groups at each layers in the evaluation index system, during the process of optimizing the traditional equipment to a certain extent. However, some problems still exist: 1) Even though the traditional fuzzy method improves the hard division of the index judgment value at some kind, it cannot describe the hesitation degree of the ambiguity; 2) The ANP method only uses subjective evaluation information to calculate the bottom index weight value, and ignoring the quantitative index has the objective data information; 3) It lacks of the stability analysis towards the preferential model in the empirical cases.

In order to solve the problems mentioned before, this paper proposes an HMC-GDM model combined with the VIKOR algorithm, which is used for procurement and optimization of power grid equipment. The remaining content of this paper is organized in the following order: Section 2 illustrates the overall research framework; Section 3 describes the HMC-GDM-VIKOR model; Section 4 provides an empirical case analysis through a grid device; Section 5 presents the discussions and conclusions.

2. Research framework
The technical route framework of the power grid equipment optimization decision model is shown in Figure 1. The left-hand-side block shows the solution route of subjective weight value of evaluation index based on DEMATEL-IFN-ANP. And the right-hand-side block describes the technical route of calculating objective weight value based on the entropy method.

![Figure 1. The technical framework of the power grid equipment optimization decision model.](image)

3. The HMC-GDM-VIKOR model

3.1. Solution of subjective weights of multi-attribute indicators based on IFN-ANP
The judgment matrix in the ANP model is the basic object for calculating the influence degree between specific indexes from multi dimensions [4][8]. In order to solve the problem of decision-makers’ subjective limitations when they make judgment towards the importance indexes, an
intuitionistic fuzzy theory is proposed to describe the importance of elements/element groups [9-10]. Thus, the IFN model can be represented by a formula shown in Eq. (1).

$$A = \left[ x, u_a(x), \gamma_a(x) \right]_{x \in X}$$ (1)

According to Eq. (1), $u_a(x)$ is the membership function of the element $x$ for the set A, and $\gamma_a(x)$ is the non-membership function of the element $x$ for the set A. Therefore, it can be expressed as followed:

$$ u_a(x): X \rightarrow [0,1], x \in X \rightarrow u_a(x) \in [0,1] 
\gamma_a(x): X \rightarrow [0,1], x \in X \rightarrow \gamma_a(x) \in [0,1]$$ (2)

In Eq. (2) $x \in X$, $0 \leq u_a(x) + \gamma_a(x) \leq 1$. Meanwhile, the intuition fuzzy hesitation value on set A is shown in Eq. (3).

$$\pi_a(x) = 1 - u_a(x) - \gamma_a(x) \cdot (0 \leq \pi_a(x) \leq 1)$$ (3)

Therefore, $\alpha = (u_a, \gamma_a, \pi_a)$ can be named as IFN value.

Based on IFN and ANP relationship structure model to calculate the underlying index weights [11-12], the process is as follows:

**Step1:** Construct the judgment matrix for IFN scale. Setting the control layer element $P_i (i = 1, \ldots, n)$ as the criterion, then constructing an IFN judgment matrix based on the influence degree of the elements in the element group $C_i$ to the element $e_{jl}(l=1,2,\ldots,n_j)$ in $C_j$. The IFN transformation value is shown in Table 1, which indicates the importance degree of $\alpha_i$ relative to $\alpha_j$. And then, the normalized eigenvector of the matrix is calculated by the Eigen root method.

| Table 1. IFN comparison table. |
|--------------------------------|
| IFN Division definition Language variable | \begin{aligned} E_1(0.05,0.40,0.10) & \text{equal general} \\ E_2(0.05,0.95,0.00) & \text{[equal, slightly]} \text{ extremely poor} \\ E_3(0.15,0.80,0.05) & \text{slightly important} \text{ very poor} \\ E_4(0.25,0.65,0.10) & \text{[slightly, obviously]} \text{ poor} \\ E_5(0.35,0.55,0.10) & \text{obviously} \text{ minimally poor} \\ E_6(0.65,0.25,0.10) & \text{[obviously, mightily]} \text{ minimally good} \\ E_7(0.75,0.15,0.05) & \text{mightily} \text{ good} \\ E_8(0.85,0.10,0.05) & \text{[mightily, extremely]} \text{ very good} \\ E_9(0.95,0.05,0.00) & \text{extremely} \text{ extremely good} \end{aligned} |

**Step2:** Calculate the weight value of each factor and normalize it. According to the judgment matrix between element groups, the normalized weight value of element $C_{jh}$ in $C_j$ group to $C_{ih}$ in the $h$.th element in $C_j$ can be calculated, the formula is as shown in Eq.(8).

$$ w_{ih}^a = s(c_{ih}^a) \sqrt{\sum_{i=1}^n c_{ih}^a} $$ (4)

In Eq. (4), $c_{ih}^a$ is the importance degree value and $s(c_{ih}^a)$ is the score function. Then, it can derive the formula shown in Eq. (5).

$$ c_{ih}^a = \left( 1 - \prod_{x=1}^n (1 - \mu_a) \right) \prod_{x=1}^n \gamma_a $$

$$ s(c_{ih}^a) = 1 - \prod_{x=1}^n (1 - \mu_a) - \prod_{x=1}^n \gamma_a $$ (5)

Thus, the normalized weight vector value can be listed as $w_{ih}^a = (w_{ih}^a, w_{i1}^a, L, w_{in}^a)^T$. 


Step3: Consistency test. When $C.R < 0.1$ the consistency of judgment matrix is considered acceptable. There is a formula for $C.R$ shown in Eq. (6).

$$C.R = C.I/R.I.$$  

In Eq. (6), $C.I.$ refers to the consistency test index. Its calculation formula is shown in Eq. (7).

$$C.I. = \frac{(\lambda_{\max} - n)}{(n - 1)}$$  

$$\lambda_{\max} \approx \frac{1}{n} \sum_{i=1}^{n} \sum_{j=1}^{n} E_{ij} W_{j} / W_{i}$$  

According to Eq. (6), the value of $R.I.$ can be found in reference [13].

Step4: Calculate the weight matrix of the bottom element set structure. Repeat Step1-Step3 so that we can obtain the sorting vector of each factor of element group $C_i$ relative to other factors of group $C_j$, and combine vectors $w_{j,i}$ to get fuzzy super-matrix $W_{j}^p$.

Similarly, according to Step4, the influence relationship weight matrices of other element groups is obtained respectively. Then, combining these weight matrices to form a super-matrix $W$.

Step5: Normalize the super-matrix $W$. Setting $P_i$ as a criterion, comparing the relative importance of each two element groups, denoting it as $c_{ij}$. The weight value of fuzzy components between element groups can be calculated by using the same method as Step2-Step4. Finally, the calculated weight of the fuzzy weighted super-matrix is obtained, as shown in Eq. (8).

$$\bar{W} = c_{ij} W_{j}^p (i = 1,...,N; j = 1,...,N)$$

3.2. Objective weight calculation based on entropy method

In order to avoid the one-sidedness of subjective weight value calculation, the entropy method is used to calculate the objective criterion weight value.

Assuming the potential candidate is $A_i (i=1,2,...,n)$, the bottom index is $C_j (j=1,2,...,m)$. There are P experts who make subjective judgements on each candidates based on their empirical experience. And assuming $\lambda_s$ be the weight value of the decision-maker $D_s (s=1,2,...,P)$. Based on the element information data of the evaluation indexes, follow these steps bellowed to calculate the objective weight value by using entropy method [14].

Step1: Alternative programmes’ data collection and classification. The data were divided into objective evaluation information (quantitative data) and subjective evaluation information (qualitative data).

Step2: Dimensionless processing of objective data. If the evaluation data $x_{ij}$ is a positive index, then it can be called benefit type data, named as B; otherwise, it is cost type data which named as C. After the dimensionless processing, $x_{ij}'$ is obtained. Assuming $x_{ij} = x_{ij}'$, the formula is shown in Eq. (9).

$$x_{ij}' = \begin{cases} \left( x_{ij} - \min \{ x_{ij}, \ldots, x_{ij}\} \right) \left( \max \{ x_{ij}, \ldots, x_{ij}\} - \min \{ x_{ij}, \ldots, x_{ij}\} \right), & x_{ij} \in B \\ \left( \max \{ x_{ij}, \ldots, x_{ij}\} - x_{ij} \right) \left( \max \{ x_{ij}, \ldots, x_{ij}\} - \min \{ x_{ij}, \ldots, x_{ij}\} \right), & x_{ij} \in C \end{cases}$$

Step3: Define the weight value of decision-makers. The decision-maker’s objective weight value $\lambda_i$ can be calculated by the formulas:

$$\lambda_i = B_1(\pi) \left( \sum_{j=1}^{c} \left( \sum_{k=1}^{n} \sum_{s=1}^{n} \pi_{ks} \right) \ln \left( \sum_{j=1}^{c} \sum_{s=1}^{n} \pi_{ks} \right) \right)$$

$$B_1(\pi) = -1 \left( \sum_{j=1}^{c} \sum_{s=1}^{n} \pi_{ks} \ln \left( \sum_{j=1}^{c} \sum_{s=1}^{n} \pi_{ks} \right) \right)$$

Step4: Calculation of overall subjective evaluation information. Weighting and integrating the weight value of decision-makers and their corresponding subjective evaluation information, then the subjective group decision information can be obtained by following formula:
\[ x_i = \left( 1 - \prod_{j=1}^{n} (1-u_{ij})^k \cdot \prod_{j=1}^{n} (1-v_{ij})^k \cdot \prod_{j=1}^{n} (1-u_{ij})^k \right) \]

**Step 5:** Calculate the objective weight value of the bottom layer by the entropy value method. Combining the overall subjective data and objective data and calculating the mean value of each alternative programme’s bottom evaluation index, the formula is shown in Eq. (12).

\[ x_i = \left( -\frac{1}{n} \sum_{j \in S_1} x_{ij} \cdot x_{ij} \right) \quad \text{if} \quad x_{ij} \in S_1; \]
\[ x_i = \left( -\frac{1}{n} \sum_{j \in S_1} x_{ij} \cdot x_{ij} \right) \quad \text{if} \quad x_{ij} \in S_2. \]

According to Eq. (12), S1 is a numeric index and S2 is an IFN evaluation value. The entropy value of each bottom index Cj can be calculated by using the formulas shown in Eq. (13).

\[ P_j = d \left( x_j, x^* \right) / \sum_{j \in S} d \left( x_j, x^* \right) \]
\[ H_j = -\ln \left( \frac{1}{n} \sum_{P_j} \ln (P_j) \right) \]

In Eq. (13), \( d \) is the Euclidean distance between \( \alpha, \beta \), which can be calculated by the formula in Eq. (14).

\[ d(\alpha, \beta) = \sqrt{\frac{1}{2} \left( (\alpha - \beta) + (\gamma - \gamma_0)^2 + (\pi - \pi_0)^2 \right)} \]

Then the weight value of each index can be calculated:

\[ w_j = R_j / \sum_{j=1}^{m} R_j \]

In this formula, \( R_j \) is the information entropy redundancy value, and \( R_j = 1 - H_j \).

### 3.3. Weight correction

In order to eliminate the difference between the weight values under various indexes calculated in different ways, the paper will introduce the distance function to make weight value correction. The method can be summarized as follow:

Assume the weight value of \( i \) index element calculated by the ANP method is \( w_{i1} \), and the weight value of \( i \) index element calculated by entropy method is \( w_{i2} \), then the weight distance function of different calculation methods for the same index is:

\[ d(\alpha, \beta) = \sqrt{\frac{1}{2} \left( (\alpha - \beta) + (\gamma - \gamma_0)^2 + (\pi - \pi_0)^2 \right)} \]

\[ d(\alpha, \beta) = (\alpha - \beta)^2 \quad \text{and} \quad \alpha + \beta = 1 \]

In Eq. (17), \( w_j, w_i \) is the allocation coefficient of \( \alpha, \beta \). Therefore, the overall weight value of each index after correction is:

\[ w_j = \alpha \cdot w_{i1} + \beta \cdot w_{i2} \]

### 3.4. VIKOR method

The basic principle of the VIKOR method is based on the Lpmetric's assembly function [15], which is:

\[ L^*_i \left( \left\{ \sum_{j=1}^{m} w_j \left( \left| f_j^* - f_j \right| / \left| f_j^* - f_j^* \right| \right) \right\} \right)^{1/p} \]

Where \( 1 \leq p \leq \infty, j = 1, 2, \ldots, m \). The specific implementation steps of the VIKOR decision ranking method are as follows:
Step1: Evaluation value boundary calculation. Let that the evaluation value $f^*_j, f_j$ is expressed as the optimal and worst evaluation value of the candidate object $A_i$ relative to each evaluation index $C_j$, for the positive index:

$$f^*_j = \max f_j, f^-_j = \min f_j$$  \hspace{1cm} (20)

For the anti-proportional index:

$$f^*_j = \min f_j, f^-_j = \max f_j$$  \hspace{1cm} (21)

Step2: Sorting indicator value calculation. The measure $L_{s,i}$ is defined as the maximum group utility value of the decision scheme, denoted as $S_i$; $L_{e,i}$ is defined as the minimum individual regret, denoted as $R_i$, as shown in Eq. (22).

$$S_i = L_i = \sum_{j=1}^{m} w_j \left( \frac{|f^*_j - f^-_j|}{|f^-_j - f^-_j|} \right)$$

$$R_i = L_{e,i} = \max_j \left( w_j \left( \frac{|f^*_j - f^-_j|}{|f^-_j - f^-_j|} \right) \right)$$  \hspace{1cm} (22)

Thus, the $Q$ value of each alternative is:

$$Q_i = v \left( \frac{S_i - S^-}{S^- - S^+} \right) + (1 - v) \left( R_i - R^- \right)$$  \hspace{1cm} (23)

Where $S^- = \min S_i, S^+ = \max S_i, Q^- = \min Q_i, Q^+ = \max Q_i$, and $v$ is the coefficient of the decision mechanism.

Step3: Compromise scheme determination. The VIKOR method by sorting the value about $S_i, R_i, Q_i$, in order to incrementally sort the alternatives $Q_i$, and get the device preferred object sort as $A_i^{(1)}, A_i^{(2)}, \ldots, A_i^{(n)} (i=1,2,\ldots,n)$. At the same time, the results obtained need to meet the two conditions shown in literature [16-17].

4. Empirical case

Taking the procurement bidding case of power grid equipment E as an example, after formal and qualification evaluation, the company selected five alternative suppliers and organized three experts in decision making to evaluate the suppliers. Then, according to the overall evaluations, it ranks suppliers in order to make the best choice of power grid equipment.

This paper summarizes the value indicator system (shown in Table 2) based on some results of empirical investigations and equipment demand reports.

Based on the above information, calculate the weight value of each index by using the model algorithm described in section 3 and rank every suppliers based on the overall evaluation information.

4.1. Weight value solution

4.1.1. Subjective weight value solution. Firstly, the company should organize experts to give scores to the weight value of each element group compared with other groups in the technical, business, and economic field. Secondly, framing the weighted super-matrix based on the weighted matrixes of each layer index group. Then, normalizing the weighted super-matrix to obtain the subjective weight value of each bottom layer index. Due to its complexity, more details can be found in section 3.1. Finally, the subjective weight value $w_j^i$ can be obtained:

$$w_j^i = (0.0369, 0.0612, 0.0736, 0.0452, 0.0316, 0.0986, 0.0684, 0.0195, 0.0623, 0.0226, 0.0193, 0.0315, 0.0243, 0.252, 0.153)$$

4.1.2. Objective weight value solution. According to the algorithm described in 3.2, the process of calculating the objective weight value of the bottom index is as followed:

Step1: Data pre-processing. Normalize the collected quantitative data by using the formula shown in Eq. (17), the results are:
Table 2. The equipment purchasing and sourcing value index system for E.

| Level 1 | Level 2 | Level 3 | Bottom Mark | Type | Form |
|---------|---------|---------|-------------|------|------|
| Technology | Quality technical parameters | | load loss | C1 | Quantitative | Accurate value |
| | | | no-load loss | C2 | Quantitative | Accurate value |
| | | | temperature rise | C3 | Quantitative | Accurate value |
| | | | partial discharge | C4 | Quantitative | Accurate value |
| | | | noise level | C5 | Quantitative | Accurate value |
| Source value of procurement | Technical performance | | production | C6 | Quantitative | Accurate value |
| Manufacturing environment | purification ability A | | | C7 | Quantitative | Accurate value |
| | purification ability B | | | C8 | Quantitative | Accurate value |
| Research level | R & D capabilities | | | C9 | Qualitative | IFN |
| Business | Honesty | bad behaviour | | C10 | Qualitative | Language variable |
| | dishonesty situation | | | C11 | Qualitative | Language variable |
| Complex | financial situation | | | C12 | Qualitative | Language variable |
| | production scale | | | C13 | Qualitative | Language variable |
| Economic | price | | | C14 | Quantitative | Accurate value |
| | price fluctuation | | | C15 | Qualitative | IFN |

Step 2: Subjective evaluation information synthesis. According to the Eq. (10), and obtain results of the decision weight value, that is $\lambda_1 = 0.337, \lambda_2 = 0.3296, \lambda_3 = 0.3334$. Then, put these values into Eq. (11), and obtain value of the subjective evaluation information which integrates the experts’ decision weight value. The result are:

\[
\begin{bmatrix}
0.758 & 1 & 0.961 & 0.50 & 1 & 0.112 & 0.450 & 0.933 \\
1 & 0.759 & 0.954 & 0.75 & 0.716 & 0.369 & 0.156 & 0.949 \\
0.8314 & 0.907 & 0.910 & 0.60 & 0.900 & 0.198 & 0.250 & 0.833 & 0.975 \\
0.899 & 0.828 & 1 & 0.913 & 0.300 & 0.300 & 0.833 & 0.933 \\
0.957 & 0.661 & 0.973 & 0.50 & 0.969 & 0.487 & 1 & 0.933
\end{bmatrix}
\]

Step 3: Combination of evaluation information matrices. Combine every supplier’s nine standardized index values obtained in Step 1 and the qualitative index decision information obtained in Step 2. Then, the overall evaluation information matrix can be formed: $C = [C_{11}, C_{12}, C_{13}, L, C_{99}]$.

Step 4: Calculate the weight value based on the entropy method. By using the Eq. (12)-(15), the weight value of each evaluation index can be obtained as followed:

\[
\begin{bmatrix}
(0.82,0.12,0.06) & (0.79,0.13,0.08) & (0.85,0.10,0.05) & (0.74,0.18,0.08) & (0.70,0.21,0.09) & (0.60,0.30,0.10) \\
(0.95,0.05,0.00) & (0.95,0.05,0.00) & (0.85,0.10,0.05) & (0.90,0.08,0.02) & (0.87,0.10,0.03) & (0.90,0.10,0.00) \\
(0.85,0.10,0.05) & (0.93,0.06,0.01) & (0.85,0.11,0.04) & (0.85,0.10,0.05) & (0.74,0.20,0.06) & (0.86,0.14,0.00) \\
(0.75,0.15,0.10) & (0.82,0.12,0.06) & (0.79,0.13,0.08) & (0.60,0.29,0.11) & (0.60,0.30,0.10) & (0.70,0.30,0.00) \\
(0.76,0.16,0.08) & (0.75,0.15,0.10) & (0.69,0.21,0.10) & (0.67,0.25,0.08) & (0.60,0.30,0.10) & (0.60,0.30,0.10) \end{bmatrix}
\]

4.1.3. Weight value correction. Through Eq. (16)-(17), we can obtain the difference distribution coefficients of the subjective and objective weight values, that is $\alpha = 0.6014, \beta = 0.3986$. After putting the values into Eq. (18) for correcting, the overall weight value can be reformed as:

\[
\begin{bmatrix}
(0.0548,0.0755,0.1378,0.0506,0.1151,0.1125,0.0935,0.0215,0.0550,0.0713,0.0178,0.0928,0.0443,0.0407,0.0168) \\
(0.0440,0.0669,0.0992,0.0474,0.0649,0.1042,0.0784,0.0203,0.0594,0.0420,0.0187,0.0559,0.0323,0.1677,0.0987) \end{bmatrix}
\]
4.2. Comprehensive evaluation information sorting

According to the aggregated evaluation information matrix, this paper uses the VIKOR algorithm to rank the candidate suppliers. And through Eq. (20)-(21), we can obtain the best and the worst evaluation values and of each index.

When \( a = 0.5 \), the comprehensive evaluation information of the candidate suppliers is sorted by Eq. (22)-(23). The results are shown in Table 3.

It can be seen from Table 3 that the ranking result is A5-A3-A2-A1-A4 in terms of the Q value, obeying the principle of small to big, reflecting the priority of the candidate suppliers. Therefore, supplier A5 can be the first preferred supplier for this power grid equipment E.

| S   | R   | Q   | RANK |
|-----|-----|-----|------|
| A1  | 0.589 | 0.147 | 0.9148 | 4     |
| A2  | 0.613 | 0.127 | 0.8450 | 3     |
| A3  | 0.436 | 0.085 | 0.4121 | 2     |
| A4  | 0.605 | 0.158 | 0.9899 | 5     |
| A5  | 0.216 | 0.058 | 0     | 1     |

4.3. Model stability verification

When subjectively assigning a weight to each index, experts’ judgements and evaluations may be influenced by some objective reasons. As a result, this situation may cause a slight impact on the weight value of the last index. Therefore, when small weight fluctuations occur between simulation indicators, the VIKOR and TOPSIS method can be used to make a rank of comprehensive information evaluation in order to assess the stability of the preferred model. The simulation process is as followed:

**Step1:** Weight fluctuation data generation. According to \( \xi: (0.01, 0.02^2) \), 200 samples are randomly generated, and 100 samples in the range of \( [u-3\sigma, u+3\sigma] \) interval are selected and used as the weight fluctuation transformation value.

**Step2:** In the fluctuation transformation samples generated by Step1, 7 sample data are randomly selected and denoted as \( \xi_j, (i=1, 2, \ldots, 7) \). Then, \( \xi_j \) is randomly assigned to 7 indexes in \( w_j \), and the index after fluctuation is obtained as \( w_j + \xi_j \); and \( -\xi_j \) is randomly assigned to 7 indexes in the remaining \( w_j \). Let the index weight after fluctuations is denoted as \( w_j' \).

**Step3:** Combining with the weight of the index after the fluctuation, the evaluation information is ranked based on the VIKOR sorting algorithm and the TOPSIS algorithm. (The TOSIS algorithm is described in the literature [18-19]).

**Step4:** Cycle simulation, repeat the step1-step3 process for 100 times, and calculate the ranking result of each supplier and the number of changes in the ranking order of suppliers. The simulation results are shown in Figure 2.

![Figure 2](image-url)
According to Figure 2, in the 100-time simulations, when the weight value changes, the suppliers’ order has changed for 6 times in the VIKOR sorting method; and the number of supplier order fluctuation in TOPSIS ranking method is 16 times, and the suppliers’ order is A5-A3-A2-A4-A1. However, the optimal supplier has always been A5, and it is not influenced by any slight fluctuations of the weight values. In conclusion, the VIKOR method is more stable than the TOPSIS method in the field of ranking the comprehensive information, and the slight fluctuation of the weight value has small impact on the ranking of candidate suppliers. And compared with the TOPSIS algorithm, it is more suitable for the selection of equipment suppliers when the situation involves the multi-attribute criteria of power grid material equipment.

5. Conclusion
(1) This paper proposes to use the IFN to improve the index judgment matrix formed by the traditional ANP algorithm, and solving the problem of strong subjective weight value existed in point value scale of the traditional judgment matrix; (2) Putting forward the entropy weight method to calculate the objective weight value of the indexes, and introducing the distance function to modify the subjective and objective weight values so that it can eliminate the differences between the weight values of the indicators calculated in different ways; (3) Using the VIKOR algorithm to rank the mixed multi-attribute evaluation information which solves the problem of the one-sidedness of the evaluation information type to a certain extent; (4) According to the case study, it shows that the algorithm model can objectively and effectively calculate the weight values of the bottom indicators in the complex network, and have good applicability to equipment optimization.

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