Research on Investment Benefit Evaluation Technology of Wind Power Project

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Abstract: Wind power projects have high investment costs and long payback periods, so comprehensive investment returns and wind power project assessments are essential. Based on the current status and development trends of Chinese wind power projects, this paper builds an index system and model for evaluating the investment benefits of wind power projects based on TOPSIS theory. The research results can provide reference and guidance for the comprehensive evaluation of investment benefits of wind power projects.

1. Introduction
Wind energy is an inexhaustible source of renewable energy¹⁻². Wind power construction projects have high investment costs and long operating cycles. Once investment errors occur, the losses caused will be difficult to measure. Therefore, it is of great significance to strengthen the comprehensive benefit evaluation of investment in wind power construction projects³⁻⁵.

This paper takes wind power investment projects as the research object, and explores the establishment of a comprehensive benefit evaluation system for wind power investment projects in the new situation, thus providing a scientific and effective basis for project investment decision-making, and reducing the blindness and the risk of decision-making.

2. Analysis of factors affecting investment in wind power projects
By sorting out relevant literature and combining with the characteristics of wind power project construction and operation, the main factors affecting the level of investment efficiency of wind power projects include resources, technology, costs, policies, scale, etc., as shown in Figure 1 below:

Figure 1. Framework diagram of the impact mechanism of wind power investment.
3. Construction of investment benefit evaluation index system for wind power projects

This paper constructs a comprehensive evaluation index system for investment benefits of wind power projects in three aspects, namely, economic benefit evaluation, social benefit evaluation, and environmental benefit evaluation, as shown in Table 1 below:

Table 1. Evaluation index system construction.

| Index System for Comprehensive Benefit Evaluation of Wind Power Projects | Economic benefits | Social benefit | Environmental benefits |
|---|---|---|---|
| | Financial net present value | Dynamic payback period | Volatility of power generation revenue |
| | Financial internal rate of return | Interest reserve ratio | Internal rate of return of the national economy |
| | Project comprehensive energy consumption rate | Reduce environmental pollution | Impact on living environment |
| | GDP growth rate per capita | Promote employment effects | Effect of adjusting energy structure |

4. Construction of Evaluation Model

4.1 Determination of weights

Critic method (Criteria Importance Although Intercrteria Correlation) is an objective weighting method proposed by Diakoulaki. It is based on two basic concepts. The first is the intensity of comparison. Based on the idea of standard deviation method, it is believed that if the evaluation schemes have greater differences in the value of the same index, the greater the amount of information contained, this is in contrast to the entropy weight method, the coefficient of variation method, and the standard deviation. The difference method has the same effect. In Critic assignment method, standard deviation is used to indicate the value gap of each evaluation scheme on the same indicator. The larger the standard deviation, the larger the value gap between the schemes, the greater the amount of information, and the higher the corresponding weight. The second is the conflict between the evaluation indicators, which is also special about the Critic empowerment law. The conflict between indicators is based on the correlation between indicators. For example, a strong positive correlation between two indicators indicates that the two indicators have low conflict.

4.2 Evaluation model construction of TOPSIS method

In this paper, the TOPSIS method is used to compare the comprehensive benefits of the schemes when evaluating the comprehensive benefits of multiple wind power projects. The TOPSIS method is a method for comprehensively evaluating and ranking alternatives according to their relative proximity. The specific steps are as follows:

1. Establish original data matrix X and standardized judgment matrix R.

\[
Z = (z_{ij})_{nm} = (\omega_j \times r_{ij})_{nm} = \begin{pmatrix}
\omega_1 r_{11} & \omega_2 r_{12} & \cdots & \omega_m r_{1m} \\
\omega_1 r_{21} & \omega_2 r_{22} & \cdots & \omega_m r_{2m} \\
\vdots & \vdots & \ddots & \vdots \\
\omega_1 r_{n1} & \omega_2 r_{n2} & \cdots & \omega_m r_{nm}
\end{pmatrix}
\] (1)

2. Establish a weighted standardized judgment matrix. The weight determined by the Critic method is combined with the standardized judgment matrix R determined in step (1) to obtain a weighted standardized judgment matrix Z. The expression is as follows:
(3) Determine the positive ideal solution $z^+$ and the negative ideal solution $z^-$. Because the vector planning method is used for dimensionless processing of data in (1), and the types of indicators are not unified, it is necessary to distinguish between very large indicators and very small indicators to determine the ideal solution. The expressions are:

$$z^+ = (z_1^+, z_2^+, \cdots, z_m^+)$$  \hspace{1cm} (2)

among them:

$$z_j^+ = \begin{cases} \max \{z_{ij}\}, j \in \Theta^+ & i = 1,2,\cdots,n; j = 1,2,\cdots,m \\ \min \{z_{ij}\}, j \in \Theta^- & i = 1,2,\cdots,n; j = 1,2,\cdots,m \end{cases}$$  \hspace{1cm} (3)

$$z^- = (z_1^-, z_2^-, \cdots, z_m^-)$$  \hspace{1cm} (4)

among them:

$$z_j^- = \begin{cases} \min \{z_{ij}\}, j \in \Theta^- & i = 1,2,\cdots,n; j = 1,2,\cdots,m \\ \max \{z_{ij}\}, j \in \Theta^+ & i = 1,2,\cdots,n; j = 1,2,\cdots,m \end{cases}$$  \hspace{1cm} (5)

In the formula: $j \in \Theta^+$ indicates that the $j$ index is a positive index (very large index); $j \in \Theta^-$ indicates that the $j$ index is a negative index (very small index).

(4) Calculate the Euclidean distance $y_i^+$ from each solution $(z_{i1}, z_{i2}, \cdots, z_{im})$ to the positive ideal solution $z^+$ and the Euclidean distance $y_i^-$ to the negative ideal solution $z^-$, respectively. The expressions are:

$$y_i^+ = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_j^+)^2}, i = 1,2,\cdots,n$$  \hspace{1cm} (6)

$$y_i^- = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_j^-)^2}, i = 1,2,\cdots,n$$  \hspace{1cm} (7)

(5) Calculate the relative closeness $T_i$ of each solution to be evaluated and the ideal solution. This article takes the closeness to the positive ideal solution as the standard. The calculation formula is:

$$T_i = \frac{y_i^-}{y_i^+ + y_i^-}$$  \hspace{1cm} (8)

(6) Sort the pros and cons of each scheme to be evaluated according to the relative closeness $T_i$. The greater the relative closeness $T_i$, it indicates that the evaluation plan is farther away from the negative ideal solution, that is, the closer it is to the positive ideal solution, the better the plan is; otherwise, the worse the plan is. Therefore, the schemes can be sorted according to the relative closeness $T_i$ from large to small. At this time, the schemes are ranked from good to bad.

4.3 Empirical calculation analysis

This paper evaluates the comprehensive investment benefits of five wind power projects with the same installed capacity and scale. It is preferable to have six indicators that are independent of each other and cover all aspects of evaluation as much as possible, namely: financial internal rate of return, interest reserve ratio, fluctuation level of power generation income, per capita GDP growth rate, comprehensive energy consumption rate of the project, and reduction of environmental pollution.

(1) Calculate weights according to Critic method
1) Establish a raw data judgment matrix and a standardized judgment matrix. The Critic method is an objective weighting method like the entropy weighting method. It requires the support of several actual project data. The value of the preferred 6 indicators in 9 wind power projects is used as the raw data judgment matrix of the Critic weighting method. Not listed in detail. Similarly, a standardized judgment matrix can also be obtained.

| Wind power project | A  | B  | C  | D  | E  |
|--------------------|----|----|----|----|----|
| y_i^+              | 0.081 | 0.041 | 0.066 | 0.058 | 0.064 |
| y_i^-              | 0.052 | 0.072 | 0.073 | 0.068 | 0.056 |
| T_i                | 0.393 | 0.635 | 0.524 | 0.541 | 0.467 |

Sort the solutions from best to worst 5 1 3 2 4

Therefore, the ranking of the overall investment benefits of the five wind power projects is: B > D > C > E > A.

5. Research conclusions
This paper conducts in-depth exploration and research on the comprehensive evaluation of investment benefits of wind power projects, constructs a TOPSIS evaluation model based on Critic weighting, and conducts empirical analysis to verify the scientific rationality and effectiveness of the model. Benefit evaluation has certain reference significance.

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