Research on construction of comprehensive benefit evaluation model for UHV projects

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Abstract. As a major infrastructure related to the development of national economy, the comprehensive benefit evaluation system of UHV transmission project should be constructed from the dimensions of direct economic benefit, indirect economic benefit, environmental benefit and social benefit, and should also include power grid benefit and technical benefit. On this basis, the advantages and disadvantages of common comprehensive benefit evaluation methods and applicable conditions are analyzed, the selection and construction of comprehensive benefit evaluation methods for UHV projects are carried out, and the comprehensive evaluation model of UHV transmission projects is constructed by Fuzzy-AHP. Then the weight design and model construction are carried out, and fuzzy comprehensive evaluation is applied on the basis of analytic hierarchy process. The two complement each other and jointly improve the reliability and effectiveness of evaluation.

Keywords: Fuzzy logic; UHV Engineering; Comprehensive Benefits; Evaluation Model

1 Introduction

The implementation of the project is not only affected by the project itself, but also by the external natural environment and social environment. Therefore, the comprehensive benefits of the project cover a wide range, including tangible economic benefits, including intangible environmental benefits and social benefits. Tangible is the part that can be measured in the form of monetization, such as the net profit generated by the project, internal rate of return, etc. Intangible benefits are those that cannot be measured in terms of monetization, such as the impact of the project on the overall environmental protection of the region, the promotion of the city's visibility, and technological innovation. These are of great significance to the long-term development of a region, but they cannot be measured in tangible value. The main contents of comprehensive benefit evaluation include market analysis, technology evaluation, economic benefit evaluation and social benefit evaluation.[1]

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2 Comprehensive benefit evaluation of major projects

2.1 Project comprehensive benefit evaluation theory

Market analysis is a necessary condition for the feasibility study of the project. Its purpose is to investigate the market structure of the project product. It generally adopts the methods of market research, forecast and trend comprehensive analysis, and focuses on the market conditions related to the project product. It includes market condition survey, product demand and supply forecast, product price forecast, target market analysis, market competitiveness analysis and market risk analysis. [2]

Technical evaluation is the feasibility evaluation of the technical equipment conditions used in the project and the project engineering design scheme. The economic and social benefits of any project are based on the evaluation of the project's technical equipment and engineering design scheme. Therefore, before the evaluation of the project's economic and social benefits, it is necessary to evaluate the project's technical equipment and engineering design scheme, so as to judge the technical feasibility of the project. The technical equipment evaluation of the project is mainly aimed at the source of the technical equipment of the project, that is, whether the technical equipment is imported from abroad or purchased domestically, as well as the corresponding advantages and disadvantages and compatibility evaluation of the technical equipment. The evaluation of the compatibility includes the evaluation of the project technical equipment itself, the project construction and operation conditions, and the related supporting software. The evaluation of the project design scheme is mainly to evaluate the project design scheme. Due to the long life cycle of the project, it is necessary to analyze the advantages and disadvantages of the project design scheme. The main contents of project design scheme evaluation include the coordination between project engineers, scheme and other technologies, as well as organization and safety management design. [3]

The economic benefit evaluation of the project is to calculate the cost and benefit of the project according to the construction conditions of the project, and to analyze and demonstrate the financial feasibility of the project by combining quantitative and qualitative analysis methods, so as to provide scientific and effective theoretical basis for the project investment decision. The purpose of project economic benefit evaluation is to obtain the maximum output with the least input and maximize the economic benefit of project investment.

The economic benefit evaluation of the project can be divided into two aspects: financial evaluation and national economic evaluation. Financial evaluation is a micro evaluation, which analyzes the project from the financial perspective of the project enterprise under the established fiscal and tax system and price system, including preparing financial statements, calculating and evaluating the basic viability, financial profitability and solvency of the project, and judging the financial feasibility of the project. [4]

The financial evaluation of the project mainly includes the following aspects :1) the basic viability of the project. It means that according to the cash flow statement of the financial plan, it shall investigate the cash inflow and outflow generated by investment activities, financing activities and operating activities in each year during the calculation period of the project, calculate the net cash flow and accumulated surplus funds, and analyze whether the project has sufficient net cash flow and net income to maintain normal operation. 2) Profitability of the project. It refers to the profitability level after the project is put into operation, which is mainly evaluated from two aspects. On the one hand, the enterprise profit in the normal production year of the project and its ratio to the total investment are calculated by static method, such as investment profit rate, static investment payback period and other indicators. On the other hand, it examines the time value of funds through dynamic methods, and calculates the financial income and total rate of return of the enterprise during the whole project life cycle, such as financial net present value and financial internal rate of return. 3) Solvency of the project. Refers to the ability of a project to repay maturing debts on time, commonly used indicators such as loan repayment period. The solvency of a project is the basis for banks to make decisions on project loans, and it is also an important standard for analyzing and evaluating the solvency of a project. 4) Anti-risk ability of project investment. Through uncertainty analysis such as break-even analysis, sensitivity analysis and risk analysis such as probability analysis, the influence of changes in objective uncertainty factors on project income and investment loan repayment period and other evaluation indicators is predicted and analyzed to evaluate the ability of investment projects to withstand various risks.

The national economic evaluation of the project belongs to macro evaluation, which analyzes, calculates and evaluates the net contribution of the project to the national economy, evaluates the resource allocation efficiency of the project investment, and judges the economic rationality of the project. [5]

The social benefit assessment of the project refers to the contribution made by the project to achieve the national and local social development goals, which mainly includes two aspects: the environmental impact assessment and the social impact assessment of the project. Project environmental impact assessment refers to the identification, prediction and evaluation of the possible impact of the project on the natural environment on the basis of full investigation before the project starts, so as to ensure the coordination between the project and environmental protection. It is conducive to the project location and improve the rationality of the project layout, and is conducive to the proposal and implementation of relevant environmental protection measures, and promote the development of project-related environmental science and technology. Project social impact assessment is the analysis and evaluation of social equity and social environment. The scope of social impact assessment of a project is very wide, including social impact analysis, national and local macroeconomic analysis, culture, spiritual civilization construction, organizational concepts, etc., and also includes the impact of the project on the social and environmental sustainable development of the region.

From the analysis of the market conditions of the investment project, the macro-environment and micro-environment of the investment project are evaluated. Then from the technical, financial and national economic aspects of the project comprehensive benefit evaluation; Finally, analyze the project's environmental impact, social impact and other aspects of social benefits. [6]

2.2 Comprehensive benefit evaluation theory of major projects

Domestic and foreign scholars mainly from the direct economic benefit, indirect economic benefit, environmental benefit, social benefit and other dimensions to build a major project benefit evaluation system. At present, the evaluation of major engineering projects in various industries mainly focuses on the quantitative evaluation of economic benefits, and major power grid projects not only have economic benefits, but also have power grid benefits, environmental benefits, social benefits and technical benefits. [7]

On the premise of covering the above dimensions, a quantitative evaluation model is established to form a complete comprehensive benefit evaluation method for major projects. Evaluation methods are mainly divided into two categories: single evaluation and comprehensive evaluation. In the past, single evaluation was carried out only from economic benefit, and the evaluation methods were mainly value analysis, cost-benefit method and feasibility analysis method. Comprehensive evaluation, also called multi-attribute or multi-index evaluation method, is one of the most effective methods in systematic evaluation. At present, the methods of comprehensive evaluation mainly include: Delphi method; Principal component analysis or factor analysis; Fuzzy comprehensive evaluation method; Analytic hierarchy process; Artificial neural network method, etc. However, there are still deficiencies in the comprehensive benefit evaluation of major projects, which lacks comprehensive and systematic research considering the heterogeneity of stakeholders, the dynamic nature of life cycle and the diversity of value objectives.

3 Research on comprehensive benefit evaluation method

The comprehensive benefit evaluation of UHV project is a complex systematic project, which has the following characteristics: First, the complexity of the evaluation work. The comprehensive benefits of UHV projects involve many aspects of project operation. In order to have a more accurate evaluation of the comprehensive benefits, it is necessary to identify the benefits and impacts of UHV projects in various aspects and fields such as power grid, environment, economy and society, and conduct systematic analysis and judgment to extract reasonable evaluation indicators and finally obtain comprehensive evaluation results. Therefore, it is quite complicated. The second is the fuzziness of the evaluation results. The evaluation process involves a number of qualitative indicators, especially the qualitative indicators in the economic and social benefit indicators, the subjectivity of experts' scoring is strong, and the evaluation results of different experts are not completely consistent. In addition, the comprehensive evaluation process needs to determine the weight of indicators, and the process of weight determination is also subjective and fuzzy, so the evaluation result has a certain fuzziness. The pursuit of the accuracy of the results will also lose the significance of comparison, but also lose the significance of evaluation as a means of diagnosis and discovery of problems. Third, the dynamic nature of the evaluation object. The construction and operation of UHV transmission project is a dynamic process. With the progress of the construction and operation of the project and the changes of the external environment, its influence and benefits on the power grid, environment, society and economy will also change dynamically. [8]

Based on the characteristics of UHV transmission projects and the complexity of comprehensive benefits, the characteristics and applicability of various comprehensive evaluation methods are analyzed.

(1) Entropy evaluation method

Entropy method is an objective weighting evaluation method, and the entropy theory can be used to assign objective values to each index. The core of its application is to calculate the difference between the data corresponding to the index according to the evaluation object data of each index, so as to determine the weight. In other words, the determination of indicator weights completely depends on the collected data, so the data must be accurate and complete. However, there are many qualitative indexes in the comprehensive benefit evaluation of UHV transmission projects, which cannot fully meet the requirements of the application of entropy method.

(2) Method of AHP

The comprehensive benefit evaluation of UHV transmission projects involves rich contents and many indicators. The recursive relation of AHP can effectively reduce the complexity of evaluation, so this method is more suitable. However, there are some limitations, such as the evaluation itself is more subjective, more suitable for quantitative calculation of qualitative indicators.

(3) Grey triangle whitening weight function

Grey triangle whitening weight function can make full use of known information to dilute unknown information, objectively and truly reflect the nature of the system, which is suitable for the system with different evaluation indexes and dimensions and arbitrary distribution of sample data. At the same time, using many people to participate in the evaluation and introducing grey evaluation coefficient can eliminate the bias caused by the subjective evaluation as much as possible. However, it is necessary to extract effective information from a large number of data samples, which is more suitable for comprehensive evaluation of local indicators.

(4) Fuzzy comprehensive evaluation method

The fuzzy comprehensive evaluation method is suitable for situations with more qualitative indicators, and the comprehensive benefit evaluation of UHV transmission projects will involve more qualitative indicators. In addition, the fuzzy comprehensive evaluation method can integrate other methods, so it is more suitable.

(5) Synthetic evaluation method of artificial neural network based on BP algorithm

The key to the application of artificial neural network lies in machine learning, which also requires massive data. For the comprehensive benefit evaluation of UHV transmission projects, there are few reference data, so this method is not suitable.

In view of the complexity, fuzziness, dynamics and other characteristics of comprehensive benefit evaluation of UHV transmission projects, as well as the characteristics of qualitative indicators in the index system, a single evaluation method can not get good results, so it is considered to transform and integrate two or more methods to obtain a new evaluation method. In this paper, Fuzzy-AHP comprehensive evaluation method is adopted to construct comprehensive benefit evaluation model of UHV transmission project. Fuzzy-ahp method is the combination of analytic hierarchy process and Fuzzy comprehensive evaluation method, which is mainly embodied in dividing the evaluation index system into hierarchical structure, using analytic hierarchy process to determine the weight of each index, and then conducting fuzzy comprehensive evaluation at different levels, and finally obtaining the overall evaluation result. The advantage of this method is that it can not only ensure the system and rationality of the model, but also make full use of the rich experience and judgment ability of the decision-makers.

4 Construction of comprehensive benefit evaluation model

In terms of weight determination, it is proposed to use the combined weighting method based on the "Delphi - Analytic Hierarchy Process" model to configure the weight of each dimension and each index, and give full play to the experience grasp and guidance role of senior experts in the industry on the comprehensive benefit of UHV engineering. In terms of evaluation model, the Fuzzy-AHP comprehensive evaluation model is constructed, which mainly consists of two parts: analytic hierarchy process and Fuzzy comprehensive evaluation method. Among them, fuzzy comprehensive evaluation is carried out on the basis of analytic hierarchy process, and the two complement each other to improve the reliability and effectiveness of evaluation.

4.1 Weight design

Analytic hierarchy process (AHP) is a system analysis method proposed by A.L. Schaty, a professor at the University of Pittsburgh in the United States, in the 1970s. It integrates qualitative and quantitative analysis and simulates people's decision-making thinking process. It has the characteristics of clear thinking, simple method and strong systematicness, and is a powerful tool for analyzing complex large-scale systems with multi-objectives, multi-factors and multi-criteria. The steps are as follows:

1) Establish the hierarchical structure model

On the basis of in-depth analysis of practical problems, the factors affecting the benefits of UHV projects are decomposed into several levels. The hierarchical structure model here corresponds to the evaluation index system of each benefit, so it is no longer a separate hierarchical structure model.

2) Construct judgment matrix

Starting from the second level of the hierarchical model, the judgment matrix is constructed by pairwise comparison for the factors belonging to (or affecting) each factor in the previous level, until the last level. The degree of pairwise comparison method is indicated by the scale in Table 1:

Table 1. Importance degree definition

Scale	**Definition**
1	Factor *i* is as important as factor B
3	Factor *i* is slightly more important than factor *j*
5	Factor *i* is more important than factor *j*
7	Factor *i* is more important than the factor *j*
9	Factor *i* is absolutely more important than factor *j*
2,4,6,8	The intermediate state between the above two judgments corresponds to the scale value
Reciprocal	If factor *i* is compared with factor *j*, the judgment value is $a_{ij} = 1/a_{ji}$,$a_{ij} = 1$

Assume that a single index is weighted and there are m third-level indicators under the second-level indicators of this attribute. Take this as an example to calculate the weights of each index. The evaluation of the importance of indicators by experts in different fields is collected, and the average of each evaluation is taken as the final evaluation result, that is, the judgment matrix is obtained as follows:

$$A_{ij} = \begin{bmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mm} \end{bmatrix} \tag{1}$$

In the formula, a_{ij}represents the average score result obtained by$i$factor compared with$j$factor.

3) Calculate the weight vector and do consistency check

For each judgment matrix, the maximum eigenroot and its corresponding eigenvector are calculated, and the consistency index, random consistency index and consistency ratio are used for consistency test. If the test passes, the eigenvector (normalized) is the weight vector; If not, then consider reconstructing the judgment matrix. The approximation of the eigenvector is usually obtained by summation method or root method.

The steps for consistency testing are as follows:

(1) Calculate the consistency test index

$$CI = \frac{\lambda\, max - n}{n-1} \tag{2}$$

Where λ_{max}represents the maximum eigenroot of the judgment matrix.

(2) Finds the corresponding average random consistency index RI

Table 2 shows the average random consistency index obtained from 1000 calculations of the 1-9 order judgment matrix.

Table 2. RI value distribution

N	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.24	1.36	1.41	1.45

(3) Calculate the consistency ratio CR

$$CR=CI/RI \tag{3}$$

When CR<0.1, the consistency of the judgment matrix is acceptable. When CR>0.1, the judgment matrix should be modified appropriately.

In this chapter, the root method is used to calculate the eigenvector and eigenvalue. The specific process is as follows:

Step 1: Multiply each row of data and raise it to the m power

$$W_i^* = m\sqrt{\prod_{j=1}^{m} a_{ij}} \tag{4}$$

Resulting vector$W^* = (w_1^*, w_2^*, \dots, w_m^*)^{\mathrm{T}}$

Step 2: Normalize W^* to obtain weight vector $W = (w_1, w_2, \dots, w_m)^{\mathrm{T}}$, where,

$$w_i = w_i^* / \sum_{i=1}^{m} w_i^* \tag{5}$$

4.2 Fuzzy synthetic evaluation model

The comprehensive benefit evaluation of UHV projects involves many indexes, such as power grid benefit, environmental benefit and economic and social benefit, and it is necessary to judge the subordinate degree of each index to the evaluation level with the help of fuzzy mathematics thought. Fuzzy comprehensive evaluation is a method that uses the principle of fuzzy relation synthesis, quantifies the factors that are difficult to quantify and the boundary is fuzzy, and judges and analyzes the evaluation result of the evaluation object according to the membership status of many factors. At present, the fuzzy comprehensive evaluation model has been widely used and has a good effect. The main steps are as follows:

(1) Build factor set

According to the scope and level involved in the evaluation object, A hierarchical evaluation index system is established, and the element set of the factor layer in the index system constitutes factor set U:

$$U = \{U_1, U_2, \dots, U_m\} \tag{6}$$

(2) Create a collection of comments

According to the evaluation objectives, a set of evaluation grades is given for the excellence of evaluation factors. The determination of specific evaluation grades should be combined with the specific situation of evaluation objects, the number and scope of grades. Suppose n evaluation level is given, and the standard for each level is the number of intervals:

$$V = \{v_1, v_2, \dots, v_n\} \tag{7}$$

(3) Fuzzy relation matrix construction

Fuzzy relation matrix, membership matrix, is a matrix expressed by membership degree after constructing hierarchical fuzzy subset, which evaluates each index of the evaluation object in turn. Membership degree represents the degree to which the evaluation index actually belongs to a certain level. The value range is [0,1]. The principle of membership degree calculation is the same as that of index standardization, as shown in Figure 1.

$$R_{m\times n} = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} \tag{8}$$

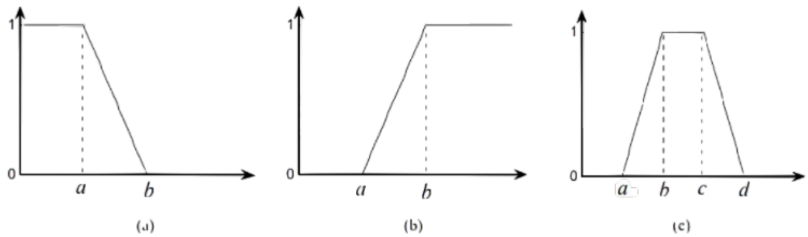

Fig. 1. (half) ladder function image

(4) Determine the weight of evaluation factors

The weight vector of comprehensive benefit index of UHV project calculated by AHP is represented by

$$w = (w_1, w_2, \dots, w_n)$$

(5) The fuzzy matrix synthesis operation is used for comprehensive evaluation

The fuzzy relationship between the evaluation index and the evaluation object is represented by the weight vector, and the relationship between the evaluation index and the review set is obtained through synthetic calculation. If the fuzzy relationship is represented as B, the calculation formula is as follows:

$$B = w \cdot R \tag{9}$$

According to the principle of maximum membership degree, the evaluation grade corresponding to the maximum value in B is taken as the comprehensive benefit evaluation result of UHV project, so as to analyze the stage evaluation result of the evaluation object.

5 Conclusion

(1) Major power grid projects not only have economic benefits, but also have power grid benefits, environmental benefits, social benefits and technical benefits. There are still deficiencies in the comprehensive benefit evaluation of major projects, which lacks

comprehensive and systematic research considering the heterogeneity of stakeholders, life-cycle dynamics and diversity of value objectives.

(2) the UHV engineering comprehensive benefit evaluation is a complicated system engineering, because of the complexity of the UHV power transmission engineering comprehensive benefit evaluation, fuzzy and dynamic characteristics, and have the features of qualitative indicators into the indicator system, using a single evaluation method and can't get good effect, will consider adopting two or more methods for reconstruction and integration. This paper adopts Fuzzy-AHP comprehensive evaluation method to construct comprehensive benefit evaluation model of UHV transmission project. It can not only ensure the system and rationality of the model, but also make full use of the rich experience and judgment ability of decision makers.

(3) in the aspect of determining weight, based on the Delphi, analytic hierarchy process (AHP) model is the combination of the power configuration of each dimension and the weight of each index, and give full play to the industry, a senior expert of the experience of the UHV project comprehensive benefit and guiding role. In terms of evaluation model, the Fuzzy-AHP comprehensive evaluation model is constructed, which mainly consists of two parts: analytic hierarchy process and Fuzzy comprehensive evaluation method. Among them, fuzzy comprehensive evaluation is carried out on the basis of analytic hierarchy process, and the two complement each other to improve the reliability and effectiveness of evaluation.

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