Research on investment strategy of single power grid project based on combination weighting method

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Abstract: Under the dual carbon target, it is a big problem for power grid enterprises to accurately invest and help the high-quality construction of new power systems. Under the situation of large-scale new energy grid connection, the grid investment strategy needs to be more reasonable and efficient. Therefore, this paper proposes a single project evaluation method of power grid based on combination weighting method, which provides a basis for the ranking of power grid projects, and also provides theoretical support for solving the investment decision-making problem of power grid single projects

Key words: Combination empowerment; Project evaluation; Investment decisions; Power grid project

1. Introduction

The power grid project has always played a very important role in China's electricity industry. It is not only closely related to people's daily activities, but also to the economic development of each place and the stability of society. In the past, due to the lack of understanding of the status and role of power grid projects, there has been no scientific planning and systematic management of investments in power grid projects, therefore, how to apply the limited funds to enhance the economic reliability of the power grid is an urgent issue to be considered.

Research on the evaluation of power grids has focused on the pre-evaluation and post-evaluation of power grid projects. In the pre-evaluation, literature [1] evaluates transmission and substation projects based on three dimensions: financial, technical and cost. Literature [2-3] all evaluate the risks of grid projects and propose corresponding risk response measures. In the post-evaluation, literature [4] combines whole life cycle costs and constructs an economic efficiency model to evaluate grid technology transformation projects. Literature [5-6] adopts fuzzy analysis method with fuzzy comprehensive evaluation to construct the secondary index evaluation of profitability, operation and debt servicing. The above studies evaluate grid projects before and after by improving the evaluation methods, but little has been done on the evaluation of grid operations.

For the research on grid investment optimisation, literature [7] constructs a multi-objective multi-operational decision optimisation model based on smart grid investment with the objective of optimal comprehensive benefits. In [8], an objective function is established based on the maximum utility of investment, taking into account economic rationality, social development and grid security, so as to construct an optimization model. The literature [9] considers the social and reliability of grid construction projects based on the economic efficiency of grid investment, and gives the optimal investment portfolio model. In order to consider the actual electricity demand in different regions, literature [10] carried out the investment optimisation analysis based on the optimal economic efficiency, and added regional factors in the analysis, so as to maximise the investment efficiency. The literature [11] constructs an investment optimisation model based on the annual expected maximum return, and the calculation example verifies that the model provides effective guidance for enterprises to rationalise project investment. In the literature [12], a multi-objective optimisation model is constructed by taking into account the economic, feasibility and developmental aspects of the grid investment, taking into account the financial and project constraints. To sum up, this paper adopts a combined weighting method that combines subjective weighting method with objective weighting method to evaluate the advantages and disadvantages of power grid engineering projects, which can effectively give play to the advantages of subjective weighting and objective weighting. The evaluation results support the decision-makers to screen the grid investment projects, which is conducive to laying the foundation for the subsequent investment behavior.

2. A comprehensive evaluation methodology for the initial screening of projects

2.1 Basic concepts of the Portfolio Empowerment Method

The combined weighting method is a weighted combination of subjective and objective weights. On the one hand, considering the complexity and uncertainty of the target and the decision maker's own preference for the target, it is very difficult to assess the target. On the other hand, considering that the merit of an assessment target is determined by the ranking of the comprehensive evaluation value, the greater the comprehensive value of the assessment target, the better the corresponding assessment target will be, so an increase in the comprehensive evaluation value will lead to an increase in the sum of the comprehensive evaluation values.

2.2 General steps of the Portfolio Empowerment Method

(1) Optimisation model for minimising the sum of squares of the subjective and objective weight deviations

Let the vector of indicator weights derived from the subjective assignment method be W1j=(w11，w12，...，w1n)T，and the vector of indicator weights derived from the objective assignment method be W2j=(w21，w22，...，w2n)T，Then, considering the minimization of the sum of squares of deviations based on the subjective and objective weights, we can construct the following optimization model.

$$\min Z = \sum_{j=1}^{n}\left(\alpha W_{1j} - \beta W_{2j}\right)^2 \quad (1)$$

$$\mathrm{S.t} \quad \sum_{j=1}^{n} W_{1j} = 1, (j = 1,2,\cdots,n)$$

$$\sum_{j=1}^{n} W_{2j} = 1, (j = 1,2,\cdots,n) \quad (2)$$

$$\alpha + \beta = 1,（\alpha \geq 0, \beta \geq 0）$$

(2) Optimisation model to maximise integrated evaluation value

Considering that the larger the combined assessment value of the assessment objectives, the better the corresponding assessment objectives, we can again construct the following optimization model.

$$\max G = \sum_{i=1}^{n} S_i = \sum_{i=1}^{m}\sum_{j=1}^{n} b_{ij}\left(\alpha W_{1j} + \beta W_{2j}\right) \quad (3)$$

$$\mathrm{S.t} \quad \sum_{j=1}^{n} W_{1j} = 1, (j = 1,2,\cdots,n) \quad (4)$$

$$\sum_{j=1}^{n} W_{2j} = 1, (j = 1,2,\cdots,n) \quad (5)$$

$$\alpha + \beta = 1, (\alpha \geq 0, \beta \geq 0) \quad (6)$$

where Si is the combined assessment value of each assessment target, and $S_i = \sum_{j=1}^{n} b_{ij} w_j, (i = 1,2,\cdots,m)$;Wj is the combined attribute value of the indicator, Wj=(w1，w2，w3，...，wn)T; and bij denotes the normalised attribute value of the i-th target for the j-th attribute aj.

（3）Optimisation modeling of the portfolio assignment method

Generally speaking, multiple optimization objective functions cannot reach their optimal values at the same time, there will be more or less conflicts between them, so in order to synthetically solve the above two optimization models, we can construct the following optimization model based on minimization of the objective function and maximization of the objective function.

$$\min Q = \sum_{j=1}^{n}(\alpha W_{1j} - \beta W_{2j})^2 - \sum_{i=1}^{m}\sum_{j=1}^{n} b_{ij}\left(\alpha W_{1j} + \beta W_{2j}\right) \quad (7)$$

$$\mathrm{S.t} \quad \sum_{j=1}^{n} W_{1j} = 1, (j = 1,2,\cdots,n) \quad (8)$$

$$\sum_{j=1}^{n} W_{2j} = 1, (j = 1,2,\cdots,n) \quad (9)$$

$$\alpha + \beta = 1, (\alpha \geq 0, \beta \geq 0) \quad (10)$$

At this point, on the extreme value problem subject to the constraints of the model, we can construct the Lagrangian function and use the Lagrangian multiplier method to solve for.

$$F(W_1, W_2, W_3, \cdots, W_n, \lambda) = \sum_{j=1}^{n}(\alpha W_{1j} - \beta W_{2j})^2 \quad (11)$$

$$-\sum_{i=1}^{m}\sum_{j=1}^{n} b_{ij}(\alpha W_{1j} + \beta W_{2j}) + \lambda(\alpha + \beta - 1)$$

where λ is the Lagrangian operator, and let $\frac{\partial F}{\partial \alpha} = 0$. This gives

$$2j{=}1n(\alpha W1j{-}\beta W2j)W1j{-}i{=}1mj{=}1nbijW1j{+}\lambda{=}0 \quad (12)$$

Letting $\frac{\partial F}{\partial \beta} = 0$, it follows that

$$-2j{=}1n(\alpha W1j{-}\beta W2j)W2j{-}i{=}1mj{=}1nbijW2j{+}\lambda{=}0 \quad (13)$$

Letting $\frac{\partial F}{\partial \lambda} = 0$, it follows that

$$\alpha + \beta - 1 = 0 \quad (14)$$

The formula (15) (16) is combined to solve for the values of α, β.

$$\alpha = \frac{\frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{n} b_{ij}(W_{1j} - W_{2j}) + \sum_{j=1}^{n} W_{2j}(W_{1j} + W_{2j})}{\sum_{j=1}^{n}(W_{1j} + W_{2j})^2} \quad (15)$$

$$\beta = \frac{\sum_{j=1}^{n} W_{1j}(W_{1j} + W_{2j}) - \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{n} b_{ij}(W_{1j} - W_{2j})}{\sum_{j=1}^{n}(W_{1j} + W_{2j})^2} \quad (16)$$

That is, α reflects the extent to which the decision maker favours subjective weights and β reflects the extent to which the decision maker favours objective weights.

（4）Calculate the weight of each indicator

Calculate the coefficient according to α and β The weight of each index in the combination weighting method can be calculated by the following formula：

$$W_{3j} = \alpha W_{1j} + \beta W_{2j} \;\; (j = 1,2,\cdots,n) \quad (17)$$

2.3 Establish hierarchical structure system

Taking the "investment benefit of power grid projects" as the target layer, a top-down hierarchical structure has been formed, with 3 module criteria layers and 12 attribute indicator layers. A hierarchical index system as shown in Figure 1 has been established：

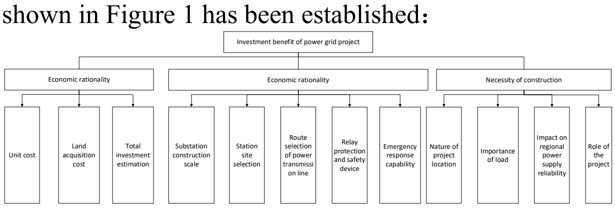

Figure 1 Investment Benefit Index System of Power Grid Project

3. Case study

The basic data collection includes the information collection of power grid investment projects and the collection of experts' scoring results of various indicators of different projects. There are 7 power grid engineering projects to be selected.
First, calculate the proportion of weight distribution α and β The specific values are shown in Table 1:

Table 1 Proportion of weight distribution of combination weighting method

Proportion of distribution	α	β
numerical value	0.43	0.57

Further, calculate the weight coefficient of each index. Allocate proportion according to weight α and β The weight of each indicator in the combination weighting method can be calculated by the formula. The specific results are shown in Table 2:

Table 2 Index weight coefficient calculated by combination weighting method

index	C1	C2	C3	C4	C5	C6
weight	0.091462	0.117407	0.15891	0.082826048	0.102524	0.073603
index	C7	C8	C9	C10	C11	C12
weight	0.063689	0.060544	0.07204	0.06407	0.058876	0.05405

The size of the index weight reflects the importance of the index to the comprehensive evaluation. The summary table of subjective and objective weights and comprehensive weights of the index is as follows:

Table 3 Summary of Index Weights

Indicator code	Index name	Subjective	Objective	Combination
C1	Unit cost	0.103681	0.0822446	0.091462265
C2	Land acquisition cost	0.163654	0.0825180	0.117406533
C3	Total investmentest imation	0.257365	0.0846370	0.158910093
C4	Substation construction scale	0.083383	0.0824058	0.082826048
C5	Station site selection	0.127011	0.0840506	0.102523599
C6	Route selection of power transmission line	0.057113	0.0860421	0.073602597
C7	Relay protection and safety device	0.037953	0.0831042	0.063689188
C8	Emergency response capability	0.02834	0.0848384	0.060544104
C9	Nature of project location	0.058241	0.0824499	0.072040117
C10	Importance of load	0.039762	0.0824071	0.064069708
C11	Impact on regional power supply reliability	0.027041	0.0828918	0.058875989
C12	Role of the project	0.016456	0.0824099	0.05404976

Table 4 Comprehensive score calculated by combination weighting method

Serial No	Power grid project	Comprehensive score
1	A	79.85
2	B	77.99
3	C	72.78
4	D	78.27
5	E	80.94
6	F	80.04
7	G	78.19

According to the comprehensive evaluation results, the advantages and disadvantages of each power grid project are as follows: E＞F＞A＞D＞G＞B＞C.

4. Conclusion

Considering the project investment portfolio involved in the power grid investment, this paper needs to comprehensively consider the relevant constraints and objective requirements when making investment decisions, not only to meet the investment demand, but also to arrange various investments within the allowable scope of investment capacity, and finally achieve the optimization of comprehensive benefits. Therefore, based on the comprehensive evaluation of the subjective and objective weighting method, the power grid engineering projects are sorted by single project, and the alternative investment projects are selected. Through the analysis of calculation examples, the following conclusions can be concluded:
The investment decision of power grid project mainly takes into account the overall benefits of power grid investment, and analyzes from the dimensions of the economic rationality, technical feasibility, construction necessity.The Company's investment management and control ability and management level have been improved, which effectively supports the operation decisions of power grid enterprises and realizes the sustainable development of power grid enterprises.

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