Research on the Comprehensive Evaluation Technology of Power Grid Investment Benefit Based on the Material Element Extension Model

Jiawei Lin[a], Meihua Zou[b], Yonghong Li[c], Jing Yu[d], Chen Chen*

State Grid Fujian Economic Research Institute, Fuzhou, Fujian Province, 350013, China

[a]364227383@qq.com, [b]zou_meihua@fj.sgcc.com.cn, [c]357041190@qq.com, [d]345332300@qq.com,
*Corresponding author's e-mail: cheninachen@hotmail.com

Abstract. With the continuous improvement of the national economy, the power load is also increasing. In order to meet the increasing demand for power, the power grid enterprises must constantly increase their investment, expand the scale of the distribution network, and optimize the structure of the distribution network. At the same time, under the carbon peak, carbon neutral target, with the deepening of energy transformation, how to introduce the carbon metering system traditional investment evaluation mechanism, realize carbon measurement penetration and fusion, expand the investment evaluation concept method and application scenarios, improve new power grid investment project decision optimization and considerations elements systematic upgrade, to improve the investment efficiency and power grid efficiency is of great significance.

Keywords: power grid investment, carbon measurement, extension model, investment benefit, evaluation technology

1 Introduction

With the rapid development of renewable energy and energy storage, the scale of new power grids is also expanding, and the requirements for project investment decision management and the improvement of project investment efficiency of power grid enterprises are also getting higher and higher.

Literature [1] used the super-efficiency DEA model and the Malmquist index model to analyze and evaluate the investment efficiency and heterogeneity of H Power Grid Company, and combined with the evaluation results, three suggestions were put forward: investment planning, evaluation methods and scientific and technological innovation.

Literature [2] established an evaluation index system for investment efficiency of power grid enterprises under the new electricity reform. Based on this, relevant data was collected, and a three-stage DEA model and a stochastic frontier model were used to calculate the investment efficiency of 31 provincial-level power grid enterprises in

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China under the new electricity reform. Empirical analysis results proved the effectiveness of this method. Literature [3] summarizes and studies the characteristics of power grid investment, and on the basis of fully investigating the current investment evaluation scheme of power grid enterprises, the power grid investment post-evaluation model is designed, and the application software system is developed and applied in practice, to provide decision support for power grid enterprises to conduct power grid investment evaluation system. Literature [4] puts forward a set of Shanghai power grid investment economic evaluation method based on value theory, gives the steps of the evaluation method, and in northern Shanghai power grid a 500kV power supply area of 220kV and above power grid for the research object of evaluation, comparison and analysis, in order to provide a reference for Shanghai power grid investment decision. Literature [5] established an Analytic Hierarchy Process (AHP) structural model and a Fuzzy Analytic Hierarchy Process (FAHP) model for the economic post evaluation of power grid construction projects, and used a 220kV substation construction project as an example to verify the effectiveness and rationality of the established model. Literature [6] puts forward suggestions for mechanism optimization from the aspects of pre-decision-making, in-process implementation, and post-evaluation of project investment, in order to improve the level of benefit control of power grid investment projects. Literature [7] analyzes the investment benefits of power grid and the risk control of power grid investment from the perspective of whole-process control, and constructs a power grid investment benefit evaluation system with engineering applicability and investment guidance based on the development trend of China's power grid and relevant national policies. Literature [8] analyzes the current situation and problems of investment decision-making in power grid construction, and discusses how to improve the accuracy and scientificity of decision-making.

To sum up, the current existing technology is to establish the precise allocation and calculation model of power grid project investment adapted to the transmission and distribution price reform, and to invest in the projects that must be invested in power grid projects. For the rest of the flexible investment project, according to the reform of the reform of the power grid project investment benefit evaluation index system, using the dynamic benefit evaluation model results, and reflect the economic benefit of the enterprise, to maximize the value of the value of the target function, with total constraints, investment allocation ratio, the correlation between the project as the constraints, the power grid project investment accurate allocation planning, but this way subjective factors influence too much, affect the power grid investment benefit management efficiency.

2 Research Ideas

The idea behind this article is illustrated below:

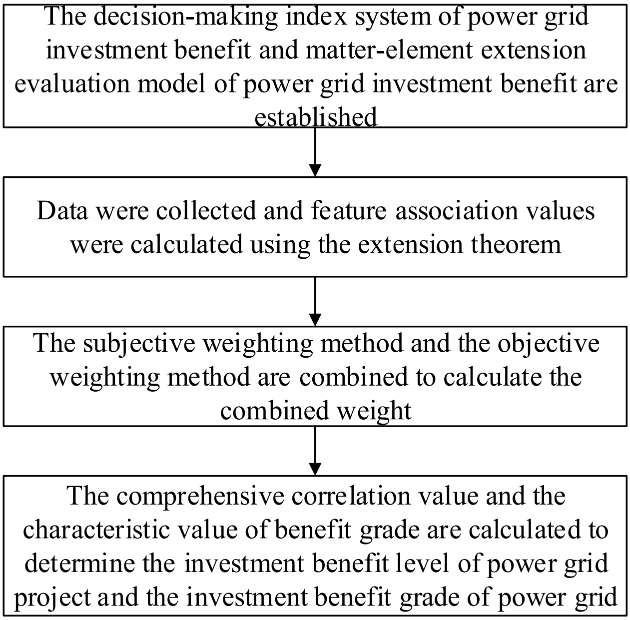

Fig. 1. Technical ideas are studied in this paper Based on the grid.

As can be seen from Figure 1, the technical ideas of this paper are as follows: firstly, the evaluation index of investment is used to construct the decision-making index system of power grid investment benefit, and the matter-element model of power grid investment benefit is established based on the decision-making index system of power grid investment benefit. According to the established power grid investment benefit decision-making index system, the corresponding data are collected, the mean index value is calculated according to the collected data, and the feature correlation value is calculated by using the extension theorem. The subjective weighting method and the objective weighting method were combined, and the portfolio weights were calculated according to the mean of the indicators. According to the combination weight and characteristic correlation value, the comprehensive correlation value and the characteristic value of the benefit level are calculated, and the level of power grid investment benefit level and the power grid investment benefit level are determined according to the comprehensive correlation value and the characteristic value of the benefit level. The present invention adopts the form of subjective weighting method and objective weighting method to obtain the combination weight, provides a new relatively objective way, can improve the efficiency of power grid investment benefit management.

3 Construction of the Comprehensive Evaluation Model of Power Grid Investment Benefit Based on the Material Element Extension Model

3.1 Construction of Evaluation Index System for Power Grid Investment Benefit

The index system of power grid investment benefit decision-making includes the target layer, the dimension layer and the index layer, the target layer is the power grid investment benefit evaluation index, the dimension layer includes policy indicators, safety indicators, economic indicators, competitive indicators, risk indicators and social indicators, and the index layer includes the project adaptation policy level, project urgency, power supply reliability rate improvement value, net present value rate, return on investment, distribution network distribution point growth rate, emerging power market share growth rate, electricity price policy change risk, risk electricity, The degree of carbon dioxide emission reduction and the degree of land resource optimization area, among which the improvement value of power supply reliability rate, net present value rate, return on investment, distribution network distribution growth rate, and emerging power market share growth rate are positive indicators, risk electricity is a negative indicator, and the project adaptation policy level, project urgency, electricity price policy change risk, carbon dioxide emission reduction degree and land resources optimization area degree are qualitative indicators. Table 1 shows the details:

Table 1. Construction of a comprehensive evaluation system for investment benefits

Target layer	Dimension layer	Index layer	order of evaluation			
			K1	K2	K3	K4
Comprehensive evaluation index of power grid investment benefit U	Policy indicator: U1	Project adaptation to the policy level U11	(8,10)	(6,8)	(3,6)	(0,3)
	Safety indicator, U2	Project construction urgency U21	(8,10)	(6,8)	(3,6)	(0,3)
		Power supply reliability improvement value U22	(0.065,0.070)	(0.060,0.065)	(0.055,0.060)	(0.050,0.055)
	Economic index: U3	NPV ratio U31	(300,350)	(250,300)	(200,250)	(150,200)
		Investment reporting rate: U32	(35,40)	(30，35)	(25,30)	(20,25)
	Competitive indicator, U4	Distribution network distribution growth rate U41	(0.045,0.050)	(0.040,0.045)	(0.035,0.040)	(0.030,0.035)
		New electricity market share growth rate U42	(0.035,0.040)	(0.030,0.035)	(0.025,0.030)	(0.020,0.0325)
	Risk indicator U5	Electricity price policy change risk U51	(8,10)	(8,10)	(8,10)	(8,10)
		Risk power quantity U52	(7,8)	(8,9)	(9,10)	(10,11)
	Social indicator U6	Carbon dioxide emission reduction	(8,10)	(6,8)	(3,6)	(0,3)

	degree U61 Optimization area of land resources is U62	(8,10)	(6,8)	(3,6)	(0,3)

3.2 Construction of extension evaluation model

The calculation steps of the extension model are as follows:

Step 1 determines the classical domain element matrix.

The matter element matrix composed of the feature c_n of thing N and the standard range of its features is the classical domain matter element matrix, denoted as R_j, which includes:

$$R_j = \begin{bmatrix} & c_1 & (a_{j1}, b_{j1}) \\ & c_2 & (a_{j2}, b_{j2}) \\ N_j & c_3 & (a_{j3}, b_{j3}) \\ \cdots & \cdots & \cdots \\ & c_n & (a_{jn}, b_{jn}) \end{bmatrix} \tag{1}$$

Among them, N_j represents the $\mathrm{j-th}$ evaluation level of the target object $N(j = 1,2,...,n)$; $\mathrm{c_i}$ is the $\mathrm{i-jth}$ evaluation indicator $(i = 1,2,...,n)$; $V_{jt} = (a_{jt}, b_{jt})$ represents the range of values for indicator i in level j.

Step 2 determines the node domain element matrix

The element matrix composed of the feature c_n of thing N and its extended range of features is called the nodal element matrix, denoted as R_p, then there is:

$$R_p = \begin{bmatrix} & c_1 & (a_{p1}, b_{p1}) \\ & c_2 & (a_{p2}, b_{p2}) \\ N_p & c_3 & (a_{p3}, b_{p3}) \\ \cdots & \cdots & \cdots \\ & c_n & (a_{pn}, b_{pn}) \end{bmatrix} \tag{2}$$

Among them, N_p represents the overall evaluation level of things; c_i is the $\mathrm{i-}$ jth evaluation indicator $(i = 1,2,...,n)$; $V_{pi} = (a_{pi}, b_{pi})$ i represents the range of values taken by indicator i on the entire level, obviously $V_{pi} \subset V_{jt}$.

Step 3 determines the element matrix to be measured. For a certain thing N to be evaluated, if the value of the $\mathrm{i-jth}$ evaluation index c_i is v_i, then the test matrix is:

$$R_0 = \begin{matrix} & c_1 & v_1 \\ & c_2 & v_2 \\ N_p & c_3 & v_3 \\ \cdots & \cdots & \cdots \\ & c_n & v_n \end{matrix} \tag{3}$$

Step 4 calculates the correlation degree according to the association function.

The correlation function represents the extent to which the range of the object conforms when the value of the element is taken as a point on the real axis. The correlation function is a transformation tool of the quantity change of things, which can quantitatively represent the qualitative problems.

$$K_j(v_i) = \begin{cases} -\dfrac{\rho(v_i, V_{ji})}{\left|V_{ji}\right|}, v_i \in V_{ji} \\ \dfrac{\rho(v_i, V_{ji})}{\rho(v_i, V_{pi}) - \rho(v_i, V_{ji})}, v_i \notin V_{ji} \end{cases} \tag{4}$$

Among,

$$\rho(v_i, V_{ji}) = \left|v_i - \frac{a_{ji} + b_{ji}}{2}\right| - \frac{b_{ji} - a_{ji}}{2} \tag{5}$$

$$\rho(v_i, V_{pi}) = \left|v_i - \frac{a_{pi} + b_{pi}}{2}\right| - \frac{b_{pi} - a_{pi}}{2} \tag{6}$$

$$\left|V_{ji}\right| = (b_{ji} - a_{ji}) \tag{7}$$

In the formula, $\rho(v_i, V_{jt})$ represents the distance between the value v_i of each indicator and the classical domain interval V_{ji}, where a_{ji} and b_{ji} are the two endpoints of the interval, respectively; $\rho(v_i, V_{jt})$ represents the distance between the metric value v_i and the segment v_{pt}, with a_{pi} and b_{pi} representing the two endpoints of the segment, respectively; The calculation result is the $K_j(v_i)$ correlation degree. The correlation degree is similar to the membership degree in fuzzy comprehensive evaluation, according to the maximum correlation degree criterion:

$$K_j(v_i) = max\, K_j(v_i), j = 1,2,...,m \tag{8}$$

So the evaluation level of indicator c_i is determined as j, and formula (7) can achieve the evaluation and analysis of each indicator.

The correlation degree and index weight of each index can be obtained by synthesis:

$$K_j = \sum_{i=1}^{n} w_i K_j(V_i), i = 1,2,...,n; j = 1,2,...,m \quad (9)$$

The characteristic values of benefit level include w_i as the indicator weight, $K_j(V_i)$ as the correlation degree of indicator i at level j, and K_j as the correlation degree of evaluation objectives. The final comprehensive evaluation level is determined according to formula (9) to achieve the overall evaluation of the power grid project.

4 Empirical Analysis

This paper takes the actual data of the investment benefit of a power grid enterprise as the object for the empirical analysis. The collected data are standardized as shown in Table 2 below:

Table 2. Standardized data processing results.

Dimension layer	Evaluating indicator	Eigenvalue	Minimum value	Maximum value	Maximum standard deviation	Coefficient of variation
Policy indicator U1	U11	9.13	8.8	9.5	0.269	0.0283
Safety indicator U2	U21	8.96	9.3	8.7	0.227	0.0241
	U22	0.06	0.06	0.06	0.001	0.0243
Economic indicator U3	U31	281.41	273.54	302.36	12.119	0.0431
	U32	31.10	25.87	39.91	5.315	0.1709
Competitive indicator U4	U41	0.04	0.04	0.05	0.003	0.0663
	U42	0.04	0.04	0.03	0.003	0.0742
Risk indicator U5	U51	8.78	8.9	8.50	0.164	0.0019
	U52	9.83	10.3	8.89	0.572	0.0582
Social indicator U6	U61	7.55	7	8.01	0.384	0.0509
	U62	8.08	7	9.02	0.811	0.1004

The characteristic correlation value reflects the compatibility degree between each evaluation index and the evaluation level of each power grid investment benefit, so that the membership level of each evaluation index can be judged, and the preparation can be made for obtaining the comprehensive correlation value of each level. The affiliation level of the evaluation index follows the principle of maximum membership.

The weight calculation results of the evaluation indicators are shown in Table 3 below:

Table 3. Evaluation index weight calculation results.

Dimension layer	Layered weights	Dimension layer	Subjective weight	Objective weight	Combined weight
U1	0.430	U11	0.430	0.2305	0.526
U2	0.040	U21	0.120	0.1962	0.1251
		U22	0.120	0.1670	0.1064
U3	0.154	U31	0.131	01670	0.1162
		U32	0.023	0.1670	0.0204
U4	0.125	U41	0.102	0.1670	0.0905
		U42	0.023	0.0648	0.0079
U5	0.027	U51	0.020	0.0648	0.0069
		U52	0.007	0.0016	0.00006
U6	0.024	U61	0.006	0.0016	0.00005
		U62	0.018	0.0014	0.00014

Combining the basic principle of the extension model, the calculation results are shown in Table 4 below:

Table 4. Comprehensive correlation values and characteristic values of benefit grade.

Grade	L1	L2	L3	L4
Comprehensive correlation value	0.043	-0.248	-0.450	-0.562
Benefit level characteristic value		1.522		

As can be seen from the above calculation results, The characteristic value of power grid investment is $max\, Hi(h) = H_1(h) = 0.043 > 0$ miax . It means that the investment benefit level of the power grid is grade L1.The benefit grade characteristic value is $i^* = 1.522$, Between 1 and 2 means that the grid is between L1 and L2, If the benefit value is greater than 2, It means that the investment benefit level of the power grid is L2, If the benefit value is greater than 3, It means that the investment benefit level of the power grid is L3, If the benefit value is greater than 4, It means that the investment benefit level of the power grid is L4. Among the 11 evaluation indicators, the U21 index of project urgency is at L3 level, the U52 index of risk power is at L4 level, and the other indicators are at L1 level. The investment benefit level of the power grid represents the investment benefit level of the power grid, and the level indicates the level of the investment benefit of the power grid. L1, L2, L3 and L4 respectively represent the four levels of the highest, high, general, low and lowest investment benefit of the power grid. The foregoing is only a preferred embodiment of the invention and is not intended to limit the modification, and any modification or improvement of the same within the spirit and principles of the invention shall be included in the scope of protection of the invention.

5 Conclusion

This paper considers the dimensions of policy, safety, economy, competition, risk and social benefit, constructs the comprehensive evaluation index system of investment benefit of power grid project, and then constructs the comprehensive evaluation model of investment benefit of power grid project based on material extension, and verifies the effectiveness of the model by combining empirical analysis. This model can further guide power grid enterprises to improve the investment efficiency and efficiency of power grid projects.

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