Research On Investment Benefit System of Various the Power Grid Emerging Business Under the Background of Value Network Theory

Lei Wang[1st,1], Yanchao Lu[2nd,2], Xiaohui Wang[3rd,3], Hao Liu[4th,4*], Chen Liu[5th,5], Huijuan Huo[6th,6], Shuo Wang [7th,7]

[1]963306544@qq.com, [2]1441769978@qq.com, [3]982705764@qq.com, [4]1332892714@qq.com, [5]NCEPUliuchen@163.com, [6]527952453@qq.com, [7]759781647@qq.com

[1]Institute of Industrial Economics, Chinese Academy of Social Sciences. Beijing, China

[2]State Grid Economic Technological Research Institute Co., Ltd. Beijing, China

[3]State Grid Economic Technological Research Institute Co., Ltd. Beijing, China

[4]School of Economics and Management, North China Electric Power University. Beijing, China

[5]School of Economics and Management, North China Electric Power University. Beijing, China

[6]State Grid Economic Technological Research Institute Co., Ltd. Beijing, China

[7]State Grid Economic Technological Research Institute Co., Ltd. Beijing, China

Abstract—With the continuous advancement of the power system reform, the emerging business investment in the power grid is gradually rising. How to evaluate it effectively is directly related to the income of the power grid investment. Based on the value of network system, the screen grid emerging business investment value quantification factors indicators, using the G1 - entropy weight synthesis to determine the subjective weight and objective weight of each index combining subjective and objective integrated comprehensive weights, emerging business investment evaluation system and evaluation model is set up, and calculate each business comprehensive score. Three key emerging businesses, smart power grid and value-added services, integrated energy services and high-end equipment manufacturing are selected to verify the validity of the investment value evaluation model. This study is helpful to improve the efficiency and precision of the power grid investment, and accurately evaluate the power grid investment benefit, which has important practical significance.

Keywords-value network, the power grid emerging business, G1-entropy weight method, investment quantification

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1 INTRODUCTION

Value network theory was put forward at the beginning of the 21st century. It is the extension and expansion of value chain theory in the Internet era. Value network is a system integrated by multiple interacting value chains, which are connected and exchanged in multiple links through the interaction between different levels and different subjects in the network. Value network starts from the transformation of the traditional supply chain system. Supply chain alliance is an important part of value network. Based on the value network system, the power grid enterprises can optimize the value network to quickly determine who can provide products and services required by customers at appropriate prices, so as to accelerate the time of entering the market and customer response.

With the development of a new round of electric power system reform and the increasing competition in the market, the power grid enterprise profit way change, traditional value chain has been a certain degree of impact, only rely on the traditional business cannot support the steady growth of enterprise benefit, the power grid enterprise needs to dig new efficiency point, build new value network, Actively cooperate with the national reform policy while expanding the emerging business. Under the new value network system, the power grid enterprises need to evaluate the investment value of emerging business and select the business that is most beneficial to enterprise development.

Document [1] uses decision model analysis to evaluate the investment benefit of the power grid, so as to achieve accurate prediction and quantitative evaluation. In literature [2-3], the evaluation index system of the power grid efficiency and benefit including new energy access is constructed from two perspectives of the power grid operation efficiency and benefit. Based on the background of the reform of power transmission and distribution price and the liberalization of incremental power distribution business, literature [4-6] conducts benefit analysis and risk analysis on the investment business of the power grid enterprises. In literature [7-8], the investment contribution degree and economic indicators of emerging the power grid businesses are integrated to optimize and rank the power grid construction projects. Literature [9-10] conducts economic evaluation on investment decisions of the power grid projects based on the background of new electricity reform and fuzzy analytic hierarchy process.

2 VALUATION MODEL OF EMERGING BUSINESS INVESTMENT

2.1 Establish an investment evaluation system for emerging businesses

The power grid investment evaluation system is a comprehensive evaluation system which takes the key factors that affect the investment mode and investment amount as indexes. The traditional investment evaluation system of the power grid is mainly set from three aspects: the power grid security, the power grid cleanliness and the power grid income level. For the investment of emerging business, innovation index should be introduced into the evaluation system. Through qualitative analysis by experts and combined with many assessment indicators of emerging businesses, it is proposed to introduce "intelligence level" as an

innovation evaluation index in the evaluation system. In order to evaluate the potential efficiency of each emerging business of the power grid enterprises, the establishment of power grid investment business evaluation system is shown in Table 1.

Table 1. Emerging business score composite indicator

Objective	Primary indicator	Secondary indicator
Emerging business score composite indicator	Grid Security	Average power outage time
		Peak shaving and valley filling capacity
		Maximum load factor of the power grid
	Grid Cleanliness	Energy consumption and emissions per unit
		Carbon emission intensity
		Percentage of installed renewable energy
	Grid revenue level	Cost of revenue ratio
		Net profit margin
		Gearing ratio
	Intelligent level	Technology R&D investment ratio
		Smart device penetration rate
		Intelligent fault detection accuracy

In this evaluation system, the safety indexes of the power grid include: average outage time, peak clipping capacity, maximum load rate of the power grid; Grid cleanliness index includes: unit energy consumption emissions, carbon emission intensity, renewable energy installed ratio; Grid income level indicators include: income cost ratio, net profit rate, asset-liability ratio; Intelligence level indicators include: proportion of investment in science and technology research and development, penetration rate of intelligent equipment, intelligent fault detection accuracy rate.

2.2 Index weighting and comprehensive scoring

The G1-entropy weight synthesis method is used to assign weights to each indicator and calculate the comprehensive score of each business. The G1-entropy weight synthesis screening method combines the subjective weights determined by the G1 method with the objective weights determined by the entropy weight method to obtain the comprehensive weights of subjective and objective integration and make a more comprehensive judgment on the critical degree of each indicator. The screening steps are as follows.

2.2.1 Calculate the subjective weight w_i of each indicator by the G1 method.

The rational assignment given by the expert is recorded as r_k, and the subjective weight w_m is calculated as

$$w_m = \left(1 + \sum_{k=2}^{m} \prod_{i=k}^{m} r_i\right)^{-1} \tag{1}$$

The subjective weight w_i of each indicator is calculated by the formula

$$w_{k-1} = r_k w_k (k = m, m-1, m-2, \ldots, 3, 2) \tag{2}$$

In the equation: m is the number of indicators and w_k is the subjective weight of the k-th indicator.

2.2.2 Calculate the objective weights φ_i of each indicator by the entropy weight method.

The proportion p_{ij} of the j-th the power grid business index value under the i-th satisfaction evaluation index is calculated as

$$p_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}} (i = 1, 2, 3, \ldots, m; j = 1, 2, 3, \ldots, n) \tag{3}$$

The entropy value e_i of the i-th indicator is calculated as

$$e_i = -\frac{1}{\ln n} \sum_{j=1}^{n} p_{ij} \ln p_{ij} (i = 1, 2, 3, \ldots, m) \tag{4}$$

The entropy weight φ_i of the i-th indicator is calculated as

$$\varphi_i = \frac{1 - e_i}{\sum_{i=1}^{m} (1 - e_i)} (i = 1, 2, 3, \ldots, m) \tag{5}$$

2.2.3 Combine the subjective and objective weights to find the comprehensive weight.

The linear weighted combination method was used to solve for the combined weights, calculated as

$$\lambda_i = \alpha w_i + \beta \varphi_i \tag{6}$$

In the equation: α is defined as the importance coefficient of the subjective assignment method and β is defined as the importance coefficient of the objective assignment method, and the subjective and objective assignment weighted attribute values of the evaluation indicators of the grid investment business are defined as $\alpha w_i r_{ij}$ and $\beta \varphi_i r_{ij}$, respectively, and the degree of closeness of the subjective and objective attribute values of the grid investment business j is calculated by the formula

$$Z_j = \sum_{i=1}^{m} (\alpha w_i r_{ij} - \beta \varphi_i r_{ij})^2 \tag{7}$$

An optimization model is developed using the linear weighting method as shown in the following equation.

$$\begin{cases} \min Z = \sum_{j=1}^{n} Z_j = \sum_{j=1}^{n} \sum_{i=1}^{m} (\alpha w_i r_{ij} - \beta \varphi_i r_{ij})^2 \\ \alpha + \beta = 1, \alpha\beta \geq 0 \\ 0 \leq \alpha \leq 1 \\ 0 \leq \beta \leq 1 \end{cases} \tag{8}$$

From the above equation, it can be seen that the optimization model is a binary optimization problem about the importance coefficient and, through MATLAB programming calculation, the subjective and objective importance coefficients can be obtained to derive the combination weights. After the weighting design of each indicator, the combined weight of the indicators and the weighted average of the scores of each indicator are finally obtained as the combined score of each business to evaluate the investment value.

3 EXAMPLE

The three key emerging businesses of smart grid and value-added services, comprehensive energy services and high-end equipment manufacturing are used to verify the quantitative investment value evaluation algorithm and illustrate the effectiveness of the investment value evaluation model.

Taking the intelligence level of the primary indicator as an example, the comprehensive weights of the three secondary indicators are calculated. Firstly, the secondary indicators are ranked by the expert group according to the degree of importance, and the quantitative scale of importance among the order of indicators is determined, as shown in Table 2.

Table 2. Expert ranking results of secondary indicators

m	1	2	3
Importance ranking	Technology R&D investment ratio	Intelligent device penetration rate	Intelligent fault detection accuracy
Sorting basis	Degree of importance: Important →→ Not important		
Importance quantitative	1.5	1.2	
r_k	r_2	r_3	

The data in the table were substituted into equations (1) and (2) to obtain the subjective weights of the secondary indicators based on the G1 method, as shown in Table 3.

Table 3. Subjective weights w_i of secondary indicators

Primary Indicator	Secondary indicator	Subjective weight w_i /%
Intelligent level	Technology R&D investment ratio	43.24
	Intelligent device penetration rate	30.28
	Intelligent fault detection accuracy	26.48

A sample survey was conducted in the relevant departments of the power grid company on the satisfaction of the secondary indicators of emerging business intelligence level, and the scores are shown in Table 4.

Table 4. Scores of secondary indicators of satisfaction in each department

Department	Technology R&D investment ratio	Intelligent device penetration rate	Intelligent fault detection accuracy
A	79.6	80.2	83.1
B	82.5	76.3	83.6
C	77.4	72.4	82.3
D	76.3	79.6	86.7
E	79.6	81.4	84.8

The data in the table were substituted into equations (3) to (5) to obtain the objective weights of the secondary indicators, as shown in Table 5.

Table 5. Objective weights u_i of secondary indicators

Primary Indicator	Secondary indicator	Objective weight u_i /%
Intelligent level	Technology R&D investment ratio	34.32
	Intelligent device penetration rate	42.68
	Intelligent fault detection accuracy	23.0

Substituting the subjective weights w_i shown in Table 3 and the objective weights u_i shown in Table 5 into the optimization model of equation (8) and solving it using MATLAB programming, the optimal combination coefficient sum is obtained as

$$\begin{cases} \alpha = 0.6239 \\ \beta = 0.3761 \end{cases} \tag{9}$$

Substitute equation (9) into equation (6) to obtain the combination weight λ_i of secondary indicators of emerging business intelligence level, as shown in Table 6.

Table 6. Combination weights λ_i of secondary indicators

Primary Indicator	Secondary indicator	Combination weight λ_i /%
Intelligent level	Technology R&D investment ratio	28.22
	Intelligent device penetration rate	52.34
	Intelligent fault detection accuracy	19.44

The comprehensive weights of the secondary indicators of primary indicators grid security, grid cleanliness and grid revenue level are calculated in the same way as above. The scores of each index are obtained by combining expert scoring and sampling survey, and the weighted average of the scores is used to obtain the comprehensive score of each business, as shown in Table 7.

Table 7. Comprehensive score of each business

Business	Smart grid and value-added services	Comprehensive energy services	High-end equipment manufacturing
Grid Security	0.46	0.37	0.74
Grid Cleanliness	0.88	0.76	0.85
Grid revenue level	0.52	0.42	0.63
Intelligent level	0.86	0.84	0.81
Comprehensive score	0.62	0.69	0.74

As can be seen from the above table, under the investment evaluation indicator system, the emerging business scores of the grid are smart grid and value-added services, comprehensive energy services, and high-end equipment manufacturing in descending order, and the investment value model can effectively quantify and evaluate the investment value of each emerging business.

4 CONCLUSION

In order to enhance the core competitiveness of the power grid enterprises in the increasingly competitive market, based on the value network system, this paper establishes the investment evaluation system and evaluation model of the power grid emerging business, obtains the comprehensive weight of subjective and objective integration of each indicator, and calculates the comprehensive score of each business. The key emerging business of the power grid is selected for example solution analysis to obtain the ranking of each business score, among which the investment value of smart the power grid and value-added service is the largest. Through verification, the evaluation model is feasible, which enriches the value evaluation system of the power grid business investment and provides reference for the power grid enterprises to carry out emerging business investment and reduce investment risk under the value network system.

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