Research on Investment Portfolio Optimization Strategy of Comprehensive Planning Management Project of Power Grid Corp under the New Electric Market Reform

Yongxiu He[1], Yutong Ye[1*], Qian Chen[1] , Zhibin Yan[2] and Lei Yu[2]

[1] School of Economics and Management, North China Electric Power University, Beijing, 102206, China

[2] STATE GRID NINGXIA ELECTRIC POWER CO.LTD, Ningxia 750001, China

[*]Corresponding author's e-mail: 1035383989@qq.com

Abstract. The new electric market reform leads to the change of investment demand of power grid. In order to realize the precision investment of the power grid, we aims at maximizing the comprehensive benefit, and establishes an optimization model of the investment portfolio of the power grid comprehensive plan management project with the constraints of the total investment, the proportion of the investment distribution and the relation between the projects. Taking a certain area in Tianjin as an example, the optimized project portfolio is obtained, which can be used to guide the investment decision-making of power grid and realize sustainable development.

1. Introduction

Under the background of the new power system reform, the profit model of the power grid crop will change greatly. The cost of the power grid crop will be more transparent and open, so that grid crops pay attention to reduce internal losses and control production costs and management costs. Under this background, research on the comprehensive plan management project investment optimization strategy is conducive to grid to avoid investment risks, ensure the stability of grid company's business development direction, and promote the sustainable development of power grid crop.

At present, power grid companies are paying more and more attention to macro-level layout and development strategy analysis, and pay more attention to scientific and rational investment decision analysis. In foreign countries, competitive market analysis has been integrated into the reform of the electricity market in Europe and the United States. Some engineering and technical issues, such as power supply reliability and risk control, have become the main aspects of foreign investment capacity analysis and economic technology evaluation[1-2]. Braga A S D proposed a dynamic analysis model of transmission network investment planning based on long-term marginal cost calculation, which considers three factors: investment cost, operating cost and power supply shortfall expectations[3]. Harris K E studied the probabilistic model of power generation and transmission coordination planning based on reliability and economy. This model can be used to classify transmission network investment projects and help to promote transmission reliability and ease the transmission resistance plugging research[4]. Wu F F reviews the research literature of previous transmission grid investment and planning methods, and proposes an analytical framework to clarify the inherent relationship between economics and engineering technology indicators of transmission network investment projects[5]. Chang Yan builds a micro-investment decision-making model based on dynamic programming theory and conducts empirical research, in order to solve the investment decision-making problem of power grid from the micro level of project investment decision-making[6]. TANG Yafang aims to maximize the expected annual benefit, establishes the optimization model of distribution network investment decision, and uses genetic algorithm to solve the model[7]. It can be seen that the research of these references mostly focuses on grid planning, investment benefit evaluation and investment capacity measurement, but fails to combine these aspects to form a complete investment decision-making system.

The aim of this paper is to maximize the comprehensive benefit of the power grid, considering the total investment, the proportion of the investment distribution and the relation between the projects, and establishing an optimization model of the investment portfolio of the power grid comprehensive plan management project, which is used to guide the investment decision of the power grid and promote the high-quality development of the power grid.

2. Investment portfolio optimization model of comprehensive planning management project of power grid based on 0-1 Programming

In this paper, the investment portfolio optimization decision system is set up. Firstly, according to the basic data, the project is sorted and organized, and the basic project database of each category is established. Then, the comprehensive evaluation of various types of projects is carried out according to the established comprehensive benefit evaluation index system, and the project is sorted according to the results. Finally, based on the 0-1 programming, a number of project portfolios are selected from all kinds of project storehouses to produce a project set , and the annual comprehensive planning management project investment plan is obtained.

2.1. Objective function

The optimization of the project portfolio must have quantitative indicators to carry out. Therefore, this paper starts from the value engineering theory and takes “value” as the decision value of the project. The idea of investment optimization based on value engineering is to find the most valuable investment portfolio under limited investment. The calculation formula is as follows.

$$V = \frac{F}{C} \tag{1}$$

Where V represents value, F represents function, and C represents cost.

As power grid investment belongs to the entity investment project, the total investment and the investment amount of each project are fixed. The use of general linear programming cannot solve the fixed cost problem. It is necessary to use 0-1 programming. In order to determine whether a project is adopted or eliminated, 0-1 vector X can be introduced.

$$X = \left[x_1, x_2 \ldots x_i \ldots x_n \right] \tag{2}$$

Where x_i represents the selection of the i-th project, x_i is a variable, only takes 0 or 1, when 0 is taken, the project is not selected, when 1 taken, the project is selected. n is the total number of alternative projects.

Therefore, the objective function of the comprehensive planning management projects is as follows:

$$\max V = \sum_{i=1}^{n} \frac{F_i}{C_i} \times x_i \tag{3}$$

Where V represents the total value of the project portfolio, that is, the decision value, F_i represents the comprehensive evaluation of the i-th project, C_i represents the planned investment of the i-th project.

2.2. constraint condition

The constraints of investment optimization of comprehensive planning management projects mainly include total investment constraints, investment allocation ratio constraints, and the relationship between projects.

(1) Total investment constraint

The constraint of total investment can be expressed as:

$$\sum_{i=1}^{n} C_i \times x_i \le T \tag{4}$$

Where C_i represents the planned investment of the i-th project, x_i is a variable, only takes 0 or 1, when 0 is taken, the project is not selected, when 1 taken, the project is selected. n is the total number of alternative projects, T represents total investment.

(2) Investment allocation ratio constraint

The constraint of investment allocation ratio can be expressed as:

$$s.t.\begin{cases} T_k = T \times f_k \\ f_1 : f_2 : \cdots : f_m = F_1 : F_2 : \cdots : F_m \end{cases} \tag{5}$$

Where T_k represents the investment in category k projects, f_k represents the proportion of investment allocation for category k projects, m represents the number of project classes.

(3) Association constraints between projects

The relationship between projects includes mutual exclusion, dependence, and strict complementarity.

1) Mutual exclusion

If i-th project and j-th project are mutually exclusive, and only one of them can be taken, the constraint equation can be expressed as:

$$x_i + x_j \le 1 \tag{6}$$

2) Dependency relationship

For example, the dependence of the low voltage level on the high voltage level in the grid infrastructure project. If there are project k and project l, and the occurrence of project k must be established in the case of project l, the constraint equation can be expressed as:

$$x_k - x_l \le 0 \tag{7}$$

3) Strict complementarity

If project m and project n must exist at the same time or do not exist at the same time, the constraint equation can be expressed as:

$$x_m - x_n = 0 \tag{8}$$

3. Case analysis

3.1. Basic data

We take the investment situation of a regional power grid in Tianjin as an example. There are 16 projects to be invested in this region in 2017, including 4 fields. The project alternative database is shown in Table 1.

Table 1. Investment situation of a regional power grid in Tianjin in 2017.

Project category	Project number	Planned investment (Ten thousand yuan)	Comprehensive evaluation value
	1	11.24	2.74
I	2	69.41	4.22
	3	42	4.20

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	4	25.25	1.48
	5	17.63	3.25
	6	18.64	4.66
	7	38.44	4.81
II	8	77.68	4.50
	9	103.52	1.34
	10	65	2.91
	11	38.44	4.11
III	12	15	1.94
	13	49.17	1.47
	14	4.7	4.76
IV	15	24.61	3.46
	16	42.68	2.21

Among them, I, II, III, IV represent voltage level 10kV and below, 35kV, 110kV and 220kV power grid infrastructure investment projects, respectively.

3.2. *Making investment decisions*

Refer to formula (3) to establish the objective function as shown below.

$$\max V = \sum_{i=1}^{16} \frac{F_i}{C_i} \times x_i \tag{9}$$

According to the total investment and the comprehensive evaluation results of all kinds of projects, the investment proportion and investment ceiling of projects in various fields are obtained as shown in Table 2.

Table 2. Investment distribution of various projects.

Project category	Comprehensive evaluation value	Proportion of investment distribution	Upper limit of investment (Ten thousand yuan)
I	15.89	30.52%	106.83
II	18.22	35%	122.49
III	7.52	14.44%	50.56
IV	10.43	20.03%	70.12

The portfolio model is a 0-1 integer programming problem, and the model is solved by Lingo. The calculation results are shown in Figure 1.

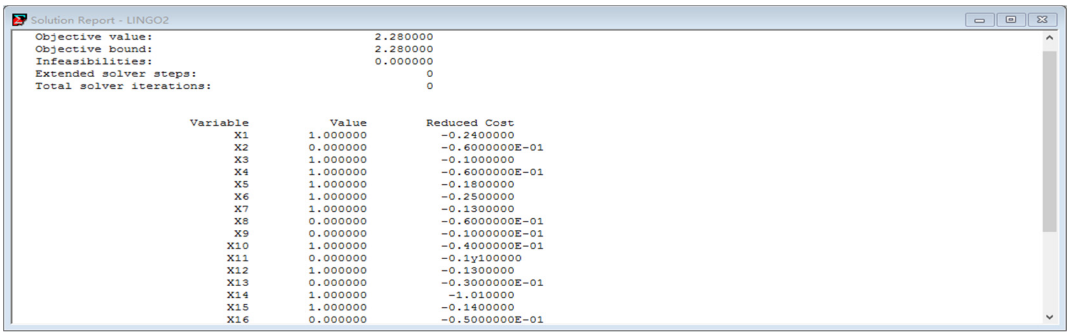

Figure 1. Optimization decision result of project investment portfolio based on Lingo.

The results of project portfolio optimization based on Lingo software are shown in Table 3.

Table 3. Calculation result .

Project category	Optimization results
I	1,3,4,5
II	6,7,10
III	12
IV	14,15
Project decision value	2.28
Comprehensive evaluation value	34.21
Total investment(Ten thousand yuan)	262.51
Surplus(Ten thousand yuan)	87.49

Due to the constraint of the proportion of investment funds of different categories of projects, the investment fund is surplus after optimization. For all non-selected investment projects, the second optimization is carried out without distinction between investment categories.

Combined with the two optimization results, the final result is shown in Table 4.

Table 4. Final decision .

Project category	Optimization results
I	1,3,4,5
II	6,7,10
III	11,12
IV	14,15,16
Project decision value	2.44
Total investment(Ten thousand yuan)	343.63
Surplus(Ten thousand yuan)	6.37

In the final decision, the comparison between the actual investment ratio of various projects and the proportion of planned investment is shown in Table 5. It can be seen that the optimal results are basically the same as the proportion of the planned investment distribution.

Table 5. A slightly more complex table with a narrow caption.

Project category	Planned investment ratio	Planned investment (Ten thousand yuan)	Actual investment ratio	Actual investment (Ten thousand yuan)
I	30.52%	106.83	27.97%	96.12
II	35%	122.49	35.53%	122.08
III	14.44%	50.56	15.55%	53.44
IV	20.03%	70.12	20.95%	71.99

4. Conclusions

In this paper, the investment portfolio optimization decision system of comprehensive planning management is established, Taking a certain area of Tianjin as an example, the investment optimization calculation is carried out, and the following conclusions are obtained.

(1) The project investment optimization decision model established in this paper, under the limitation of the total amount of investment, selects a reasonable proportion of investment allocation, pursues comprehensive benefits rather than maximizing single economic benefits, so that investment

projects have good implementation effects and can promote the sustainable development of the Power Grid Corp under the new electric market reform.

(2) The model established in this paper uses the original optimization model for the second time optimization considering the existence of the remaining investment funds, which not only ensures the maximum decision value, but also makes full use of investment funds.

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