Study on Optimal Strategy of Investment Decision of Power Supply Company based on System Dynamics

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Abstract. Power supply industry is the basic industry that affects the development of national economy. The operation development and reform trend of power supply enterprises has been highly concerned by the society. With the proposal of No. 9, the process of electric power system reform has been further deepened, and the requirements of power supply enterprises on the scientific and accuracy of investment decision-making have been continuously improved. This paper identifies and analyzes the important indexes of the power supply enterprises in the investment decision and operation process, and screens out the business indexes closely related to the investment decisions of the power supply enterprises. Taking the important business indexes as constraints, the optimization model of the investment decisions of the power supply enterprises is constructed by adopting the idea and method of system dynamics. Taking the operational parameters of a local power supply enterprise in a southern province of China as an example, the optimal investment scale of power supply enterprises under the constraint of business objectives is calculated, providing a reference basis for the investment decision of enterprises, giving priority to the optimal allocation of resources, and promoting the healthy and sustainable development of power supply enterprises.

Keywords: Power supply enterprise; investment decision; system dynamics.

1. Introduction

With the formal issuance of "No. 9 document", the power system reform started a new chapter after 2013. Compared with the plan of 2002, the new round of electricity reform plan focuses more on institutional reform, and analyzes the links of power generation, transmission, sales and purchase. In the Ninth Document, part of the reform tasks is clearly defined, and the four "liberalizations" and one "independence and one strengthening " are the most valued by the outside world. Four release, namely, the sale of electricity business, transmission and distribution outside the operating price, public welfare and regulatory outside the power generation plan and incremental distribution business liberalization; independence, refers to the independence of the trading platform; strengthening, refers to strengthening the planning [1-2]. The new round of electricity reform is better than the previous one, and now the goal is different from the original one. From the time to meet the demand for electricity, it has changed to improve the efficiency of resource allocation, and put it in the first place. [3]

As one of the main bodies of the power market, the power supply enterprises undertake the main power supply tasks of the whole society, and their production and operation activities are related to the overall situation of economic development and social stability. [4] For a long time, the production and operation management of power supply enterprises is generally based on professional planning, that is, adopting the relatively independent management of each unit and department. Due to the lack of coordination mechanism between the professional planning objectives and the overall objectives of enterprises and the various professional plans, this management mode leads to contradictions and inconsistencies between the professional planning objectives and the overall goals and professional plans of the enterprises. This situation results in the incoordination and low efficiency in the process of enterprise operation, and it is difficult to realize the optimal allocation of various elements resources within the enterprises. [5-6] Therefore, it is of great significance to optimize the investment decision-making of power supply enterprises and promote the optimal allocation of internal resource. According to the defects of traditional safety investment decision method. [7] Literature [8] introduces real option theory into the safety investment decision of power supply enterprise, constructs the framework of safety investment decision of power supply enterprise based on real

option theory, and establishes a safety investment decision model of power supply enterprise based on two fork tree model. Document [9] combined with the application demand of post evaluation of power grid investment benefit, researched and developed the key technologies in its informatization implementation, and established a decision support system for post evaluation of power grid investment benefit. Document [10] constructs a new index system suitable for risk assessment of human capital investment in power supply enterprises, and applies risk theory to the analysis of human capital investment behavior of enterprises, and puts forward specific methods to evaluate the risk of human capital investment in power supply enterprises. In the application of system dynamics, some scholars and enterprises at home and abroad have tried to use the system dynamics to build simulation models, to establish a set of scientific tools to accurately analyze the operation of enterprises and provide decision support. [11-13] Through the related research at home and abroad, we can find that the research on the optimization of investment decision-making in power supply enterprises is not detailed and the system dynamics has not been applied to the research in this field.

In view of this, this paper focuses on the analysis of the current situation of power enterprises' operation decisions in China, especially the investment decision making, and establishes the index system of power supply enterprises' operation decision making in China. Through the system dynamics and optimization calculation method, it makes an optimization analysis of the investment decisions of power supply enterprises, aiming at proposing effective investment decision-making optimization methods for power supply enterprises. The scientification and refinement of business decision-making can provide reference.

2. Applicability Analysis of System Dynamics Applied to Investment Decision of Power Supply Enterprises

System dynamics is not only a subject of analyzing and studying information feedback system. but also, an interdisciplinary subject of recognizing and solving system problems. System dynamics is modeled from the microscopic structure of the system, and the mechanism of problem generation within the system is excavated with the idea of systematic thinking, and with the help of computer simulation technology to construct the basic structure of the system, qualitatively and quantitatively analyze and study the system, and then simulate and analyze the dynamic behavior of the system.

From the perspective of system theory, the system includes elements, connections, functions or goals. It is a whole that composed of a set of interconnected elements and can achieve a certain goal. It is adaptive, dynamic and purposeful, and can self-organize and evolve. The research object of system dynamics is mainly the social economic system. The way to analyze and solve the problem is not to set up a set of differential equations to solve, but to analyze the interaction (driving and feedback relations) between the system structure and the system variables, and quantify the resource driven delayed effect in the driving relationship. Then the intuitive model is established and computer simulation is carried out to solve the problem. System dynamics is a kind of theory and analysis tool which is good at solving dynamic, delayed and complex non-linear system problems. Introducing the idea of system dynamics into the process of business simulation of an enterprise is based on the following considerations: consistency of system thinking and system analysis; consistency of strategic map and system flow diagram; complementarity of simple cause and effect and complex cause and effect; complementarity between static index and dynamic index.

The problems encountered in the operation and management of power supply enterprises are usually not isolated from each other, but interact with each other and change dynamically, especially in a dynamic context consisting of a series of complex systems. In this situation, enterprise investment decision-making is not only to solve the problem, but also to excavate the internal problem generation mechanism of the system with the concept of the system. The use of system dynamics modeling can fully consider the dynamic complexity of power supply enterprises' business decisions, simulate the various business behaviors, establish causal driving relationships among indicators, and achieve the transformation of the management decision-making of power supply enterprises from the framework

qualitative analysis to the systematic quantitative analysis, and from the one-way drive to the closed-loop feedback.2.1.2 Sub heading

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3. Operating Index System of Power Supply Enterprises in China

The indicators closely related to the income of power supply enterprises are divided into three main categories: the first category is a profitability index, which mainly includes total profit, economic value added, main business income and so on. The second category belongs to the operational efficiency index, which mainly includes the fixed assets sales volume of 10000 yuan, the unit power supply cost and so on. The three categories belong to resource input indicators, including various types of fixed assets investment and power supply cost. Generally, the investment decision-making and operation indexes of power supply enterprises are shown in Table 1.

Table 1. index table for investment decision and operation of power supply enterprises

Index type	First level index	Two level index
Profitability indicators	Total profit	Main business income
	EVA	Average price of electricity sale
	Analog economic added value	Net profit after tax
Operational efficiency index	Ten thousand yuan fixed assets sale of electricity	Original value of fixed assets
	Unit power supply cost	Electricity sale
Resource input index	Investment in fixed assets	Investment in power grid construction
		Investment in technological transformation
		Information investment
		Investment in science and technology projects
		Small investment in infrastructure
	Total cost of power supply	Labor cost
		Material cost
		Repair cost
		Depreciation charge
		Other costs

The schematic diagram of the overall relationship is shown in Figure 1. The change of resource input index affects the change of profitability index and operation efficiency index. The change of business efficiency index also affects the change of profitability index to a certain extent, and the change of profitability index will also restrict resource input index in turn.

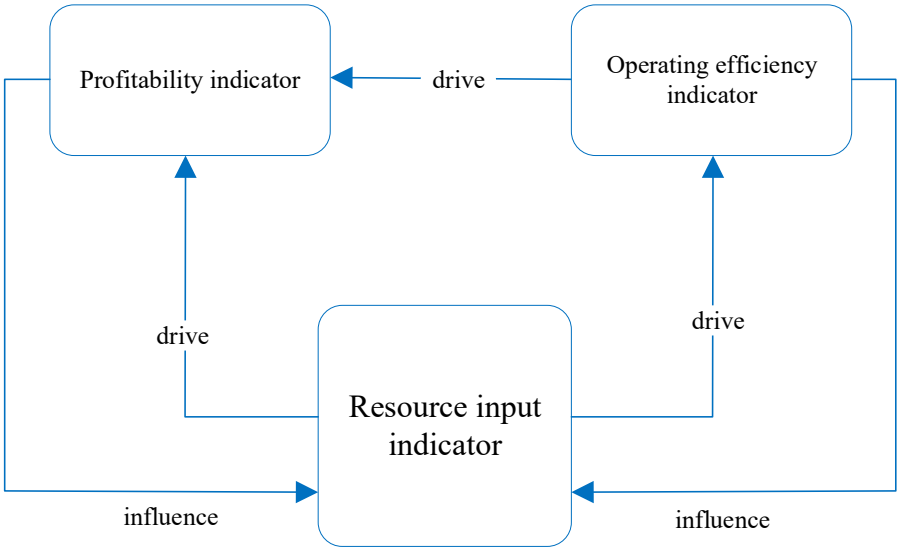

Fig. 1 Schematic diagram of the overall relationship

4. Optimization Simulation Model for Investment Decision of Power Supply Enterprise

In this chapter, the optimization logic and calculation process of power supply enterprise investment decision optimization simulation model are determined. Based on this, an optimization simulation model of power supply enterprise investment decision is established based on system dynamics.

4.1 The Optimization Logic and Calculation Process of the Model

According to the operation index system of power supply enterprises, four target constraint indicators are set: total profit, EVA, unit power supply cost and fixed assets sales volume of 10000 yuan. Among them, the sales of fixed assets of 10000 yuan are affected by investment. The cost of unit power supply is mainly affected by cost, and the factors that are affected by investment are relatively small. The total profit and EVA are affected by investment and cost at the same time, and the four constraint indicators are reverse relationship with investment and cost, that is, the smaller the investment and cost, the closer the index is to the target.

From the above relations, the model can be optimized. First, judge whether the sales of fixed assets and the unit power supply cost reach the target through the ten thousand-yuan fixed assets. If the target is not up to standard, the investment and cost will be reduced to achieve the target of the fixed assets sales and the unit power supply cost per 10000 yuan, and the total profit and EV in the process of investment and cost adjustment. An increase because of the decrease in investment and cost; secondly, we judge whether the total profit and EVA are up to standard; if we fail to meet the target, we will adjust the investment and cost at the same time, and finally make the four indicators achieve the goal. Among them, the adjustment of investment and cost is realized through the adjustment coefficient of grid investment and cost respectively. The calculation formulas are as follows:

$$\delta_I = \delta_i + \delta_{EVA} + \delta_s + \delta_c \tag{2}$$

Among them, δ_I is the power grid investment adjustment coefficient, δ_i is the total profit adjustment coefficient, δ_{EVA} is the EVA adjustment coefficient, δ_s is the fixed asset sales volume adjustment coefficient of 10000 yuan, δ_c is the unit power supply cost adjustment coefficient.

$$\delta_C = \delta_c + \delta_i + \delta_{EVA} \tag{3}$$

Among them, δ_C is the cost adjustment coefficient.

The adjustment coefficients in the model are set as follows by the "IF THEN ELSE" function in VENSIM:

Adjustment coefficient of fixed asset electricity sales of 10,000 yuan δ_s = IF THEN ELSE (difference of fixed asset electricity sales of 10,000 yuan > 0, -0.01,0) (4)

Unit power supply cost adjustment factor = IF THEN ELSE (unit power supply cost gap > 0, -0.01, 0) (5)

EVA adjustment coefficient δ_{EVA} =IF THEN ELSE (EVA difference >0:AND: unit power supply cost adjustment coefficient =0:AND: 10000-yuan fixed assets sales adjustment coefficient =0, -0.01, 0) (6)

Total profit adjusted coefficient δ_i =IF THEN ELSE (profit gap >0:AND: million-yuan fixed assets sales adjustment coefficient =0:AND: unit power supply cost adjustment coefficient =0, -0.01, 0) (7)

The specific operation of the model is as follows:

The first step is to calculate the value of financial indicators according to investment and cost;

The second step is to judge the difference between the sales of fixed assets and the cost of unit electricity and the target of each unit, if the gap is 0, then jump to the fourth step; if the gap is not 0, then the output coefficient of fixed assets δ_s and the adjustment coefficient of unit power supply cost δ_c will be exported;

The third step is to modify the input value of investment and cost according to the adjustment coefficient of fixed assets δ_s and the unit power supply cost adjustment coefficient δ_c, and then recalculate the financial indicators until the sales of fixed assets and the unit power supply cost meet the target requirements;

The fourth step is to judge the total profit and the gap between EVA and their respective goals. If the gap is 0, then jump to the sixth step; if the gap is not 0, then the total profit adjustment coefficient and EVA adjustment coefficient will be exported;

The fifth step: combining the total profit adjustment coefficient δ_i and EVA adjustment coefficient δ_{EVA} to modify the input value of investment and cost, and then recalculate the financial indicators until the fixed assets sales volume and the unit power supply cost of 10000 yuan meet the target requirements;

Step 6: The investment and cost after the output calculation stops, that is, the optimized resource allocation scale.

4.2 System Dynamics-based Optimal Model for Investment Decision-making of Power Supply Enterprises

When building the model, around the four target constraints index EVA, the total profit, unit power supply cost and 10,000-yuan fixed assets electricity sales are carried out in turn. In order to reflect the characteristics and characteristics of the different variables that can't be reflected in the causal relationship between the system, the quantitative relationship between the variables of the system is further defined, and the function mechanism inside the system is clearer and clearer. The causality diagram is transformed into the system flow graph and the corresponding model equation is established.

The optimal value of power supply cost and its related sub-influencing factors in the model are shown in figure 2, and the optimal calculation function is formulated (8).

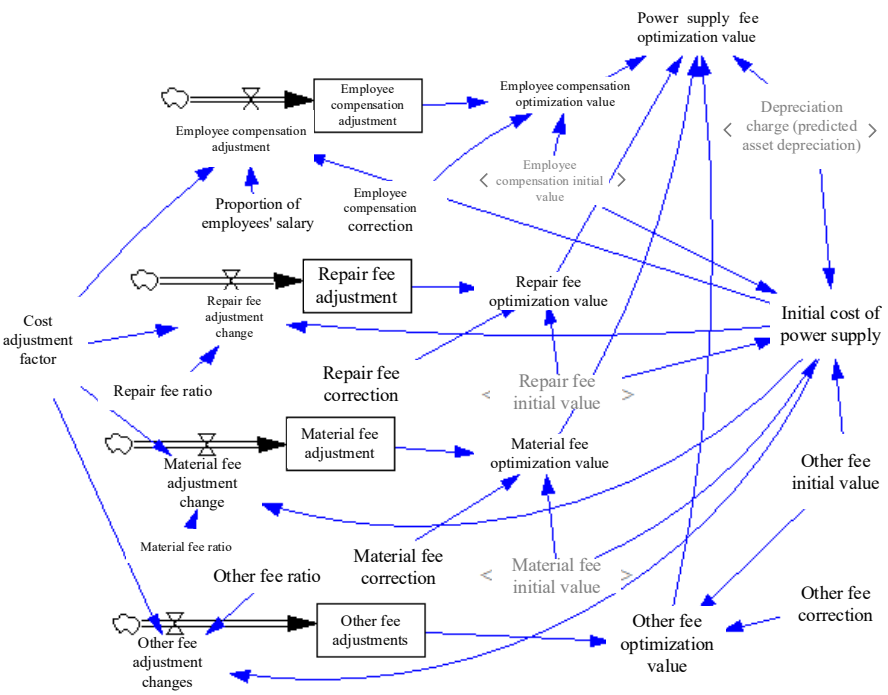

Fig. 2 optimal calculation model of power supply cost

$$C_{optimal} = C_f + C_d + C_m + C_s + C_o \tag{8}$$

Among them, $C_{optimal}$ is the optimization value of power supply cost, C_f is the optimization value of repair cost, C_d is the depreciation cost (estimated assets depreciation), C_m is the optimized value of material cost, C_s is the optimized value of the salary of the staff, and C_o is the optimized value for other expenses.

In the model, the optimal value of fixed asset investment and its related sub-influencing factors are shown in figure 3, and the optimal calculation function is formulated (9).

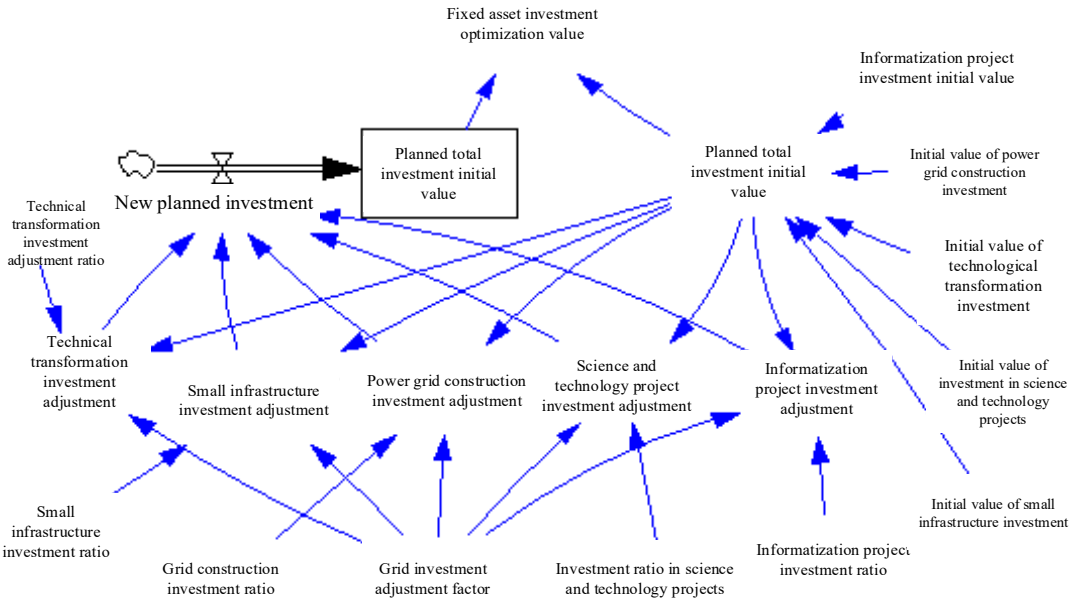

Fig. 3 optimal calculation model of fixed assets investment

$$I_{optimal} = I_p + I_{pa} \tag{9}$$

Among them, $I_{optimal}$ is the optimal value of fixed assets investment, I_p is the initial value of total planned investment, I_{pa} is and the adjustment amount of total planned investment.

$$I_p = I_i + I_b + I_t + I_B + I_T \tag{10}$$

Among them, I_i is the initial value of information project investment, I_b is the initial value of small infrastructure investment, I_t is the initial value of technological transformation investment, I_B is the initial value of investment for power grid construction, I_T is and the initial investment value for science and technology projects.

$$I_{pa} = I_{ia} + I_{ba} + I_{ta} + I_{Ba} + I_{Ta} \tag{11}$$

Among them, I_{ia} is the amount of investment adjustment for informatization projects, I_{ba} is the amount of adjustment for small infrastructure investment, I_{ta} is the amount of adjustment for technological transformation investment, I_{Ba} is the adjustment of investment for power grid construction, and I_{Ta} is the adjustment of investment in science and technology projects.

Index EVA, total profit, unit power supply cost and 10,000-yuan fixed assets electricity sales are optimized as follows:

EVA = adjusted operating profit - adjusted net fixed assets * average cost of capital / 100 (12)

Total Profit = Operating Profit + Net Out-of-Business Income = Operating Income - Total Operating Cost + Fair Value Change Income + Investment Income (13)

Unit power supply cost = optimal value of power supply cost / electricity sales / 10 (14)

Ten thousand-yuan fixed assets electricity sales = electricity sales * 100 000 / average fixed assets (15)

According to EVA, the objective constraints of the model are as follows: gross profit, unit power supply cost and electricity sales of 10,000 yuan of fixed assets.

$$EVA \geq EVA_{goal} \tag{16}$$

$$I \geq I_{goal} \tag{17}$$

$$C_c \leq C_{c,goal} \tag{18}$$

$$S_m \geq S_{m,goal} \tag{19}$$

Among them, EVA_{goal} is the EVA target of power supply enterprises, I_{goal} is the total profit target, $C_{c,goal}$ is the unit power supply cost target, $S_{m,goal}$ is and the fixed assets electricity sales target of 10,000 yuan.

5. Example Analysis

In this section, using a local power supply bureau in 2014 to compile the next five years& apos; operation index plan as an example, this model is used to optimize and simulate its financial indicators in 2015 to verify the rationality of the model.

(1) model and related parameter setting

Basic data: use EXCEL spreadsheet to build database, and use the "GET XLS LOOKUPS" function in VENSIM to call 2015 planning forecast data.

Table 2. basic management data sheet

category	Amount
Net income outside business, ten thousand yuan	5628.4
Loss of asset value, ten thousand yuan	167.6
Business tax and additional, ten thousand yuan	11832.3
Other main business income, ten thousand yuan	2552.6
Other business income, ten thousand yuan	2189.1
Financial cost, ten thousand yuan	72696.0
Initial value of investment in production, ten thousand yuan	689486.95
500kV original value of fixed assets, ten thousand yuan	372466.7
Original value of fixed assets, ten thousand yuan	4366153.6
In the construction and construction of the balance of materials, ten thousand yuan	287598.2
500kV in the construction and construction of the balance of materials, ten thousand yuan	12934.7
Planned investment transfer investment coefficient, %	0.63

Table 3. business objective table

category	Unit power supply cost target, yuan / 1000 watts	Profit target, ten thousand yuan	S-EVA target, ten thousand yuan	Ten thousand-yuan fixed assets electricity sales target, kilowatt-hour/ten thousand yuan
target	89	320000	410000	16.5

Number of operations: Set up model operations 50 times, set "INITIAL TIME = 1, FINAL TIME = 50, TIME STEP = 1" in VENSIM tool.

(2) simulation and its results

Some indexes are optimized and the results are as follows:

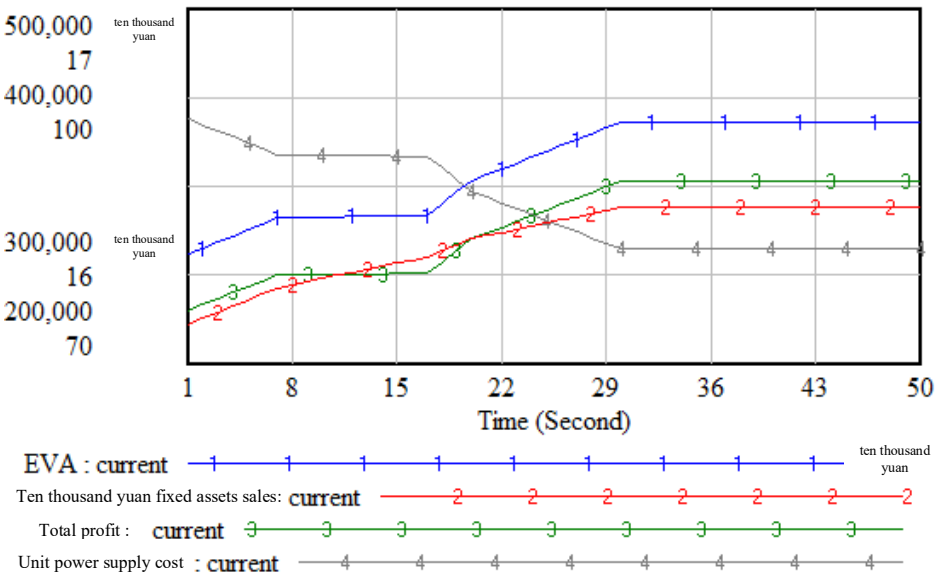

Fig. 4 optimization results of target index

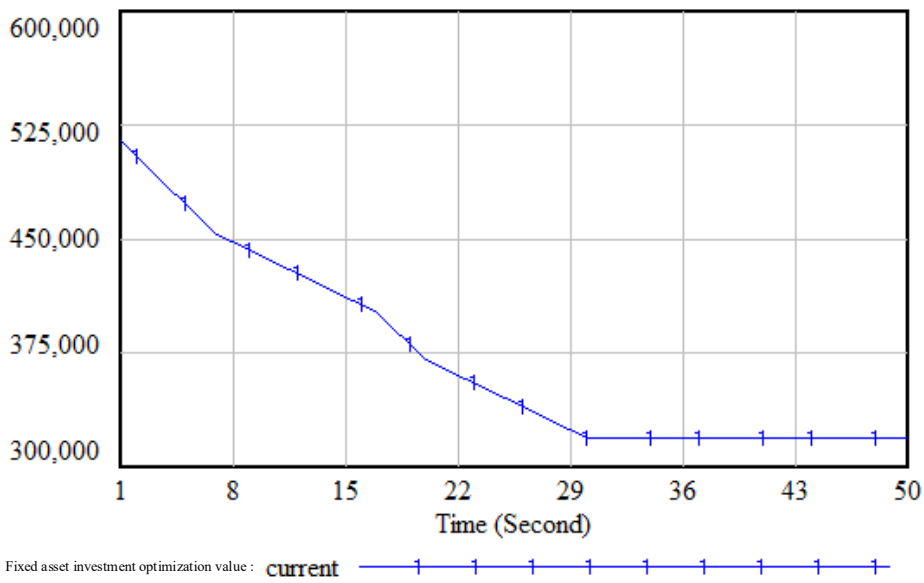

Fig. 5 The optimal value of fixed assets investment under the constraints of objective indicators

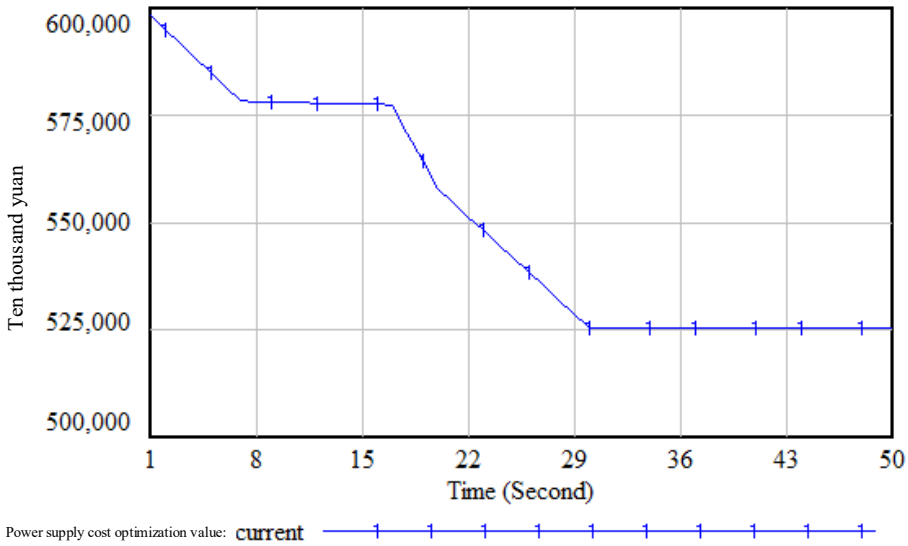

Fig. 6 Optimal value of power supply cost under the constraint of target index

Through the model, the profitability index and operational efficiency index are calculated simultaneously, and the corresponding resource input results under the target constraint are obtained. From the calculation results, under the business objectives of EVA>=400000 million yuan, total profit >=300000 million yuan, unit power supply cost <=88 yuan / 1000 kwh, and fixed assets of >=16.3 yuan per thousand yuan, the investment scale of fixed assets will be reduced than that of the original planning, that is, it needs to be reduced from 5 billion 150 million yuan to 3 billion 190 million yuan. The total cost of cost is also reduced to 5 billion 260 million yuan. With the adjustment of business objectives, the investment of fixed assets and the cost of power supply of power supply enterprises are constantly adjusted until they meet the goal of development scale and operational benefit of enterprises.

6. Conclusion and Prospect

The optimization model of power supply enterprise investment decision based on system dynamics can be applied to the operation practice of power supply enterprises. It can make timely adjustment of resources input according to the business objectives of enterprises, and is very important for improving the production and operation status of power supply enterprises and optimizing their

resource allocation capability. The meaning of it. The application of system dynamics in the management decision of power supply enterprises has strong scientificalness and applicability. But there are also the following problems to be solved:

(1) The management decision-making index system of power supply enterprises needs to be further optimized.

In this study, the index system of power supply enterprises & apos; management decision-making is sorted out. The index system includes important indicators in the operation process of power supply enterprises. However, some obstacles are not included in the scope of this research model, such as customer satisfaction and fault interruption time due to the obstacles of system modeling to the nature of the index and the limitation of the actual data. The absence of this part of the indicators may lead to a certain deviation between the balanced calculation results of the comprehensive plan and the actual situation.

(2) the quantitative relationship needs to be further studied

In this model, we consider the model relationship between resource input and financial and power grid operation indicators, as well as non-financial indicators, and realize the direct interconnection between enterprise input and enterprise growth. However, due to the inconsistent caliber of data collection, the quantitative relationship between some non-financial indicators has not been established, such as the influence of power grid structure optimization on the operation and maintenance level of the system, the feedback effect of the system operation and maintenance level on the investment and construction of the grid. These problems will be the focus of the follow-up study on the application of system dynamics to the operation decision simulation of power supply enterprises.

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