Analysis of key factors affecting investors under the Global Energy Internet

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Abstract. It’s necessary to study indexes which affect investors with the development of energy internet. Firstly, according to Delphi Method, the core factors affecting power generation investment are screened out. Then, the system structure is analyzed, the feedback mechanism inside the system is identified, and the system causality diagram is established. Next, based on causality diagram, the mathematical model between variables is confirmed and the system dynamics model is built. Finally, the influence of core factors such as tax rate and loan interest rate on investment return is simulated by using the system dynamics model. Through the analysis of the impact of the core factors on the investment income, it can provide a reference for the power generation investment of different subjects under the global energy internet background.

1. Introduction
The idea of the Global Energy Internet is becoming more popular. It is of great value to study investment decisions under the Global Energy Internet. Literatures on the impact of various factors on investment decisions have been studied at home and abroad. F. Polzin[1] explores the impact of public policy measures on renewable energy investment in institutional investors’ power generation capacity. X. Wang[2] and A. Masini[3] use qualitative and quantitative methods to study the influence of various factors on the decision of renewable energy investment. The results show that the prior belief, policy preference and the attitude to technical risk have significant influence on investment decision. There are few researches on the factors influencing investment decisions under the Global Energy Internet.

Investment decisions under the Global Energy Internet involve the diversity of clean energy, power grid planning and operation, government decision-making and incentive measures, load dynamic characteristics, and power grid security scheduling and other factors[4]. Because different investment subjects are faced with different dominant factors in different planning investment timing, it leads to the different subjects in the decision-making of net source planning investment. Therefore, it is necessary to use system dynamics theory to study the relationship between key factors affecting the benefit of investors.

In the face of the complex economic and social environment under the global energy Internet, it is of great significance to study the key factors that affect the investment of the power grid. The complexity and diversity of investment decisions under the Global Energy Internet are considered, and the various factors that affect the benefit of the investment subject are analyzed by system dynamics, and the key factors that affect the benefit of the main body are selected and the relationship between them is analyzed. Then the relationship between the key factors is quantified and the dynamic investment income model is established. Finally, sensitivity analysis is carried out based on the established model.
2. Influencing factors of investment subject benefit

There are many factors affecting the investment decisions of power generation investor on the mains side and transmission investors on the market side and users under the Global Energy Internet. This paper mainly introduces four aspects, including clean energy demand, energy Internet development, technology level and policy factors, as shown in Figure 1.

Renewable energy. The factors that affect the level of energy consumption include annual energy consumption, per capita energy consumption, energy consumption growth rate, GDP energy consumption, high carbon energy use rate and energy consumption structure. The economic level is reflected by GDP, Engel coefficient and CPI. The level of environmental protection is reflected by carbon emissions, air quality, water quality, forest volume, sustainable energy and biodiversity.

Energy internet development. The quality of renewable energy is embodied by reserves, technology development, development cost and resource complementarity. The energy system includes: fossil energy reserves, fossil energy output, fossil energy per capita reserves, fossil energy exports, clean energy and fossil energy proportion. Supply and demand mechanism, price mechanism, competition mechanism and matching mechanism constitute the market mechanism together[5].

Policy. Financial policy is related to financing policy, interest rate and exchange rate. The tax system is related to value added tax, income tax, additional tax, equipment import tariff, electricity export tax and tax preference. Energy policy includes RE subsidy policy, protection of laws and regulations, and special research and development fund. The level of international cooperation is related to the nature of the group, the original intention of the cooperation, the geographical position, the territorial dispute of resources, the economic strength, the level of development, the trade and the level of mutual investment.

Technical level. The level of power generation is determined by energy utilization rate, generation cost, installed capacity and generation hours. The power grid technology level is determined by transmission and supply reliability, power grid load ratio, transmission and supply cost, and power grid comprehensive loss rate.

3. Dynamic efficiency model of power generation investment based on system dynamics

3.1. The selection of core factors
Under the global energy Internet, different power generation investors face different dominant factors in investment. This paper mainly analyzes from the national level, that is, different subjects refer to different countries.

Because the energy Internet is in the early start stage and lacks relevant data support, the key factors of the system need to be screened in the model. The concepts and variables outside the boundary should be excluded from the model and assume that the changes in the external environment of the system do not bring the essential influence on the system behavior, and are not controlled by the internal factors of the system. In the last chapter, the factors affecting the system were preliminarily elaborated. the core factors of the system were selected, modified and improved by the Delphi method in this chapter. Assuming that there are P experts participating in the selection, there are M indicators of the core factors, and the importance level is N. The expertise concentration is defined as:

\[ Q_x = \frac{1}{P} \sum_{y=1}^{N} Q_{y} n_{y} \quad (x = 1, 2, \ldots, M) \]  

The expertise dispersion is defined as:

\[ \theta_x = \frac{1}{P} \sum_{y=1}^{N} n_{y} (Q_{y} - Q_x)^2 \quad (x = 1, 2, \ldots, M) \]  

Where, \( Q_y \) is the value of level \( y \). \( n_{xy} \) is the number of the expert who evaluated the importance of index \( x \) is \( y \). Based on the reality of power generation investment of Global Energy Internet, the limitation of core factors can be comprehensively reflected as follows.

\[ \begin{cases} Q_x \leq 3 \\ \theta_x \leq 0.5 \end{cases} \]  

By calculating the above formula, the core factors that affect the investment of power generation are screened out: per capita GDP, tax rate, subsidy for renewable energy, power generation cost OPEX(operating expense), the ratio of renewable energy and fossil energy(RE/FE), renewable energy technical exploitable amount and RE price. The final determinants are shown in figure 2.

3.2. Causality analysis of core factors based on system dynamic

The structure of the system is analyzed, the feedback mechanism inside the system is determined, and the causality diagram of system factors is constructed. The economic benefit of power generation investment is related to income and expenditure. Feedback relationship between factors is shown in
the following diagram. There is a positive feedback loop and a negative feedback loop, and a positive or negative relationship between variables is existed.

Figure 3. The causality between the core factors and the investment benefit

In figure 3, we can see clearly how the core factors affect the investment efficiency. Then, the mathematical relation between variables are determined and the system dynamics model is finally constructed.

3.3. Modeling of system dynamics

The investment income of the generators mainly includes the sale of electricity revenue and power generation subsidy. The cost of investment mainly consists of the construction cost, taxation and operation cost of power plant. The sum of investment gains and investment costs sum are selected as state variables. In the process of system dynamics simulation, gains and costs can be automatically accumulated every year, divided by the benchmark interest rate and then reduced to profit. The model of generation investment is as follows.

Figure 4. Generation investment model
In the simulation software, input the mathematical equation of the quantified variable relation to simulate the investment process of the system. The formulae that are involved in the model (here are only a part) are as follows.

\[ NPV = CI - CO \]  
\[ CI = \text{INTEGRATION}(\text{growth}) \]  
\[ CO = \text{INTEGRATION}(\text{growth}) \]  
\[ CI \text{ growth} = (\text{subsidy} + \text{sales income}) \times \text{exchange rate} 1 \]  
\[ CO \text{ growth} = (\text{Interest} + \text{Running and repairing Cost} + \text{Tax}) \times \text{exchange rate} 2 \]

4. Sensitivity analysis of influencing factors

In order to analyse the impact of core factors on investment returns (IR), the variables in the model should be assigned. It is assumed that this model is a photovoltaic power generation model. The generation capacity is supposed 10GW, the sale price is 1.15 yuan/kWh, the benchmark ratio is 10%, the tax rate, construction cost and loan rate varies with different countries. Data are from the International Energy Agency.

Different tax rates, construction costs, loan interest rates and GDP are selected for simulation. The following are model simulation results.

In figure 5, When the tax rate is 6%, all the economic indicators of the project run well, and the investment cost is recovered in the 20-21 years of investment. With the increase of tax rate, the payback period of investment is also getting longer. Figure 6 shows that the higher the unit electricity cost is, the longer the investment recovery period will be. Figures 7 and 8 show that low loan interest
rate and high GDP are good for investment. From the results above pictures, we can draw a conclusion that the lower the tax rate, the cost of construction and the interest rate of the loan, the better the investment benefit, and GDP has a positive effect on investment.

5. Conclusion
The dynamic model built by system dynamics can make up for the shortcomings of traditional NPV method, which cannot well reflect uncertainty and investment flexibility. Based on the background of global energy Internet, a dynamic generation investment model is established by combining system dynamics and net present value. Through the sensitivity analysis of investment income, we can conclude that the core factors such as tax rate and policy have a great impact on the investment income of power generation. The core factors of different countries are quite different in value. Therefore, the data of specific countries can be brought into it, and the investment is more economical and effective according to the simulation results.

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