

Analysis of Factors Affecting Investment of Power Grid Enterprises in the Era of Energy Transformation

Haixu Song^{1,a,*}, Xiaodong Li^{1,b} and Xiaoxuan Zhang^{1,c}

¹ SGCC Administrative Area, Future Science and Technology Park North Area, Beqijia Town, Changping, Beiqijia, P. R. China

^ashxstudent@126.com, ^blixiaodong@sgeri.sgcc.com.cn, ^czhangxiaoxuan@sgeri.sgcc.com.cn

*Corresponding author

Keywords: Power reform, Power grid investment, Influencing factors, Management strategy.

Abstract. Based on the background of energy transformation, this paper analyzes the influencing factors of grid enterprises' investment. The analysis shows that the macroeconomic environment directly affects the investment of power grid enterprises, and that the clean and low carbon energy transition, the improvement of comprehensive energy utilization efficiency and the reform of power system are also important factors that power grid enterprises should consider. It is recommended that grid enterprises should thoroughly analyze the impact of large-scale development of clean energy and new requirements of power grid reform on grid enterprises' development, and should continuously improve management processes including grid planning management, comprehensive program management and annual investment plan management. Grid enterprises should optimize investment-related indicator systems, build a scientific quantitative investment analysis model, and continue to strengthen lean management of power grid investment to further improve investment efficiency and effectiveness.

1. Introduction

The power industry is the fundamental industry of the national economy. The power grid investment refers to the investment related to the basic construction of the power grid, such as power transmission and transformation projects, small-scale infrastructure projects, and other special projects. The power grid investment is featured with a large scale of funds, a long construction period and high requirements for safety and reliability, and is directly related to the operation of the enterprise. The social influence of power grid investment is great, which is related to national energy security, national economy and people's living quality. Therefore, it is important for grid enterprises to analyze the influencing factors of grid investment and scientifically make investment decisions.

At present, domestic and foreign scholars have carried out a lot of research on the influencing factors of grid enterprises' investment. Denes Kucsera et al. argue that renewable energy production, uncertainty in power supply, and regulation of transmission and distribution prices have an impact on investment in the power generation and transmission markets[1]. Ryder believes that property rights regime of the transmission network will stimulate grid investment [2]. Yin Peng et al. studied the impact of investment, profit, electricity quantity, and electricity prices on investment capacity[3]. Zhao Huiru et al. used the co-integration theory to verify the long-term equilibrium relationship between grid investment and maximum electricity load, which was based on to establish a long-term equilibrium model for predicting medium and long-term grid investment[4]. Xia Huali and Ye Jinshu classified the influencing factors on grid investment into three categories: macroeconomics, fiscal policy, and electricity market. Based on the co-integration theory and vector error correction model, the mechanism of influence between grid investment and macro environmental factors was verified[5]. Basing on China's related data during 1978 to 2008, He Xiaoying found that power consumption and economic growth can cause investment changes towards the same direction[6]. Zhao Huiru and Fu Liwen used financial management, technical economics and other theories and introduced factors such as return on investment and operational factors to analyze the impact of

business conditions on investment capacity[7]. He Kelei et al. selected key indicators including total profit, unit power supply cost and ten thousand yuan fixed assets electricity sale, basing on system dynamics, to study the dynamic feedback relationship between grid investment amount and investment return[8]. Deng Guojun studied the factors affecting grid investment from the perspectives of macroeconomics and electricity market. Based on vector autoregressive(VAR) theory, Deng analyzed the dynamic relationship of factors affecting grid investment by using impulse response function and variance decomposition and concluded that there is a long-term equilibrium relationship between grid investment and gross domestic product, electricity consumption and sales price[9]. Ji Liwei et al. studied the factors affecting grid investment from the perspectives of macroeconomics and electricity market by regressing grid investment on gross domestic product (GDP), electricity consumption, industrial structure, transmission loss rate, power supply reliability and profit. They reached a law of investment that is useful for the grid enterprises[10]. Pan Liqiang et al. constructed the index system of investment capacity influencing factors from five aspects: management efficiency, grid operation efficiency, grid security, grid development and social benefits, and evaluated the investment ability of grid -enterprises in each year with TOPSIS method[11]. Considering micro-level technical indicators in power transmission and transformation projects, Hu Jinlan et al. used principal component analysis and multiple regression models to systematically study the influencing factors of investment on power projects. Then they constructed a power project investment forecasting and analysis model basing on a BP neural network model and optimized it by particle swarm algorithm[12].

At present, the research on the factors affecting grid investment is mainly focusing on general influencing factors, without considering the new situation of energy transformation or the special background of power system reform. To make up the gap, this paper analyzes the background of China's energy transformation and proposes the influencing factors of grid investment, in order to better support power grid enterprises' decision-making.

2. Energy transformation trend

Currently, global energy crisis and environmental crisis are becoming increasingly severe. A new round of energy transformation is gestating and developing, which will promote the strategic transformation of energy utilization from fossil energy-dominating to clean energy-dominating. China has proposed the "four revolutions, one cooperation" strategy of energy and is speeding up the energy transformation. Energy development will be characterized by clean and low-carbon transformation, improved comprehensive utilization efficiency, and accelerated marketization.

2.1 Clean and low carbon transformation

At present, the low carbonization of energy structure is accelerated. The Paris Agreement proposed the goal to keep the global average temperature within 2°C above the pre-industrial level. In the global context of actively facing climate change, countries around the world have proposed greenhouse gas emission reduction targets. For example, the United States proposed to reduce greenhouse gas emissions in 2020 and 2050 by 17% and 80% respectively compared with 2005; Germany proposed to reduce greenhouse gas emissions in 2020, 2030 and 2050, by 40%, 55%, and 80%-95%, compared with 1990. Japan proposed to reduce greenhouse gas emissions in 2030 by 26% compared with 2013; China also proposed that carbon emissions should reach the highest point in 2030 and the emission intensity should be decreased by 60%-65% compared with 2005.

With the development of technology, the replacement of traditional fossil energy by clean energy are also increased. According to BP World Energy Outlook (2019 edition), renewable energy will become the fastest growing energy source. By 2040, half of the world's additional energy supply will come from renewable energy, and it will replace coal as the most important power generation source. Various countries have also proposed the development goals of energy cleanliness. For example, the United States proposed that renewable energy generation should account for 25% of total generation by 2025. Germany proposed that renewable energy accounts for 35% of electricity consumption and

18% of terminal energy consumption by 2020; Japan proposed that renewable energy will account for 22% to 24% of primary energy by 2030; China also proposed that non-fossil energy should account for 15%, 20% and 50% of primary energy consumption by 2020, 2030 and 2050. Due to the randomness, intermittence and volatility of clean energy, the high proportion of injection of clean energy will change the operating characteristics of the grid, which brings higher requirements of resource allocation capacity on the power grid and directly impacts grid investment.

2.2 Improvement of comprehensive energy utilization efficiency

With the vigorous promotion of energy-saving technology transformation, industrial structure optimization, and recycling economy utilization, the development of integrated energy systems will also promote the integration of different energy supply systems and the energy cascade use, thereby facilitating the continuous improvement of energy utilization efficiency. At present, China's terminal energy utilization efficiency is still low, and it is urgent to bring the hub and conversion function of the power grid into full play and improve comprehensive energy utilization. In 2015, China's terminal unit GDP energy consumption is 1.7 times that of South Korea, 2.7 times that of the United States, 4 times that of Germany, and 5 times that of Japan and the United Kingdom. The gap is still large compared with developed countries in the world. It is necessary to fully exploit the potential of conversion and complementarity of various energy sources including power, heat, cooling and gas, and to improve the comprehensive utilization efficiency of energy.

2.3 Accelerated marketization process

The new round of power system reform has been further promoted, and the opening up of the power market has been accelerated, which is profoundly affecting the functional positioning and profit model of power grid enterprises. In terms of transmission and distribution price reform, power grid enterprises changed from the purchase-and-sale price-difference model to the permitted cost and permitted income model. Therefore, effective assets become an important basis for accounting for the permitted income of power grid enterprises and the transmission and distribution price policy become an important external constraint on the behavior of fixed assets investment on the power grid. It requires grid enterprises to strengthen investment cost management, strictly reduce the unrelated assets and unreasonable costs of the power transmission and distribution. The effectiveness of grid investment has become the key orientation and basic criteria for grid enterprises to make investment decisions. After the deregulation of incremental power distribution, social capital gradually enters and competition is formed in the field of the incremental power distribution, which pushes grid enterprises to reduce investment costs and improve operational efficiency. At the same time, the incremental power distribution network and fair and non-discriminatory opening of the grid also drives new investment of grid enterprises. In the electricity market, the construction of the electricity market provides various market information for grid investment. The market transaction price and transaction scale have become important indicators guiding new grid investment.

3. Analysis of Factors Affecting the Investment of Power Grid Enterprises

The power grid is an important pillar of economic and social development. Power grid enterprises are in the public service industry that provides safe and reliable power for economic and social development. Thus, the construction investment of the power grid is not only affected by the factors of the transformation and development of the industry itself, but also by macro factors such as economic and social development. Therefore, the factors affecting investment of grid enterprises are classified into three categories: macroeconomic factors, energy industry factors, and power reform factors.

3.1 Macroeconomic factors

Macroeconomic factors are the relevant factors that constitute the socio-economic status of the survival and development of power grid enterprises, and can reflect regional income and economic

levels. The power grid is the pillar and basic industry of the national economy, so macroeconomic factors will have a direct impact on grid enterprises' investment. When the level of economic development is high and the growth momentum is obvious, grid investment is usually increased accordingly, in order to meet the growth in electricity demand generated by economic growth. Specifically, macroeconomic factors include economic development level, economic structure, economic driving factors, macroeconomic policies, and economic operations situation. Among them, the economic development level refers to the scale, speed and level of economic development of the country or region, such as GDP, GDP per capita, and GDP growth rate; the economic structure refers to the proportion of different economic components and industrial sectors in the national economy, such as industrial structure, consumption structure and distribution structure; The economic driving factors refer to investment in fixed assets, exports, and national consumption; Macroeconomic policies refer to strategies formulated by countries or regions to achieve economic development goals, such as industrial policies, national income distribution policies, and price policies; Economic operations situation refers to the stability and health of the economic operation, such as the Li Keqiang index, price index, Purchasing Managers' index, etc.

3.2 Energy industry factors

From the perspective of business attributes, the core business of power grid enterprises is to build and operate power grids and provide power supply. Power grid enterprises radically belong to the energy industry, and the transformation and development of the energy industry will have a direct and far-reaching impact on grid investment and development. Besides, grid enterprises are also directly affected by the national energy and power policy, especially the development of clean and low-carbon energy and forces on energy conservation and environmental protection. and the increase in. Specifically, the energy industry factors include energy planning and policy, energy structure, energy supply and demand, energy conservation and environmental protection. Among them, energy planning and policy refers to the national strategic planning and related policies for energy and power development, such as energy revolution, energy development planning, power development planning, renewable energy development planning, energy conservation and emission reduction policies; The energy structure refers to the composition and proportional relationship of various primary and secondary energy sources in total energy production or total consumption, such as proportion of non-fossil energy in primary energy consumption and proportion of electricity in terminal consumption; Energy supply and demand refers to energy supply and demand conditions, such as energy production and consumption, electricity production and consumption; Energy conservation and environmental protection refers to carbon emission reduction, pollutant discharge, and energy conservation.

3.3 Power reform factors

The new round of power system reform has fundamentally changed the development pattern and mode of the power industry, and has also changed people's requirements for energy services. The reform of transmission and distribution price has turned the effective assets of the grid into the core factors affecting the transmission and distribution price. In accounting of the transmission and distribution price, the permitted income is directly related to the effective assets of the grid that can be accrued, and the effective assets are calculated by the specific investment scale of the grid enterprises multiplied by a certain fixed asset formation rate, which is determined by the government's price-administrative department. The changed way in which the price of electricity is calculated and the right to approve effective assets raises higher requirements for the economics of grid investment. It requires grid enterprises to focus on the grid investment that can form effective assets on the basis of prioritizing the development of the main business. After the deregulation of the incremental power distribution, the grid enterprises face a new competitive landscape. Most of the incremental power distribution pilot areas belong to state-level new districts, key industrial parks, and cross-border economic cooperation zones, occupied by wholesale users, who require high reliability. Large scale investment on distribution networks calls for accurate return and risk assessment of grid enterprises'

investment. The accelerated construction of the electricity market will provide price guidance for grid investment. Specifically, power reform factors include transmission and distribution price reform, incremental power distribution reform, and electricity market construction. Among them, the reform of transmission and distribution price refers to the policies and regulations of local governments on effective asset accounting, permitting cost accounting and electricity prices; Incremental power distribution reform refers to the pilots' and competitors' situation of various places; The construction of the electricity market refers to the advancement of the electricity market.

Table 1. Factors affecting power grid enterprises' investment.

Influencing factors		Main content
Macroeconomic factors	The level of economic development	The scale, speed and level of economic development of the country or region, such as GDP, GDP per capita and GDP growth rate.
	Economic structure	The proportion of different economic components and industrial sectors in the national economy, such as industrial structure, consumption structure, distribution structure, etc.
	Economic driving factors	Investment in fixed assets,, exports , national consumption, etc.
	Macroeconomic policy	Strategies or strategies developed by countries or regions to achieve economic development goals, such as industrial policies, national income distribution policies, price policies, etc.
	Economic operations situation	the stability and health of the economic operation, such as the Li Keqiang index, price index, Purchasing Managers' index, etc.
Energy industry factors	Energy planning and policy	National strategic planning and related policies for energy and power development, such as energy revolution, energy development planning, power development planning, renewable energy development planning, energy conservation and emission reduction policies, etc.
	Energy structure	The composition of primary energy and secondary energy in total energy production or total consumption, and their proportional relationship, such as proportion of non-fossil energy in primary energy consumption and proportion of electricity in terminal consumption
	Energy supply and demand	Energy supply and demand conditions, such as energy production and consumption, electricity production and consumption, etc.
	Energy conservation and environmental protection	Carbon emission reduction, pollutant discharge, energy conservation, etc.
Power reform factors	Transmission and distribution price reform	Policies and regulations of local governments on effective asset accounting, permitting cost accounting, and electricity prices.
	Incremental power distribution reform	Pilots' and competitors' situation of various places.
	Electricity market construction	The advancement of the electricity market.

4. Conclusions

Based on the background of energy transformation, this paper analyzes the influencing factors of grid enterprises' investment. The analysis shows that the macroeconomic environment directly affects the investment of power grid enterprises, and that the clean and low carbon energy transition, the improvement of comprehensive energy utilization efficiency and the reform of power system are also important factors that power grid enterprises should consider. It is recommended that grid enterprises should thoroughly analyze the impact of large-scale development of clean energy and new requirements for power grid reform on grid enterprises' development, and should continuously improve management processes including grid planning management, comprehensive program management, and annual investment plan management. Grid enterprises should optimize investment-related indicator systems, build a scientific quantitative investment analysis model, and continue to strengthen lean management of power grid investment to further improve investment efficiency and effectiveness.

Acknowledgment

This research was financially supported by the State Grid Corporate of China Science and Technology Project: Research on Influencing Factors and Mechanism of Corporate Planning Objectives.

References

- [1] Kucsera, Denes, and M. Rammerstorfer. Grid Expansion Investments When Production is Uncertain - A Real Options Model in the Context of Renewables. *SSRN Electronic Journal* 100(2010):152-161.
- [2] Ryder, Geoff, F. Shahid, and S. Yan. The Grid Intelligent Planning Framework: Planning Electric Utility Investments in a Time of Accelerating Change. *International Conference DBLP*, 2011.
- [3] Yin Peng, Zhang Wei, Fan Fei, Zhang Baihan. Comprehensive economic analysis and overall benefit evaluation of the "Twelfth Five-Year Plan" of a provincial power grid. *Jilin Electric Power*, 2011, 39(3): 45-49.
- [4] Zhao Huiru, Yang Wei, Li Chunjie, Ma Wei. Research on grid investment demand forecasting based on co-integration theory and error correction model. *Power Grid Technology*, 2011, 35(9): 193-198.
- [5] Xia Huali, Ye Jinshu. Influencing factors and growth effects of grid investment. *Power Grid Technology*, 2011, 35(Z): 12-20.
- [6] He Xiaoying, Zhou Hui. Analysis and research of power investment based on co-integration theory[J]. *Hydropower Science*, 2011, 29(06): 180-182+133.
- [7] Zhao Huiru, Fu Liwen. Quantitative research on the investment capacity of power grid enterprises. *Hydropower Energy Science*, 2012, 30(4): 191-194.
- [8] He Kelei, Zeng Ming, Qiao Hong. Research on grid investment optimization model based on system dynamics. *Shanxi Electric Power*, 2015, 43(12): 62-65.
- [9] Deng Guojun. Long-term and dynamic relationship between factors affecting grid investment based on time series analysis [D]. *Zhejiang University*, 2015.
- [10] Ji Liwei, YANG Liping, Fei Gaiying. Analysis and Forecast of Influencing Factors of Power Grid Engineering Investment[J]. *China Power Enterprise Management*, 2016(06): 85-92.
- [11] Pan Liqiang, Sheng Wei, He Hongbin, Tian Wei. Evaluation of investment capacity of 220kV power grid based on TOPSIS method. *Modern Economic Information*, 2016, (7): 380-383.
- [12] Hu Jinlan, Gao Xiaobin, Liu Chongming, Shen Chenshu. An Empirical Study on the Influencing Factors of Power Grid Project Investment Based on BP Neural Network[J]. *Engineering Economics*, 2017, 27(10):15-19.