Research on investment boundary and cost dispersal mechanism of power grid enterprises under low-carbon transformation of power grid

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Abstract. In the comprehensive implementation of China's new strategic goals of energy security, how to build an energy supply system with clean and low-carbon energy as the main body and create a new type of power system are the main issues discussed in the low-carbon transformation of power grid in the new era. In the face of challenges from various aspects such as a new balanced system, complex security incentives and cost diversion mechanism, On the basis of mastering the characteristics of the new type of power system, we should put forward new development suggestions for the new type of power system. Therefore, after understanding the opportunities and challenges faced by the development of China's new power system, this paper deeply discusses the evolution path and development strategy of the new power system under the background of low-carbon transformation of the power grid according to the research on the investment boundary and cost dredging mechanism of power grid enterprises.

Keywords: Power grid system; Low-carbon transition; Power grid enterprise; Investment margin; Cost facilitation.

1. Introducion

Faced with the development goal of low-carbon power grid transformation, China's power industry has begun to fully implement the existing energy security strategy and policy, scientifically solve the security problems existing in the construction and development of power grid enterprises, in order to give full play to the unique role of the new power system. In October 2021, the "2030 Carbon Dafen Action Plan" proposed by The State Council clearly stated that it is necessary to build a new power system with a gradually increasing proportion of new energy, and promote the optimization of a large range of clean power resources. It can be seen that the use of new energy to orderly replace traditional energy, build a new power system, and promote clean energy transformation is an effective way to achieve the carbon peak and carbon neutral development goals. Especially under the development trend of economic globalization, China's wind power photovoltaic power generation capacity has exceeded 300 million kilowatts, and the installed capacity has also reached the world's first. However, the number of solar power generation accounts for only about 10%, and the structural form and institutional mechanism of the actual power system cannot meet the higher proportion of new energy consumption needs. In the study, some scholars proposed that in the next 40 years, we should vigorously develop new energy sources such as wind power and photovoltaic, and gradually replace the traditional coal power energy model, so as to ensure the safe and stable operation of the power system.[1-3]

Nowadays, when building and applying a new type of power system, China will scientifically deal with the development contradiction between new energy and traditional energy according to the basic national conditions of excessive shortage of energy resources, to ensure that the construction and operation of the power system have the foundation of persistence, and finally realize the transformation and development from the aspects of technology, mechanism, consumption and supply. From the perspective of the long-term development of the power industry, the new power system mainly faces challenges as shown in Figure 1 below:

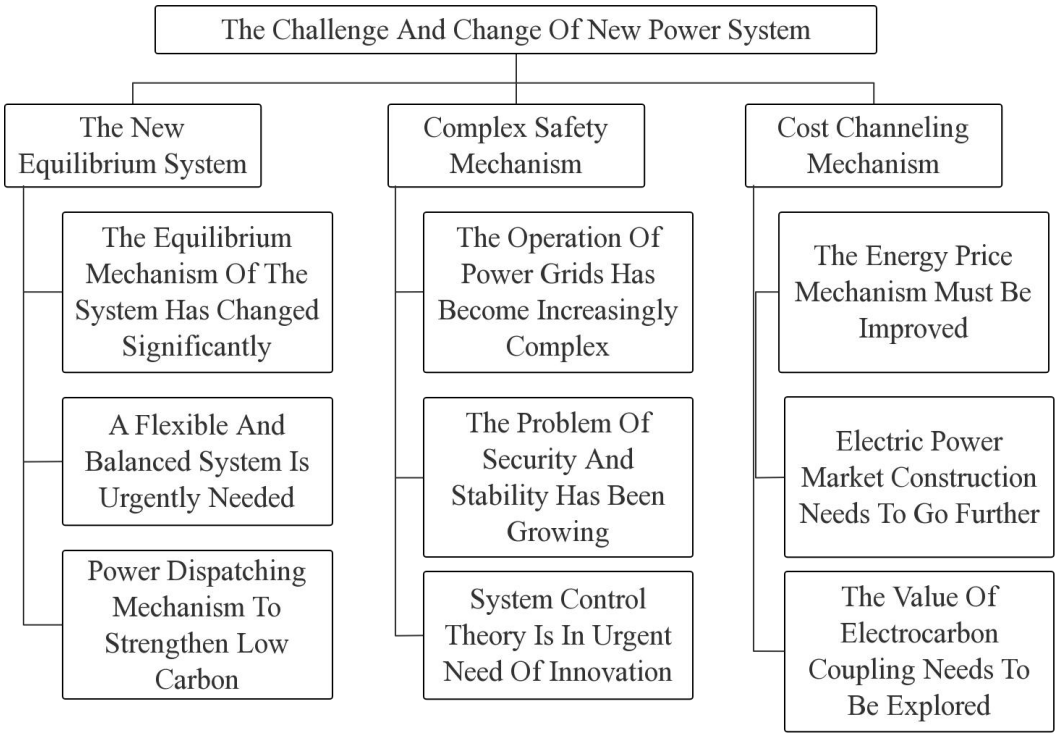

Figure 1. Challenge analysis of the new power system

According to the above study, the new balance system is mainly reflected in three aspects: first, it means that the system balance mechanism has significantly changed, second, it means that the flexible balance system needs to be improved, and finally, it means that the power dispatching mechanism has strengthened low-carbon. The complex security mechanism is mainly reflected in three aspects: first, the power grid operation mode is becoming more and more complex, second, the security and stability problem is becoming more and more serious, and finally, the system control theory innovation; The cost dredging mechanism is reflected in the following three aspects: first, it means that the energy price mechanism must be improved, second, it means that the construction of the power market needs to be deepened, and finally, it means that the value of the electric carbon coupling needs to be explored.[4-7]

In the face of the opportunities and challenges of new power systems under the background of low-carbon grid transformation, the power industry should regard low-carbon power technology innovation as the main driving force for development according to China's basic national conditions, and pay attention to the study of system functions and design architecture from the three aspects of low carbon, safety and efficiency. Therefore, after understanding the development direction of low-carbon transformation of power grid, this paper mainly studies the investment boundary and cost channeling mechanism of power enterprises according to the research status of new power systems, and then deeply discusses the evolution path and effective strategies of new power

enterprises, in order to provide reference for the development of electric power economy and system construction in the new era.[8-11]

2. Methods

2.1 Analysis of investment boundary

In the context of low-carbon power grid transformation development, the investment risk of power grid enterprises is mainly reflected in two aspects, on the one hand refers to physical investment, on the other hand refers to virtual product investment. Among them, the physical investment includes technology investment, equipment purchase, power grid construction and other contents, which has the characteristics of large impact effect, large investment amount and long time. With the continuous development of social economy and power grid enterprises, power grid enterprises have more and more understanding of investment in the financial industry, which has brought a large number of investment risks of virtual products, which are reflected in the following points: First, investment decisions of enterprises cannot adapt to macroeconomic policies. As the basic component of the construction of the whole national economic system, the power system must adapt to the advanced economic construction as soon as possible because of the particularity of the construction and operation of the power grid. However, from the perspective of practice, the investment decisions of most power grid enterprises have a certain deviation from macroeconomic policies. At the same time, because the construction of computer systems requires a long period, the investment activities of enterprises will be affected by financial policies, fiscal and tax requirements and other factors, so the investment risk of power grid enterprises will be increased. Secondly, the management of enterprise investment projects is not in place. In the process of investment projects, power enterprises pay more attention to the specific organization and implementation of the project, ignoring the feasibility demonstration and comprehensive evaluation after completion of the project, which leads to the feasibility and rationality of the project there are bad factors. The feasibility study determines more than 90% of the investment amount. Without comprehensive evaluation of the project, the demonstration investment of power grid enterprises will be unable to maintain rationality, and it will be difficult to further collect relevant problems and effective information about investment decisions, and it will be difficult to provide reference suggestions for the implementation of subsequent projects. Finally, the enterprise investment risk control mechanism is not perfect. At present, there are two risks in the investment risk control mechanism of power grid enterprises: on the one hand, the audit and supervision of investment projects is relatively old-fashioned, and the audit and supervision work related to project projects is usually implemented after the completion and settlement, but relevant problems have already arisen, and many mistakes have been unavoidable. On the other hand, there is no establishment of power grid enterprise investment risk early warning system, which leads to overly optimistic investment and operation period, does not correctly deal with the potential risk problems, and does not put forward a standardized risk treatment plan. In the context of low-carbon transformation and development of power grid, the issue of investment boundary of power grid enterprises is becoming more and more important. The investment income of most power distribution network projects mainly depends on factors such as project cost, electricity price level and power generation quantity. Therefore, when testing the project economy, it is necessary to analyze from the two aspects of cash flow inflow and cash flow outflow. The final results show that the higher the internal management security of power

grid enterprises, the stronger the marginal efficiency of actual investment. From the perspective of current power grid enterprise project investment and financing, the most common risk factors and undertakers are mainly reflected in five aspects, as shown in Table 1 below:[12-15]

Table 1 Analysis of risk factors

Risk factor	Main influencing factors	meaning	Risk taker
Construction risk	Personnel's knowledge structure, research funding, experimental conditions, technical level, information level and theoretical basis, etc.	Can it be successfully built and put into operation?	Electric power industry enterprises
Production risk	Technical foundation, capital investment and quality of technical personnel	Whether the power plant can generate electricity normally and run normally.	Electric power industry enterprises
Managing risk	Management structure, business philosophy, quality of management team, expected income, completeness of service system,	Can the enterprise process management and value chain management be carried out?	Investors and enterprises in the power industry
market risk	Target market, potential user market, competitiveness of power grid operation process, traditional culture and social concepts, market acceptability.	Can you get high profits after the industry has formed its production capacity?	Investors and enterprises in the power industry
Growth risk	Business performance, timeliness and soundness of power grid operation, government tax system and industrial policy, labor and employment system	Can the electric power industry enterprises continue to get the investment of large and medium-sized investors, so that their stock prices will rise?	Investors and enterprises in the power industry

Based on the analysis of the above table, it is found that the construction risk and production risk are mainly directly borne by the enterprises in the power industry, and directly affect the normal operation and effective management of the power system. The other three risks are jointly borne by investors and enterprises in the power industry, which directly affect the final effect of actual

operation and investment. Nowadays, scholars from various countries have gradually strengthened the risk assessment of power grid enterprise investment boundary, which can widely use various qualitative and quantitative analysis methods to grasp potential risks.

2.2 Cost channeling mechanism

First of all, energy as the main factor affecting China's economic and social development, to ensure that energy can be stable for a long time is an important strategic issue for the construction and development of modern society. The new power system has a high proportion of new energy, and the actual operating cost is low, so the construction and application of power system has the characteristics of low marginal cost. At the same time, because of the uncertainty and intermittence of new energy, it has higher capacity, cost, frequency modulation and other development needs, resulting in higher system cost characteristics of the power system. In the face of the development conflict between low marginal cost and high system cost, power enterprises in the new era should reform the energy price mechanism as soon as possible, effectively dreg the high system cost by establishing a capacity market and increasing the income of auxiliary services, and truly show the supply and demand value of energy resources in the store at different times and Spaces.

Secondly, in the new round of power system reform and development, China has established a medium - and long-term power development market, but there are still many problems in the construction of the internal market. For example, the cross-regional trading mechanism is not perfect, the market connectivity between provinces and cities is poor, there are market barriers to the development of electric power enterprises, and it is difficult to show the absorption effect of cross-regional and cross-provincial networking on new energy in a short time. The lack of market mechanisms consistent with the transformation and development of new power enterprises, the lack of clear management mechanisms and trading rules for the market development of new energy and energy storage as the main body, it is difficult to mobilize new market players to actively participate in market activities, and ultimately lead to limited scope of optimization of power resources; Lack of market mechanism to support the interaction of source and network load and storage, it is difficult to support the market players in all aspects of the new power system to participate in the market flexibly, and a variety of market players cannot access power is the system participation optimization.

Finally, in the context of low-carbon grid transformation development, in addition to the production cost of energy, the corresponding environmental value has become very important. New energy power generation has the characteristics of high environmental value and low production cost, while traditional energy production cost matters, but the environmental value is lower. Therefore, the market value of the new power system should fully consider the production cost and environmental value of different energy sources, and use the establishment of an independent market, increasing subsidies and taxes, adjusting the price mechanism, etc., to truly achieve the multiple goals of energy conservation and emission reduction

3. Result analysis

Starting from the two aspects of the investment margin and cost dispersal mechanism of power grid enterprises, it is found that the construction characteristics of the new power system are very significant, as shown in Figure 2 below:

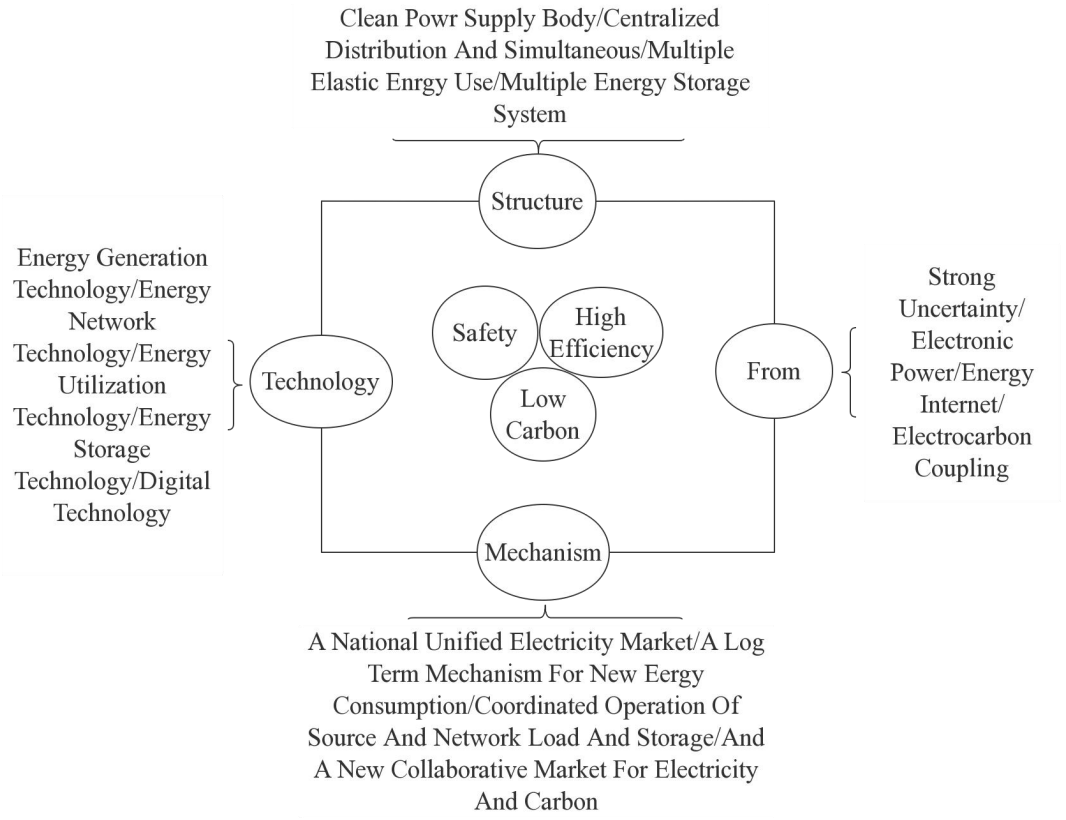

Figure 2. Feature analysis of new power system

Combined with the above analysis, we can see that when the traditional power system dominated by fossil energy is transformed and upgraded to the new power system dominated by clean and low-carbon energy, the mechanism, technology, form and structure of the power system will undergo profound changes, and finally achieve the development goals of safety, efficiency and low carbon.

As the construction of new power system is a relatively complex engineering task, different development problems need to be solved in different development stages. According to the comparison results of the characteristics of power systems in different evolution stages as shown in Table 2 below, the carbon peak period belongs to the transformation stage of the traditional power system, new energy will gradually develop into the main body of electric power installation, the power grid form presents the characteristics of large power grid and distributed, and the overall power consumption situation is very flexible and effective. The carbon neutral period belongs to the mature stage of the development of new power systems, clean energy has become the main body of variables, and the overall development shows the form of mutual compatibility and complementarity of large power sources, large power grids and distributed systems.

Table 2 Comparison results of characteristics of power systems in different evolution stages

Category stage	Peak carbon dioxide emissions period	Carbon neutralization period
mains side	The new energy has gradually developed into the main body of the installation, and the coal-fired power has been reduced in capacity and changed into a flexible power supply.	Clean energy has developed into the main body of electricity and electricity, and some coal-fired electricity has been retired without being dismantled, ensuring safety and standby.

Power grid side	Present large power grid and distributed simultaneously, Overall, it maintains high moment of inertia and AC synchronous operation.	AC-DC hybrid power grid, flexibl， Various forms of power grids such as microgrid coexist.
Load side	Clean heating and other forms of electric energy to replace acceleration, electric vehicles and other adjustable flexible loads to accelerate development.	Deep integration with terminal departments such as construction, industry and transportation will build a clean and intelligent future energy Internet.
Energy storage side	Rapid development of pumping and electrochemical energy storage	Multi-scale and multi-technology energy storage system and sharing mode
Institutional mechanism	Basically build a unified national electricity market system.	Build a unified national electricity market and carbon market in an all-round way.

Under the development trend of economic globalization, facing the development goal of carbon peaking and carbon neutrality in China, the power sector should improve the development mechanism of the new power system from the following aspects, as shown in Figure 3 below:

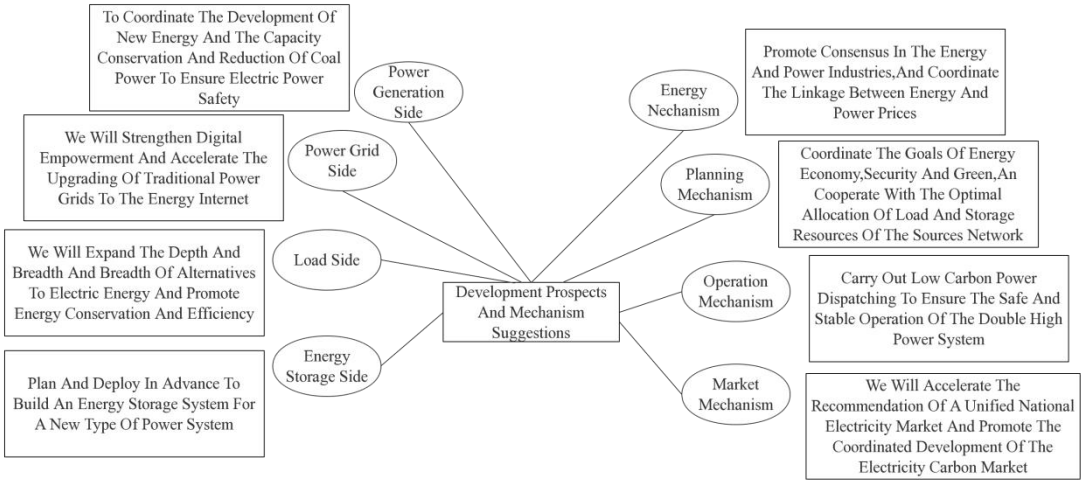

Figure 3. Development mechanism of new power system

From the perspective of long-term development, the structural form of the new power system in the future is unclear, but the development direction of the past decade is very clear, so the optimization and innovation from the power generation side, the power grid side, the load side, the energy side and the energy mechanism, the planning mechanism, the operating mechanism and the market mechanism can scientifically solve the problems faced by the transformation and development of the traditional power system. Provide basic guarantee for the construction of new power system.

Conclusion

To sum up, how to build a new type of power system suitable for China's basic national conditions is the main problem of modern economic construction exploration. Therefore, scholars in various fields should focus on the theoretical knowledge and application technology of new power

systems, promote the supply-side reform of China's energy field, and fully demonstrate the advantages of new energy technologies represented by wind energy and solar energy, so as to guide the transformation and upgrading of China's power enterprises in the direction of low-carbon environmental protection.

References

[1] Ranjie Pan,Wenzhe Li,Renxian Huang. Research on cost dredging and recovery mechanism of pumped storage power station under the background of new power system [J]. Science and Technology Innovation Review, 2022, 19(26):5.

[2] Junpeng Gao, Jie Xu, Jingde Yan, et al. Research on the linkage mechanism and price dredging mechanism between carbon market and electricity market in Gansu Province [J]. Business Situation, 2021(41):0031-0034.

[3] Qi Xing Sun,Chao Zhang,Cheng Ren Li, et al. Prediction of power system cost and price level under the goal of "carbon peaking and carbon neutrality" [J]. China Electric Power, 2023, 56(1):8.

[4] King Chen Wei holy Shang Yaru Bai Chunguang. Research on low-carbon technology investment of power supply chain enterprises under carbon cap-and-trade mechanism based on local protection [J]. Journal of UESTC: Social Science Edition, 2022, 24(5):73-87.

[5] Zhe Jin,Xinghua Zhang, Songhua Jin. Discussion on the application of digital twin technology in the cost accounting of distribution network projects of power grid enterprises [J]. Finance and Accounting, 2021(22):2.

[6] Xuelu Cao,Hengzi Huang,Wen Zhao, et al. Efficiency measurement and incentive mechanism of provincial power grid enterprises under the background of new electricity reform [J]. Journal of Finance and Economics, 2022(4):9.

[7] Zhicheng Liu,Daogang Peng, Huirong Zhao, et al. Development prospect of energy storage participating in auxiliary service of power system under dual-carbon target [J]. Energy Storage Science and Technology, 2022, 11(2):13.

[8] Xinfu Song, Honglian Zhou, Jin Yu. Thoughts and Suggestions on Promoting the Development of new energy storage [J]. China Electric Power Enterprise Management, 2022(13):2.

[9] Zhigang Zhang,Chongqing Kang. Challenges and prospects for building new power systems under carbon neutrality [J]. Proceedings of the CSEE, 2022, 42(8):13.

[10] Zhiyong Shi,Caixia Wang,Jing Hu. Price formation mechanism and cost facilitation optimization method of independent new energy storage power station [J]. Energy Storage Science and Technology, 2022, 11(12):10.

[11] Baojun Xing and Yingjun Hu. Difficulties in electricity market reform from the perspective of resolving the contradiction of coal and electricity prices [J]. Market Weekly · Theory Edition, 2022(2):0135-0138.

[12] Yakun Liu. Challenges and future prospects for building new power systems in the context of carbon neutrality [J]. Chinese Science and Technology Journal Database (full-text) Engineering and Technology, 2022(10):4.

[13] Guojing Liu,Bingjie Li,Xiaoyan Hu, et al. Energy storage related policies and power market mechanisms in Australia and their implications for China [J]. Energy Storage Science and Technology, 2022, 11(7):12.

[14] Lei Liu,Shanhao Zhong, Aixiang Tong. Mechanism and Countermeasures to resolve the cost impact of cleaner production in small and medium-sized enterprises [J]. Journal of Party and Government Cadres, 2022(7):8.

[15] Xiuzhao Zhang,Yumin Mao,Yuqin Yang,Zhengsheng Wu,Hangyu Wan, Zhimin Wang,Shuang Zhao. Strategic Research on Building a New Power System in Yunnan under the Target of "Double Carbon" [J]. Electrotechnical and Electric, 2022(12):1-6.