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Research on Implementation Guidance and Market Mechanism of Electric Energy Substitution in Hebei Province Based on Low-Carbon Energy Planning

Yi Liang[1], Yingying Fan[2,*], Zhiliang Dong[3], Yongfang Peng[1], Yongli Zhang[1], Haigang An[1], Qiaoran Yang[1], Ziyi Liang[4]

[1]School of Management, Hebei GEO University, Shijiazhuang, 050031, China
[2]School of Art, Hebei GEO University, Shijiazhuang, 050031, China
[3]Strategy and Management Base of Mineral Resources in Hebei Province, Shijiazhuang, 050031, China
[4]School of Urban Geology and Engineering, Hebei GEO University, Shijiazhuang, 050031, China
yingyingfan@hgu.edu.cn
**Corresponding author*

Abstract: *In order to achieve the established energy conservation and emission reduction goals of China and Hebei Province, this paper studies the implementation guidance and market mechanism of electric energy substitution under the environment of low-carbon energy planning. Through the analysis of the stakeholders of the electricity substitute market under the background of low-carbon energy planning, the interests of all parties are clarified. For the implementers and promoters of electric energy substitution, three guiding mechanisms for the implementation of electric energy substitution are put forward, including quota policy, new energy feed-in tariff subsidy policy and carbon tax policy. Three main applicable mechanisms of electric energy substitution are mainly put forward, including virtual power plant, auxiliary service and power generation right trading, in order to promote the optimization of energy system structure and low-carbon energy planning in Hebei Province.*

Keywords: *Low-carbon energy planning, Electricity substitution, Guiding mechanism, Market mechanism*

1. Introduction

The purpose of regional energy planning is the basis of the full interpretation of the master planning and site conditions, in the national medium and long-term development and low carbon energy strategy under the guidance of policy, through the formulation reasonable regional energy development strategy and planning, to ensure adequate and stable energy supply on the basis of optimizing adjustment of energy structure, formulate energy development goal, carry out measures of energy saving technology, In order to establish a win-win energy supply and demand system for regional economic benefits and ecological environmental benefits [1]. As a secondary energy, electric energy has multiple advantages compared with primary energy directly as terminal energy. Converting fossil energy such as coal into electric energy is one of the most efficient and environmentally friendly effective ways. With the continuous improvement of China's electric power industry, it has the ability to vigorously develop renewable energy generation. At present, China has formed a multi-pronged clean power generation mode, including wind power, nuclear power, photovoltaic and biomass [2]. Therefore, in the context of low-carbon energy planning, in order to promote and optimize the energy consumption structure of China and Hebei Province, vigorously carry out electric energy substitution projects and improve the electrification level and the proportion of electric energy in the energy consumption terminal are of great significance to achieve energy conservation and emission reduction, sustainable development and improvement of people's living standards [3]. As a commodity with special attributes, electric energy is not only related to the national economy and people's livelihood, but also related to the business benefit of electric power enterprises, so the competition of energy consumption is also the competition between energy enterprises. At the same time, due to the current situation that China is in the early stage of the electricity market reform, the market mechanism is not complete, the improvement of the proportion of electricity in the energy consumption terminal requires strong administrative execution ability, and the

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construction of electricity replacement projects needs to be directly promoted by the government [4]. Therefore, it is an important guarantee for the smooth development of electric energy substitution projects to design policy guidance mechanism and implement relevant incentive policies and promotion measures.

2. Related Stakeholders of Electric Energy Substitution

China is in the early stage of the electricity market reform, and the market mechanism has not yet taken shape. The market demand of the electric energy replacement industry will gradually emerge, but the incremental market demand is still lacking, and the customer recognition is not high. Under the background of electricity marketization just starting, the electric energy substitution industry needs to be promoted by the government, which involves relatively single stakeholders, mainly including the government, users, power grid companies, other comprehensive energy service providers in the society, energy-saving equipment manufacturers, financial institutions, etc. Among them, government represents social stakeholders, including national, social, environmental and other interests [5].

(1) The government plays an important role in promoting and guaranteeing the promotion of electric energy substitution. The government formulates policies related to electric energy substitution, environmental protection, carbon emission and electricity price, and issues financial subsidies to promote the development of electric energy substitution. Its main benefits come from the environmental protection benefits brought by energy saving and emission reduction and the whole social and economic benefits brought by the development of related industries promoted by electric energy substitution.

(2) Users are the main recipients of electric energy replacement, including industrial users, commercial users, residential users, etc. Different types of users will accept different technologies to replace electricity. Its main benefits come from the overall reduction of energy cost brought by electric energy replacement and the improvement of living environment brought by energy saving and emission reduction.

(3) Power grid company is the main promoter and executor of electric energy substitution. According to the national policy, the power grid company formulates the electric energy substitution strategy and actively promotes the development of electric energy substitution technology and market expansion. Its main benefits come from the economic benefits brought by the increase of terminal electric energy consumption and the corresponding benefits brought by the transformation and construction of distribution network. At present, the company mainly carries out the electric energy replacement project with the energy saving service company. Energy saving service companies actively play the role of comprehensive energy service providers, taking electric energy replacement as their main business.

(4) Other comprehensive energy service providers in the society can also participate in the promotion of electric energy substitution technology, which mainly benefits from the economic benefits brought by the increase of users' electricity consumption.

(5) The equipment manufacturer provides electric energy to replace the equipment that needs to be replaced or upgraded in the promotion process, and its main benefits come from the economic benefits generated by equipment sales and equipment leasing.

(6) Financial institutions can participate in the investment link of the construction of the electric energy replacement project, participate in financing, bank loans, etc., to provide funds for the electric energy replacement project. Its benefits mainly come from investment returns.

Among the above stakeholders, the government and power grid enterprises are mainly the promoters and executors of the implementation guidance mechanism. According to the interest needs of each interest subject, the corresponding implementation guidance mechanism is formulated after synthesis. The corresponding relationship is shown in Figure 1.

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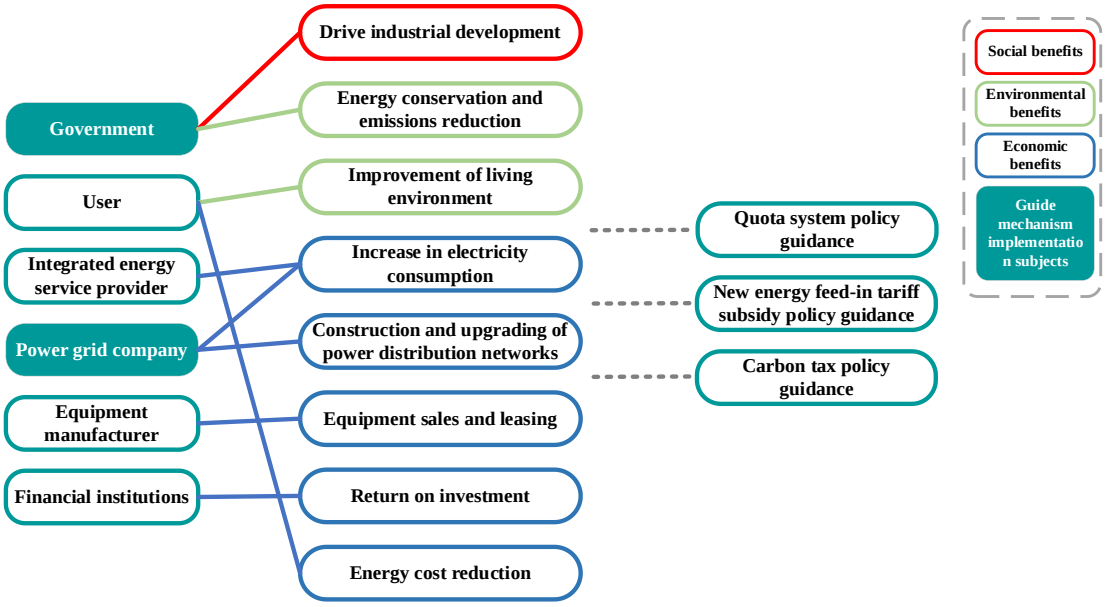

Figure 1: Coupling relationship between stakeholders and implementation guidance mechanism under low-carbon energy planning

3. Guiding Mechanism of Electrical Energy Substitution Implementation

The government needs to promote the development of electric energy substitution directly because of the high demand of capital and administrative enforcement capacity in the preliminary construction of electric energy substitution projects. At this stage, the application of electric energy substitution will be mainly concentrated in the fields where the government pays more attention to society and has a prominent demand for reducing energy consumption and carbon emissions, such as transportation and industrial enterprises with a lot of emissions. In some individual market applications, mainly promote electric heating, household electrification and so on. In terms of the commercialization of electric energy substitution projects, market demand will gradually emerge, but the incremental market demand is still lacking and the customer recognition is not high. The market mechanism is only formed initially, and the implementation of guidance mechanism will be the main driving force to promote the development of early electric energy substitution projects [6]. Based on the above analysis of the interests of all parties in the electric energy substitution project, the following three guiding mechanisms for the implementation of electric energy substitution are proposed.

(1) Quota system policy guidance

On March 3, 2016, the National Energy Administration issued a guideline on establishing a Target Guiding System for the Development and Utilization of Renewable energy. Renewable energy quota system is a country or a region in the form of law mandatory renewable energy generation proportion in the total generating capacity, and demanded that the grid companies for its full acquisitions, can not meet the requirement of the quota, the responsible persons of the corresponding punishment system of a kind of right now it's in the United States, Britain, Australia and Japan and other countries widely used.

The basic contents of China's quota system policy are as follows:

1) Subject: power generation and electricity sales enterprises;

2) Regulatory subjects: power generation enterprises, power trading institutions and power grid enterprises shall be responsible to provincial energy authorities, and provincial energy authorities shall be responsible to the National Energy Administration;

3) Regulatory content: renewable energy utilization, proportion in total energy consumption, proportion of non-hydropower renewable energy and other types of renewable energy electricity, heat and fuel included in the national energy statistics system;

4) Source of certificates: Establish a registration and trading platform for renewable energy power green certificates, and conduct transactions in accordance with the market mechanism;

ISSN 2616-5902 Vol. 4, Issue 1: 1-6, DOI: 10.25236/AJBM.2022.040101

5) Quota ratio: Except for specialized non-fossil energy producers, non-hydro renewable energy generation of each power generation enterprise shall account for more than 9% of the total power generation.

(2) New energy feed-in tariff subsidy policy guidance

At the beginning of the electric power market reform, the market mechanism is not yet perfect, the market main body is not yet mature, electrical energy alternative technology is not developed, running cost and technical characteristics is not competitive, so still need price subsidies in order to enhance its market competitiveness, but consideration shall be given to the market mechanism at the same time, pay attention to and the combination of market-oriented means, avoid the excessive subsidies, so at this stage, "Market price plus premium subsidy" is the most appropriate mechanism. At the same time, since it is the initial stage of market-oriented reform, the "dual track system" of fixed electricity price and premium mechanism can be set to give more options to the stakeholders of the electric energy substitution industry, so that they can choose corresponding price policies according to their own benefits.

As the new energy developed by electric energy substitution technology participates in market competition, its profitability cannot be guaranteed. Therefore, a reasonable range of the feed-in price of new energy can be set. When the market price is very low, the premium subsidy of the government will be increased to ensure that the revenue of the generator is greater than or equal to the lower limit price. If the market price is between the upper and lower limits, the premium is reduced to ensure that the total revenue of the new energy power generation company (market price + premium) does not exceed the upper limit. If the market price is higher than the upper limit, there is no premium and the new energy operator can only get the market price. When the market price exceeds the price threshold, the proceeds should be collected into a renewable energy development fund to pay for the government's premium subsidies.

(3) Carbon tax policy guidance

According to the report on ‘’The Issue of China's Carbon Tax’’ issued by the Ministry of Finance, from the perspective of actual tax management and operation, carbon tax should be levied in the production link, and the carbon tax should be levied as an extra-valorem tax. Carbon tax is levied on carbon dioxide emissions, divided into two cases, one is the carbon dioxide emissions in the production process, the other is the carbon dioxide caused by the burning of energy.

The collection of green tax system will eventually increase the production cost of fossil energy power sector, and then increase its price, enhance the price competitiveness of new energy power to a certain extent, and promote the replacement of fossil energy power by new energy power. As the price of coal and oil rises, energy-intensive and energy-intensive industries will seek alternative products with more economic efficiency. Under the liberalization of the power market in the future, new energy electricity in valley period has a very high price advantage, which indirectly promotes the replacement of electricity to coal and oil.

4. Typical Market Mechanism of Electric Energy Substitution

It is necessary to participate in the free competition of electric power market in the future promotion and application of electric energy substitution industry. Up to now, a variety of market mechanism models have been applied, including virtual power plants, real-time balance of electric energy, auxiliary services, principal-agent trading of power generation rights, etc. [6]. Based on the analysis of the new stakeholders in the electricity market reform and the reference of the existing multiple market mechanism models, the model of multi-agent, multi-energy form and multi-energy service provider's participation and free choice market mechanism is established.

(1) Virtual power plant

However, with the development of renewable energy and the reform of electric power, a large amount of money has been invested in the power system, and the number of new energy units has exploded. It is difficult for the power grid dispatching department to carry out specific dispatching of each new energy unit. Because the installed capacity of the new energy unit itself is small, and the output volatility is strong. In this context, virtual power plants emerge as The Times require. They can act as a bridge between the power grid dispatching department and each generator set, aggregate some power sources into a whole to accept the power grid dispatching instructions, provide their own

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operating parameters and operating data, and form an operation scheme with high efficiency, low cost and strong operability.

Similarly, in the mature electricity market in the future, the demand-side resources covered by electricity substitution projects have a considerable amount and can be used as flexible and dispatchable resources on the demand side to participate in the operation of the electricity market. Especially in the field of power supply and consumption related technologies, trans-regional and trans-provincial clean replacement technology, energy storage application technology, heat pump, electric cold storage air conditioning, thermal power storage boiler and other technologies have been promoted and applied.

(2) Auxiliary services

In each design stage, the degree of marketization of auxiliary service market is gradually deepened, its pricing mechanism is gradually transformed from cost to market, and its commitment principle is gradually changed from the original obligation of power generation companies to who benefits and who bears, which greatly improves the vitality and competitiveness of auxiliary service market. In addition, in the electricity market, both sides of the transaction only trade in electric energy, the power grid company is only responsible for the transfer of electric energy, and other power plants are not obliged to provide auxiliary services for free, so the establishment and improvement of auxiliary service market is more and more important.

According to the existing research, ancillary services market mechanism combined with electricity market reform in China, sell electricity side open, much energy service provider in the background, build power substituted industry based on the technology of electrical energy storage depth to participate in ancillary services market mechanism model, based on electric energy storage mechanism of power instead of ancillary services market, It is of great significance to give full play to the advantages of electric energy storage technology in power peak and frequency modulation to promote the healthy development of China's energy storage industry and ensure the safety of power system and the quality of electric energy products.

(3) Transaction of power generation rights

The transaction of power generation right refers to the behavior that some independent power generation enterprises sell and trade power generation right according to the transaction rules of the electricity market on the basis of obtaining the power generation license and having a certain capacity task. Its essence is to establish effective price compensation through balance transaction between power generation enterprises with different generation costs, so as to realize reasonable and optimal allocation of resources.

With the advance of electric power marketization and the liberalization of electricity sales side, low-cost and low-energy generators will occupy a more favorable position in the market with their technological advantages and promote the rapid development of China's clean energy electric energy replacement industry. Take electric energy storage technology as an example. Compared with traditional power generation methods with high energy consumption, high pollution and high carbon emissions, electric energy storage technology is cleaner and more efficient, especially the electric energy storage supported by new energy generation technology, which greatly reduces the power generation cost. It can be seen from the above introduction that under the same conditions, it is easier for the units with high energy efficiency to obtain the qualification of power generation right trading in the power market. Therefore, the electric energy replacement industry based on electric energy storage technology is very compatible with the power generation rights trading market mechanism.

5. Conclusions

Through the analysis of the stakeholders of the electricity substitute market under the background of low-carbon energy planning, the interests of all parties are clarified. On the one hand, due to the status quo in the early stage of the electricity market reform, the market mechanism is not perfect, the improvement of the proportion of electricity in the energy consumption terminal needs strong administrative execution ability, and the construction of the electricity replacement project needs the government to promote directly. Therefore, the implementers and promoters of the electricity replacement, the government and power grid companies, put forward three guiding mechanisms for the implementation of electric energy substitution under the background of regional low-carbon energy planning: quota policy guidance, new energy feed-in tariff subsidy policy guidance and carbon tax

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policy guidance, which ensured the development of electric energy substitution projects in the initial stage. This paper mainly puts forward three main applicable mechanisms of electric energy substitution: virtual power plant, auxiliary service and power generation right trading, in order to promote the optimization of energy system structure and low-carbon energy planning in Hebei Province.

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References

[1] Li Jingyuan, Shang Rui, Qi He, Li Dan. Multi-objective optimization method in regional energy planning. Urban housing, 2017, 24(12): 103-107.
[2] Chen Peng. Practice of regional building low-carbon energy planning. Shanghai Energy Conservation, 2016, 6: 310-314.
[3] Sun Shengbo, Zhang Kai, Cui Wei, Miao Liqiang, Wang Zhiwei. Research on energy replacement and energy saving transformation strategy of key industries in southern Hebei province. Electric Age, 2020, 10: 32-35.
[4] Jing Yang, Yuyi Qin, Song Bai. Research and practice of energy substitution policy promotion and market expansion. Enterprise Management, 2018, S2: 268-269.
[5] Yang Qing. Cooperative mechanism paving alternative path of electric energy. State Grid, 2016, 8: 22-25.
[6] Wang Jiping, Liu Guosheng, Yang Shuo. Hebei: Construction of electric energy substitute three-dimensional promotion mode. China Electric Power Enterprise Management, 2016, 11: 26-31.